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The Turkish Journal of Spinal Surgery is the official publication of the Turkish Spinal Surgery Society. The Turkish Spinal Surgery Society was established in 1989 in Izmir (Turkey) by the pioneering efforts of Prof. Dr. Emin Alıcı and other a few members. The objectives of the society were to: - establish a platform for exchange of information/ experience between Orthopedics and Traumatology Specialists and Neurosurgeons who deal with spinal surgery - increase the number of physicians involved in spinal surgery and to establish spinal surgery as a sophisticated medical discipline in Turkey - follow the advances in the field of spinal surgery and to communicate this information to members - organise international and national congresses, symposia and workshops to improve education in the field - establish standardization in training on spinal surgery - encourage scientific research on spinal surgery and publish journals and books on this field - improve the standards of spinal surgery nationally, and therefore make contributions to spinal surgery internationally. The Turkish Journal of Spinal Surgery is the official publication of the Turkish Spinal Surgery Society. The main objective of the Journal is to improve the level of knowledge and experience among Turkish medical society in general and among those involved with spinal surgery in particular. Also, the Journal aims at communicating the advances in the field, scientific congresses and meetings, new journals and books to its subscribers. The Turkish Journal of Spinal Surgery is as old as the Turkish Spinal Surgery Society. The first congress organized by the Society took place in Çeşme, Izmir, coincident with the publication of the first four issues. Authors were encouraged by the Society to prepare original articles from the studies presented in international congresses organized by the Society every two years, and these articles were published in the Journal. The Journal publishes clinical or basic research, invited reviews, and case presentations after approval by the Editorial Board. Articles are published after they are reviewed by at least two reviewers. Editorial Board has the right to accept, to ask for revision, or to refuse manuscripts. The Journal is issued every three months, and one volume is completed with every four issue. Responsibility for the problems associated with research ethics or medico-legal issues regarding the content, information and conclusions of the articles lies with the authors, and the editor or the editorial board bears no responsibility. In line with the increasing expectations of scientific communities and the society, improved awareness about research ethics and medico-legal responsibilities forms the basis of our publication policy. Citations must always be referenced in articles published in our journal. Our journal fully respects to the patient rights, and therefore care is exercised in completion of patient consent forms; no information about the identity of the patient is disclosed; and photographs are published with eye-bands. Ethics committee approval is a prerequisite. Any financial support must clearly be disclosed. Also, our Journal requests from the authors that sponsors do not interfere in the evaluation, selection, or editing of individual articles, and that part or whole of the article cannot be published elsewhere without written permission.

The Turkish Journal of Spinal Surgery is available to the members of the society and subscribers free of charge. The publication and distribution costs are met by membership fees, congresses, and the advertisements appearing in the journal. The advertisement fees are based on actual pricing. The Editorial Board has the right for signing contracts with one or more financial organizations for sponsorship. However, sponsors cannot interfere in the scientific content and design of the journal, and in selection, publication order, or editing of individual articles. The Turkish Journal of Spinal Surgery agrees to comply with the "Global Compact" initiative of the UN, and this has been notified to the UN. Therefore, VI our journal has a full respect to human rights in general, and patient rights in particular, in addition to animal rights in experiments; and these principles are an integral part of our publication policy

Recent advances in clinical research necessitate more sophisticated statistical methods, welldesigned research plans, and more refined reporting. Scientific articles, as in other types of articles, represent not only an accomplishment, but also a creative process. The quality of a report depends on the quality of the design and management of the research. Well-designed questions or hypotheses are associated with the design. Well-designed hypotheses reflect the design, and the design reflects the hypothesis. Two factors that determine the efficiency of a report are focus and shortness. Drawing the attention to limited number of subjects allows the author to focus on critical issues. Avoidance from repetitions (apart from a few exceptions), a simple language, and correct grammar are a key to preparing a concise text. Only few articles need to exceed 3000 words, and longer articles may be accepted when new methods are being reported or literature is being reviewed. Although authors should avoid complexity, the critical information for effective communication usually means the repetition of questions (or hypotheses or key subjects). Questions must be stated in Summary, Introduction and Discussion sections, and the answers should be mentioned in Summary, Results, and Discussion sections. Although many journals issue written instructions for the formatting of articles, the style of the authors shows some variance, mainly due to their writing habits. The Turkish Journal of Spinal Sur-

gery adopts the AMA style as a general instruction for formatting. However, not many authors have adequate time for learning this style. Thus, our journal is tolerant to personal style within the limitations of correct grammar and plain and efficient communication.

Responsibility for the problems associated with research ethics or medico-legal issues regarding the content, information and conclusions of the articles lies with the authors, and the editor or the editorial board bears no responsibility. In line with the increasing expectations of scientific communities and the society, improved awareness about research ethics and medico-legal responsibilities forms the basis of our publication policy. Citations must always be referenced in articles published in our journal. Our journal fully respects to the patient rights, and therefore care is exercised in completion of patient consent forms; no information about the identity of the patient is disclosed; and photographs are published with eye-bands. Ethics committee approval is a prerequisite. Any financial support must clearly be disclosed. Also, our Journal requests from the authors that sponsors do not interfere in the evaluation, selection, or editing of individual articles, and that part or whole of the article cannot be published elsewhere without written permission.

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The Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spinal Surgery Society. It is a peer-reviewed multidisiplinary journal for the physicians who deal with spinal diseases and publishes original studies which offer significant contributions to the development of the spinal knowledge. The journal publishes original scientific research articles, invited reviews and case reports that are accepted by the Editorial Board, in English. The articles can only be published after being reviewed by at least two referees and Editorial Board has the right to accept, revise or reject a manuscript. The journal is published once in every three months and a volume consists of four issues.

- The Journal of Turkish Spinal Surgery is published four times a year: on January, April, July, and October.

- Following types of manuscripts related to the field of "Spinal Surgery" with English Summary and Keywords are accepted for publication:

I- Original clinical and experimental research studies;
II- Case presentations; and
III- Reviews
The manuscript submitted to the journal should not be previously published (except as an abstract or a preliminary report) or should not be under consideration for publication elsewhere. Every person listed as an author is expected to have been participated in the study to a significant extent. All authors should confirm that they have read the study and agreed to the submission to the Journal of Turkish Spinal Surgery for publication. This should be notified with a separate document as shown in the "Cover Letter" in the appendix. Although the editors and referees make every effort to ensure the validity of published manuscripts, the final responsibility rests with the authors, not with the Journal, its editors, or the publisher. The source of any financial support for the study should be clearly indicated in the Cover Letter.

lt is the author's responsibility to ensure that a patient's anonymity be carefully protected and to verify that any experimental investigation with human subjects reported in the manuscript was performed upon the informed consent of the patients and in accordance with all guidelines for experimental investigation on human subjects applicable at the institution(s) of all authors. Authors should mask patients' eyes and remove patients' names from figures unless they obtain written consent to do so from the patients; and this consent should be submitted along with the manuscript. Clinically relevant scientific advances during recent years include use of contemporary outcome measures, more sophisticated statistical approaches, and increasing use and reporting of well-formulated research plans (particularly in clinical research). Scientific writing, no less than any other form of writing, reflects a demanding creative process, not merely an act: the process of writing changes thought. The quality of a report depends on the quality of thought in the design and the rigor of conduct of the research. Well-posed questions or hypotheses interrelate with the design. Well-posed hypotheses imply design and design implies the hypotheses. The effectiveness of a report relates to brevity and focus. Drawing the attention to a few points will allow authors to focus on critical issues. Brevity is achieved in part by avoiding repetition (with a few exceptions to be noted), clear style, and proper grammar. Few original scientific articles need to be longer than 3000 words. Longer articles may be accepted if substantially novel methods are reported, or if the article reflects a comprehensive review of the literature. Although authors should avoid redundancy, effectively communicating critical information often requires repetition of the questions (or hypotheses/key issues) and answers. The questions should appear in the Abstract, Introduction, and Discussion, and the answers should appear in the Abstract, Results, and Discussion sections. Although most journals publish guidelines for formatting a manuscript and many have more or less established writing styles (e.g., the American Medical Association Manual of Style), styles of writing are as numerous as authors. The Journal of Turkish Spinal Surgery traditionally has used the AMA style as a general guideline. However, few scientific and medical authors have the time to learn these styles. Therefore, within the limits of proper grammar and clear, effective communication, we will allow individual styles.

- **Permissions:** As shown in the example in the appendix (Letter of Copyright Transfer) the authors should declare in a separate statement that the study has not been previously published and is not under consideration for publication elsewhere. Also, the authors should state in the same statement that they transfer copyrights of their manuscript to our Journal. Quoted material and borrowed illustrations: if the authors have used any material INSTRUCTIONS TO AUTHORS XVI that had appeared in a copyrighted publication, they are expected to obtain written permission letter and it should be submitted along with the manuscript.

Review articles: The format for reviews substantially differs from those reporting original data. However, many of the principles noted above apply. A review still requires an Abstract, an Introduction, and a Discussion. The Introduction still requires focused issues and a ra-

tionale for the study. Authors should convey to readers the unique aspects of their reviews which distinguish them from other available material (e.g., monographs, book chapters). The main subject should be emphasized in the final paragraph of the Introduction. As for an original research article, the Introduction section of a review typically need not to be longer than four paragraphs. Longer Introductions tend to lose focus, so that the reader may not be sure what novel information will be presented. The sections after the Introduction are almost always unique to the particular review, but need to be organized in a coherent fashion. Headings (and subheadings when appropriate) should follow parallel construction and reflect analogous topics (e.g., diagnostic categories, alternative methods, alternative surgical interventions). If the reader considers only the headings, the logic of the review (as reflected in the Introduction) should be clear. Discussion synthesizes the reviewed literature as a whole coherently and within the context of the novel issues stated in the Introduction. The limitations should reflect those of the literature, however, rather than a given study. Those limitations will relate to gaps in the literature which preclude more or less definitive assessment of diagnosis or selection of treatment, for example. Controversies in the literature should be briefly explored. Only by exploring limitations will the reader appropriately place the literature in perspective. Authors should end the Discussion by summary statements similar to those which will appear at the end of the Abstract in abbreviated form. In general, a review requires a more extensive literature review than an original research article, although this will depend on the topic. Some topics (e.g., osteoporosis) could not be comprehensively referenced, even in an entire monograph. However, authors need to ensure that a review is representative of the entire body of literature, and when that body is large, many references are required. -

-Original articles; should contain the following sections: "Title Page", "Summary", "Keywords", "Introduction", "Materials and Methods", "Results", "Discussion", "Conclusions", and "References". "Keywords" sections should also be added if the original article is in English.

Title (80 characters, including spaces): Just as the Abstract is important in capturing a reader's attention, so is the title. Titles rising or answering questions in a few brief words will far more likely do this than titles merely pointing to the topic. Furthermore, such titles as "Bisphosponates reduce bone loss" effectively convey the main message and readers will more likely remember them. Manuscripts that do not follow the protocol described here will be returned to the corresponding author for technical revision before undergoing peer review. All manuscripts should be typed double- spaced on one side of a standard typewriter paper, leaving at least 2.5 cm. margin on all sides. All pages should be numbered beginning from the title page.

- Title page should include; a) informative title of the paper, b) complete names of each author with their institutional affiliations, c) name, address, fax and telephone number, e-mail of the corresponding author, d) address for the reprints if different from that of the corresponding author. It should also be stated in the title page that informed consent was obtained from patients and that the study was approved by the ethics committee. The "Level of Evidence" should certainly be indicated in the title page (see Table 1 in the appendix). Also, the field of study should be pointed out as outlined in Table 2 (maximum three fields).

- Summary: A150 to 250 word summary should be included at the second page. The summary should be in English for articles . The main topics to be included in Summary section are as follows: Background Data, Purpose, Materials- Methods, Results and Conclusion. The English versions of the Summary should be identical in meaning. Generally, an Abstract should be written after the entire manuscript is completed. The reason relates to how the process of writing changes thought and perhaps even purpose. Only after careful consideration of the data and a synthesis of the literature can author(s) write an effective abstract. Many readers now access medical and scientific information via Web-based databases rather than browsing hard copy material. Since the reader's introduction occurs through titles and abstracts, substantive titles and abstracts more effectively capture a reader's attention regardless of the method of access. Whether reader will examine an entire article often will depend on an abstract with compelling information. A compelling Abstract contains the questions or purposes, the methods, the results (most often quantitative data), and the conclusions. Each of these may be conveyed in one or two statements. Comments such as "this report describes..." convey little useful information.

- Key Words: Standard wording used in scientific indexes and search engines should be preferred. The minimum number for keywords is three and the maximum is five.

- Introduction (250 – 750 word): It should contain information on historical literature data on the relevant issue; the problem should be defined; and the objective of the study along with the problem solving methods

should be mentioned. The Introduction, although typically is the shortest of sections, perhaps the most critical. The Introduction must effectively state the issues and formulate the rationale for those issues or questions. Its organization might differ somewhat for a clinical report, a study of new scientific data, or a description of a new method. Most studies, however, are published to: (1) report entirely novel findings (frequently case reports, but sometimes substantive basic or clinical studies); (2) confirm previously reported work (eg, case reports, small preliminary series) when such confirmation remains questionable; and (3) introduce or address controversies in the literature when data and/or conclusions conflict. Apart from reviews and other special articles, one of these three purposes generally should be apparent (and often explicit) in the Introduction. The first paragraph should introduce the general topic or problem and emphasizet its importance, a second and perhaps a third paragraph should provide the rationale of the study, and a final paragraph should state the questions, hypotheses, or purposes. One may think of formulating rationale and hypotheses as Aristotelian logic (a modal syllogism) taking the form: If A, B, and C, then D, E, or F. The premises A, B, and C, reflect accepted facts whereas D, E, or F reflect logical outcomes or predictions. The premises best come from published data, but when data are not available, published observations (typically qualitative), logical arguments or consensus of opinion can be used. The strength of these premises is roughly in descending order from data to observations or argument to opinion. D, E, or F reflects logical consequences. For any set of observations, any number of explanations (D, E, or F) logically follows. Therefore, when formulating hypotheses (explanations), researchers designing experiments and reporting results should not rely on a single explanation. With the rare exception of truly novel material, when establishing rationale authors should generously reference representative (although not necessarily exhaustive) literature. This rationale establishes novelty and validity of the questions and places it within the body of literature. Writers should merely state the premises with relevant citations (superscripted) and avoid describing cited works and authors' names. The exceptions to this approach include a description of past methods when essential to developing rationale for a new method, or a mention of authors' names when important to establish historic precedent. Amplification of the citations may follow in the Discussion when appropriate. In establishing a rationale, new interventions of any sort are intended to solve certain problems. For example, new implants (unless conceptually novel) typically will be designed according to certain criteria to eliminate problems with previous implants. If the purpose is to report a new treatment, the premises of the study should include those explicitly stated problems (with quantitative frequencies when possible) and they should be referenced generously. The final paragraph logically flows from the earlier ones, and should explicitly state the questions or hypotheses to be addressed in terms of the study (independent, dependent) variables. Any issue not posed in terms of study variables cannot be addressed meaningfully. Focus of the report relates to focus of these questions, and the report should avoid questions for which answers are well described in the literature (e.g., dislocation rates for an implant designed to minimize stress shielding). Only if there are new and unexpected information should data be reported apart from that essential to answer the stated questions.

- Materials - Methods (1000-1500 words): Epidemiological/ demographic data regarding the study subjects; clinical and radiological investigations; surgical technique applied; evaluation methods; and statistical analyses should be described in detail. In principle, the Materials and Methods should contain adequate detail for another investigator to replicate the study. In practice, such detail is neither practical nor desirable because many methods will have been published previously (and in greater detail), and because long descriptions make reading difficult. Nonetheless, the Materials and Methods section typically will be the longest section. When reporting clinical studies authors must state approval of the institutional review board or ethics committees according to the laws and regulations of their countries. Informed consent must be stated where appropriate. Such approval should be stated in the first paragraph of Materials and Methods. At the outset the reader should grasp the basic study design. Authors should only briefly describe and reference previously reported methods. When authors modify those methods, the modifications require additional description. In clinical studies, the patient population and demographics should be outlined at the outset. Clinical reports must state inclusion and exclusion criteria and whether XVIII the series is consecutive or selected; if selected, criteria for selection should be stated. The reader should understand from this description all potential sources of bias such as referral, diagnosis, exclusion, recall, or treatment bias. Given the expense and effort for substantial prospective studies, it is not surprising that most published clinical studies are retrospective. Such studies often are criticized unfairly for being retrospective, but that does not negate the validity or value of a study. Carefully designed retrospective studies provide most of the information available to clinicians. However, authors should describe potential problems such as loss to follow-up, difficul-

ty in matching, missing data, and the various forms of bias more common with retrospective studies. If authors use statistical analysis, a paragraph should appear at the end of Materials and Methods stating all statistical tests used. When multiple tests are used, authors should state which tests are used for which sets of data. All statistical tests are associated with assumptions, and when it is not obvious the data would meet those assumptions, the authors either should provide the supporting data (e.g., data are normally distributed, variances in groups are similar) or use alternative tests. Choice of level of significance should be justified. Although it is common to choose a level of alpha of 0.05 and a beta of 0.80, these levels are somewhat arbitrary and not always appropriate. In the case where the implications of an error are very serious (e.g., missing the diagnosis of a cancer), different alpha and beta levels might be chosen in the study design to assess clinical or biological significance.

- Results (250-750 words): "Results" section should be written in an explicit manner, and the details should be described in the tables. The results section can be divided into sub-sections for a more clear understanding. If the questions or issues are adequately focused in the Introduction section, the Results section needs not to be long. Generally, one may need a paragraph or two to persuade the reader of the validity of the methods, one paragraph addressing each explicitly raised question or hypothesis, and finally, any paragraphs to report new and unexpected findings. The first (topic) sentence of each paragraph should state the point or answer the question. When the reader considers only the first sentence in each paragraph in Results, the logic of the authors'interpretations should be clear. Parenthetic reference to all figures and tables forces the author to textually state the interpretation of the data; the important material is the authors' interpretation of the data, not the data. Statistical reporting of data deserves special consideration. Stating some outcome is increased or decreased (or greater or lesser) and parenthetically stating the p (or other statistical) value immediately after the comparative terms more effectively conveys information than stating something is or is not statistically significantly different from something else (different in what way? the reader may ask). Additionally, avoiding the terms 'statistically different' or 'significantly different' lets the reader determine whether they will consider the statistical value biologically or clinically significant, regardless of statistical significance. Although a matter of philosophy and style, actual p values convey more information than stating a value less than some preset level. Furthermore, as Motulsky notes, "When you read that a result is not significant, don't stop thinking... First, look at the confidence interval... Second, ask about the power of the study to find a significant difference if it were there." This approach will give the reader a much greater sense of biological or clinical significance.

- Discussion (750 - 1250 words): The Discussion section should contain specific elements: a restatement of the problem or question, an exploration of limitations and assumptions, a comparison and/or contrast with information (data, opinion) in the literature, and a synthesis of the comparison and the author's new data to arrive at conclusions. The restatement of the problem or questions should only be a brief emphasis. Exploration of assumptions and limitations are preferred to be next rather than at the end of the manuscript, because interpretation of what will follow depends on these limitations. Failure to explore limitations suggests the author(s) either do not know or choose to ignore them, potentially misleading the reader. Exploration of these limitations should be brief, but all critical issues must be discussed, and the reader should be persuaded they do not jeopardize the conclusions. Next the authors should compare and/or contrast their data with data reported in the literature. Generally, many of these reports will include those cited as rationale in the Introduction. Because of the peculiarities of a given study the data or observations might not be strictly comparable to that in the literature, it is unusual that the literature (including that cited in the Introduction as rationale) would not contain at least trends. Quantitative comparisons most effectively persuade the reader that the data in the study are "in the ballpark," and tables or figures efficiently convey that information. Discrepancies should be stated and explained when possible; when an explanation of a discrepancy is not clear that also should be stated. Conclusions based solely on data in the paper seldom are warranted because the literature almost always contains previous information. The quality of any reXIX port will depend on the substantive nature of these comparisons. Finally, the author(s) should interpret their data in the light of the literature. No critical data should be overlooked, because contrary data might effectively refute an argument. That is, the final conclusions must be consistent not only with the new data presented, but also that in the literature.

- Conclusion: The conclusions and recommendations by the authors should be described briefly. Sentences containing personal opinions or hypotheses that are not based on the scientific data obtained from the study should be avoided.

- References: Care must be exercised to include refer-

ences that are available in indexes. Data based on personal communication should not be included in the reference list. References should be arranged in alphabetical order and be cited within the text; references that are not cited should not be included in the reference list. The summary of the presentations made at Symposia or Congresses should be submitted together with the manuscript. The following listing method should be used. References should derive primarily from peer-reviewed journals, standard textbooks or monographs, or well-accepted and stable electronic sources. For citations dependent on interpretation of data, authors generally should use only high quality peer-reviewed sources. Abstracts and submitted articles should not be used because many in both categories ultimately do not pass peer review. They should be listed at the end of the paper in alphabetical order under the first author's last name and numbered accordingly. If needed, the authors may be asked to provide and send full text of any reference. If the authors refer to an unpublished data, they should state the name and institution of the study, Unpublished papers and personal communications must be cited in the text. For the abbreviations of the journal names, the authors can apply to "list of Journals" in Index Medicus or to the address "http://www.nlm.nih.gov/tsd/serials/lji.html".

Journal article:
Berk H, Akçalı Ö, Kıter E, Alıcı E. Does anterior spinal instrument rotation cause rethrolisthesis of the lower instrumented vertebra? *J Turk Spin Surg* 1997; 8 (1): 5-9.

Book chapter: Wedge JH, Kirkaldy-Willis WH, Kinnard P. Lumbar spinal stenosis. Chapter-5. In: Helfet AJ, Grubel DM (Eds.). *Disorders of the Lumbar Spine*. JB Lippincott, Philadelphia 1978; pp: 61-68.

Entire book:
Paul LW, Juhl JH (Eds.). *The Essentials of Roentgen Interpretation*. Second Edition. Harper and Row, New York 1965; pp: 294-311.

Book with volume number:
Stauffer ES, Kaufer H, Kling THF. Fractures and dislocations of the spine. In: Rockwood CA, Green DP (Eds.). *Fractures in Adults*. Vol. 2, JB Lippincott, Philadelphia 1984; pp: 987-1092.

Journal article in press:
Arslantaş A, Durmaz R, Coşan E, Tel E. Aneurysmal bone cysts of the cervical spine. *J Turk Spin Surg* (In press).

Book in press:
Condon RH. Modalities in the treatment of acute and chronic low back pain. In: Finnison BE (Ed.). *Low Back Pain*. JB Lippincott, Philadelphia (In press).

Symposium:
7. Raycroft IF, Curtis BH. Spinal curvature in myelomeningocele: natural historyand etiology.*Proceedings of the American Academy of Orthopaedic Surgeons Symposium on Myelomeningocele* . Hartford, Connecticut, 5th November 1970. CV Mosby, St. Louis 1972; pp: 186-201.

Papers presented at the meeting:
8. Rhoton AL. Microsurgery of the Arnold-Chiari malformation with and without hydromyelia in adults. Presented at the *Annual Meeting of the American Association of Neurological Surgeons*, Miami, Florida, April 7, 1975. 1975

- Tables: They should be numbered consecutively in the text with Arabic numbers. Each table with its number and title should be typed on a separate sheet of paper. Each table must be able to stand alone; all necessary information must be contained in the caption and the table itself so that it can be understood independent from the text. Information should be presented explicitly in "Tables" so that the reader can obtain a clear idea about its content. Information presented in "Tables" should not be repeated within the text. If possible, information in "Tables" should contain statistical means, standard deviations, and t and p values for possibility. Abbreviations used in the table should be explained as a footnote. Tables should complement not duplicate material in the text. They compactly present information, which would be difficult to describe in text form. (Material which may be succinctly described in text should rarely be placed in tables or figures.) Clinical studies for example, of ten contain complementary tables of demographic data, which although important for interpreting the results, are not critical for the questions raised in the paper. Well focused papers contain only one or two tables or figures for every question or hypothesis explicitly posed in the Introduction section. Additional material may be used for unexpected results. Well constructed tables are self-explanatory and require only a title. Every column contains a header with units when appropriate.

- Figures: All figures should be numbered consecutively throughout the text. Each figure should have a label pasted on its back indicating the number of the figure, an arrow to show the top edge of the figure and the name of the first author. Black-and-white illustrations should be in the form of glossy prints (9x13 cm). The letter size on the figure should be large enough to be

readable after the figure is reduced to its actual printing size. Unprofessional typewritten characters are not accepted. Legends to figures should be written on a separate sheet of paper after the references. The journal accepts color figures for publication if they enhance the article. Authors who submit color figures will receive an estimate of the cost for color reproduction. If they decide not to pay for color reproduction, they can request that the figures be converted to black and white at no charge. For studies submitted by electronic means, the figures should be in jpeg and tiff formats with a resolution greater than 300 dpi. Figures should be numbered and must be cited in the text

- **Style:** For manuscript style, American Medical Association Manual of Style (9th edition). Stedman's Medical Dictionary (27th edition) and Merriam Webster's Collegiate Dictionary (10th edition) should be used as standard references. The drugs and therapeutic agents must be referred by their accepted generic or chemical names, without abbreviations. Code numbers must be used only when a generic name is not yet available. In that case, the chemical name and a figure giving the chemical structure of the drug should be given. The trade names of drugs should be capitalized and placed in parentheses after the generic names. To comply with trademark law, the name and location (city and state/country) of the manufacturer of any drug, supply, or equipment mentioned in the manuscript should be included. The metric system must be used to express the units of measure and degrees Celsius to express temperatures, and SI units rather than conventional units should be preferred. The abbreviations should be defined when they first appear in the text and in each table and figure. If a brand name is cited, the manufacturer's name and address (city and state/country) must be supplied. The address, "Council of Biology Editors Style Guide" (Council of Science Editors, 9650 Rockville Pike, Bethesda, MD 20814) can be consulted for the standard list of abbreviations.

Dear Colleagues,

We sincerely wish the happy and healthy new year to all my colleagues and their families. We are happy to accomplish the first issue of 2019.

There are 14 clinical research articles in this issue. First article is very important, in that article, measurement of spinopelvic parameters of the Turkish young population has been reported. In the second article, results of surgical treatment of the idiopathic scoliosis has been presented. Third article is retrospective study about the managing blood loss in adolescent idiopathic scoliosis surgery. Next two articles are about the management of anesthesiology in surgery of adolescent and adult scoliosis. In the sixth article, the effect of postural kinesiotaping in the treatment of thoracic kyphosis has been researched. Seventh article is about the result of the trans-sacral epiduroscopic laser decompression for lumbar disc herniation. Eighth article is results of transforaminal epidural steroid injection in the single level lumbar disc heniation. In the ninth article, the results of transforaminal lumbar interbody fusion as revision surgery for patients previously treated by discectomy or instrumentation of the lumbar spine has been presented. Tenth article is also about lumbar interbody fusion, especially assestment of complications. Eleventh and 12th articles are about the vertebroplasty. Thirteenth article is epidemiologic study about the syringomyelia. The last article is a retrospective study on autologous cervical interbody fat graft application for anterior cervical discectomies. In this issue, there is also a review article about the adult scoliosis.

We believe that all those studies will quietly interest the readers.

Unfortunately, in this issue, there is no section of the "Frontiers of the Spinal Surgery" but we will continue this section in the next issue.

We wish healthy, successful and peaceful new year to Turkish Spinal Surgery family and we present our deepest respects.

Prof. Dr. İ. Teoman BENLİ
JTSS Editor

EDITORIAL

ORIGINAL ARTICLES

SPINOPELVIC MORPHOMETRIC ANALYSIS

SURGICAL TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

MANAGING BLOOD LOSS IN AIS SURGERY

ANESTHESIA IN AIS SURGERY

THORACIC KYPHOSIS

MINIMALLY INVASIVE TECHNIQUES IN SURGERY OF LDH

POSTERIOR LUMBAR INTERBODY FUSION

VERTEBROPLASTY

CERVICAL DISCECTOMIES

SYRINGIMYELIA

REVIEW ARTICLE

Volume: 30, Issue: 1, January 2019 pp: 1-4 ORIGINAL ARTICLE

SAGITTAL SPINOPELVIC PARAMETERS IN THE YOUNG ADULT TURKISH POPULATION

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ABSTRACT

Objective: A radiological analysis of the spinopelvic paramaters and sagittal balance in a young adult Turkish population.

Method: From radiology archive, full lateral spinal radiographs were scanned. The individuals who had no diagnosed of structural spine abnormality and no sign about spinal disorder from medical records were measured by Surgimap software on digital radiography. Sagittal spinal parameters (SVA, TK, LL) and Spinopelvic parameters (PI, PT) were measured. The unpaired t-test was used for comparison of measurements of genders. $p<0.05$ considered as statistically significant.

Results: A total of 860 full lateral spine radiographs in the database were assessed and finally, 126 individuals (72 female, and 54 male) were included in the study who met all the criteria. The mean age was 27.4 ± 6.88 (range 20-40). The mean sagittal vertical axis (SVA), thoracic kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), and pelvic tilt (PT) were -46.9 mm ± 19.83, 35.5° ± 5.47, 57.8° ± 9.10, 47.4 ± 9,13, and 13.37 ± 7.32, respectively. The PI ($p=0.012$), and TK ($p=0.010$) values between females and males were statistically significant, but SVA ($p= 0.26$), PT ($p= 0.32$), and LL ($p=0.43$) were not.

Conclusion: This study was yielded to determine normative values of spinopelvic parameters in young adult Turkish population that would assist the clinical practice of spinal surgeons. The PI was found to be lower while LL was the same compared to the current literature from other countries and further studies were needed to clarify.

Key Words: Spino-pelvic parameters, pelvic insidence, sagittal balance, full lateral spine radiography.

Level of Evidence: Cross-sectional clinical study, Level III.

INTRODUCTION

Many authors have reported the importance of the sagittal plane contour in the normal function of the spine and in various disease states. [3,8,12] It is necessary to know the normative sagittal parameters in disease-free individuals in order to establish the correct diagnosis of spinal deformity, to follow up the progression and to make surgical planning. The spinopelvic sagittal parameters have a wide range of normal values and may vary with age, gender, weight, and race [1-2,15]. There are some studies on western and Asian populations, classifying the normal patterns of sagittal curvature, but very few studies on Turkish populations [13-14].

The aim of this study was to analyze the normal values of sagittal spinopelvic parameters in the young adult Turkish population.

MATERIAL – METHODS

A cross-sectional study of radiological analysis of the spinopelvic parameters and sagittal balance in a young adult Turkish population was conducted. After local Ethical committee approval, digital radiology archive was scanned. Inclusion criteria included: **1)** age between 20-40, **2)** the presence of full lateral spine radiography that was taken under appropriate dose and position, **3)** enable to access to all medical records of the individual, **4)** no previous spine surgery, **5)** no leg length discrepancy. Radiographic spinal abnormality detected

individuals, such as scoliosis more than 20°, spinal tumor and infection, ankylosing spondylitis, rigid kyphotic deformity were excluded. Finally, 126 full lateral spine radiography who met the all inclusion criteria were analyzed.

The Surgimap software (New York, New York, USA) was used to measure the sagittal spinal and pelvic parameters. Standing full-length lateral radiographs were measured by the author 2 times with 1-week interval and the average of measurements was calculated for each individuals.

The thoracal kyphosis (TK) was measured as Cobb angle between upper endplate of the T4 and lower endplate of the T12. The lumbar lordosis (LL) was measured between the upper endplates of L1 and S1by the Cobb method. The sagittal vertical axis (SVA) was measured from the distance between C7 plumb line and posterior corner of S1 endplate. It was marked as minus (-) SVA if the C7 plumb line was at the posterior of the sacrum (Figure-1).

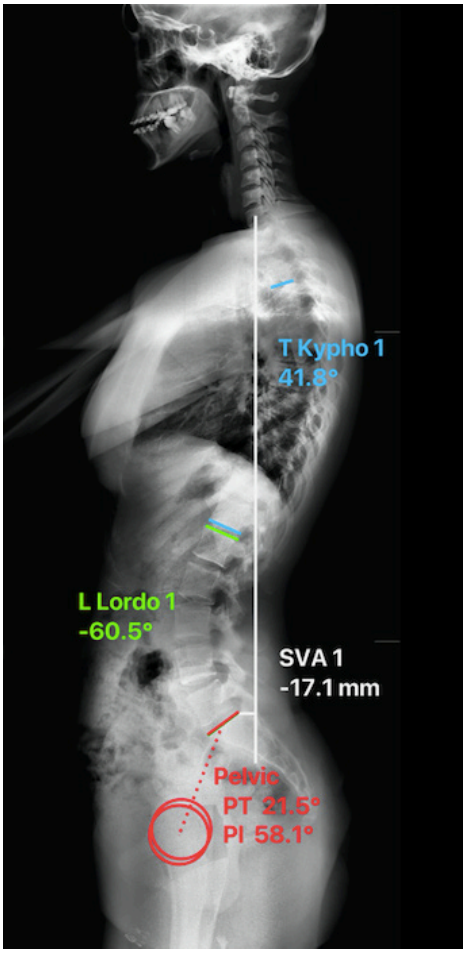

Figure-1. Demonstrates the measurement of spinal parameters (TK, LL, and SVA; measured by Surgimap software).

The pelvic tilt (PT) was measured as an angle between the vertical line and the line joining the middle of the sacral plate and the center of the bicoxo-femoral axis (the line between the geometric center of both femoral heads). The pelvic incidence (PI) was measured as an angle formed by two vectors: **1)** The line joining the bicoxo-femoral axis to the center of the sacral endplate and **2)** A line perpendicular to the sacral endplate. The sacral slope (SS) was defined as the angle between the horizontal and sacral plate, that could be calculated by the formula PI = PT + SS, therefore SS was not measured (Figure-2).

Statistical analyses were performed using SPSS software (Version 17, SPSS, Inc, Chicago, IL, USA). $p<0.05$ was considered statistically significant. All values are expressed as the mean ± standard deviation (SD). The unpaired T-test was used to analyze the differences in spinal and pelvic parameters between females and males.

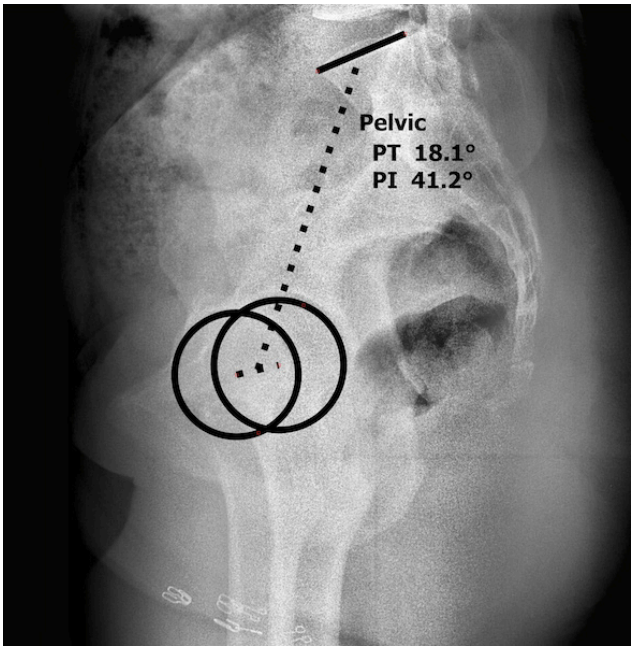

Figure-2. Demonstrates the measurement of pelvic parameters (PT, and PI; measured by Surgimap software).

RESULTS

A total of 860 full lateral spine radiographs in the database were assessed and finally, 126 individuals were included in the study who met all the criteria. The mean age was 27.4 ± 6.88 (range 20-40). There were 72 females with a mean age of 28.8 ± 7.47, 54 males with a mean age of 25.8 ±6.63. The age distribution by gender was not statistically significant (p= 0.35).

The Mean sagittal vertical axis (SVA), thoracic kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), and pelvic tilt (PT) were -46.9 mm ± 19.83 mm, 35.5° ± 5.47°, 57.8° ± 9.10°, 47.4° ± 9.13°, and 13.37° ± 7.32°, respectively. The minimum, maximum, median, mean and standard deviation (SD) values were determined (Table-1).

All of the SVA values were on minus (-) balance. The distribution of spinal and pelvic parameters according to gender is measured (Table-2).

The PI (p=0.012), and TK (p=0.010) values between females and males were statistically significant, but SVA (p= 0.26), PT (p= 0.32), and LL (p=0.43) were not.

Table-1. The range, median, mean, standard deviation (SD) and 95% Confidence Interval (Descriptive stats.).

Parameters	Minimum	Maximum	Median	Mean	Standard Deviation ±	95% Confidence Interval
Age	20	40	25	27.4	6.88	24.4-30.3
SVA (mm)	-17	-79	-49	-46.9	19.83	(-) 38.4-55.38
TK (°)	22.8	43.7	36.5	35.5	5.47	33.16-37.84
LL (°)	-32.4	-69.1	-58.2	-57.8	9.10	(-) 53.9-61.6
PI (°)	30.7	63.2	48.8	47.4	9.13	43.49-51.30
PT (°)	1.8	29.3	14	13.3	7.32	10.14-16.45

Table-2. Sex distribution of spino-pelvic parameters.

Parameters	Female	Male	p Value
Age	28.8 ± 7.47	25.8 ±6.63	0.354
SVA (mm)	-44.2 ± 23.1	-49.9 ±16.12	0.260
TK (°)	33.1 ±5.09	38.39 ± 4.60	0.010
LL (°)	(-) 57.4 ± 7.43	(-) 58.1 ± 11.07	0.430
PI (°)	48.27 ± 8.73	46.44 ± 9.93	0.012
PT (°)	14.09 ± 8.46	12.57 ± 6.18	0.320

DISCUSSION

Due to ethical concerns, this study was designed as a cross-sectional radiological analysis of sagittal spinopelvic parameters to prevent unnecessary radiation exposure to healthy individuals.

Spinal sagittal balance and spinopelvic parameters may vary with age, gender, and race. Sagittal parameters are variable, especially in children and adolescents. As the PI increases with the aging process, the SVA becomes anteriorly [3,14]. A more stable age range was sought to measure normative values. Thence, this study involved young adult Turkish population before the onset of degenerative changes that may affect sagittal alignment. The mean age was 27.4 ± 6.88 (range 20-40).

The correct positioning of the patient is essential to assess spinopelvic parameters. The knees and femurs should be in extension and parallel to film while the arms flexed forward to 45° and resting on supports. In addition, both femoral heads and the upper endplate of T4 and sacrum must be visible to obtain accurate results [11,15].

The effect of ethnicity on skeletal growth has been demonstrated by previous studies [2,4,9]. In this study, the mean sagittal vertical axis (SVA), thoracic kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), and pelvic tilt (PT) were -46.9 mm ± 19.83 mm, 35.5° ± 5.47°, 57.8° ± 9.10°, 47.4° ± 9.13°, and 13.37° ± 7.32°, respectively. Comparison of the studies of sagittal spinopelvic parameters from different countries is compared (Table-3). The PI was measured lesser while LL was the same in the current study. There is only one study from Turkey that can be compared with the current study. Tonbul et al conducted a study with juvenile, adolescent, and adults and reported similar results in the adult group [14].

Table-3. Comparison of the studies from different countries.

	Current	Lee at al. [8]	Endo et al [2]	Vialle et al [15]	Schwab et al. [12]
Country	Turkey	Korea	Japan	France	US
Age	27 (20-40)	28 (19-39)	35(23-59)	35(20-70)	49 (18-80)
TK (°)	35.5	32	27.5	40.6	41
LL (°)	57.8	49.6	43.4	60	60
PI (°)	47.4	47.8	52	51	52
PT (°)	13.3	11.5	15	13	15
No	126	80	86	300	75

The impact of sex on spinopelvic parameters remains controversial. Vialle et al. reported significant differences in LL and PI between male and female subjects [15]. While some publications were in the same conclusion [1,3,16], conversely, other researchers did not demonstrate significant sex differences in any spinopelvic parameter [6-7,10]. The variations in lumbar lordosis and sacral slope observed in those studies may be explained by a pelvic incidence that was slightly higher in women than in men. In the current study, only significant results were obtained that the TK was higher in males while the PI was higher in females (p=0.010 and p=0.012, respectively).

Asai et al reported that all parameters were significantly associated with age in men and women. The SVA, TK, and PT increased with age, and LL decreased with age [1]. Once the sagittal alignment is abnormal, more energy is required so that the body can remain balanced without external support. Therefore, abnormal sagittal spinal alignment should be restored to normal [5].

In clinical practice, radiographic reference values help identify regional angulations and linear displacements that can be considered as within the normal alignment range for a given patient [12,15]. It is very important to evaluate the sagittal balance and patterns of sagittal curvatures to estimate the normality of sagittal alignment [8].

In conclusion, this study was yielded to determine normative values of spinopelvic parameters in young adult Turkish population that would assist the clinical practice of spinal surgeons. Especially, the PI was found to be lower while LL was the same compared to the current literature from other countries and further studies were needed to clarify.

REFERENCES

1. Asai Y, Tsutsui S, Oka H, Yoshimura N, Hashizume H, Yamada H, Akune T, Muraki S, Matsudaira K, Kawaguchi H, Nakamura K, Tanaka S, Yoshida M. Sagittal spino-pelvic alignment in adults: the Wakayama spine study. *PLoS One* 2017; 12: e0178697.
2. Endo K, Suzuki H, Nishimura H, Tanaka H, Shishido T, Yamamoto K. Characteristics of sagittal spino-pelvic alignment in Japanese young adults. *Asian Spine J* 2014; 8: 599-604.
3. Gelb DE, Lenke LG, Bridwell KH, Blanke K, McEnery KW. An analysis of sagittal spinal alignment in 100 asymptomatic middle and older aged volunteers. Spine 1995; 20: 1351-1358.
4. Gilsanz V, Skaggs DL, Kovanlikaya A, Sayre J, Loro ML, Kaufman F, Korenman SG. Differential effect of race on the axial and appendicular skeletons of children. *J Clin Endocrinol Metab* 1998; 83: 1420–1427.
5. Glassman SD, Bridwell K, Dimar JR, Horton W, Berven S, Schwab F. The impact of positive sagittal balance in adult spinal deformity. *Spine* 2005; 30: 2024–2029.
6. Jackson RP, Hales C. Congruent spinopelvic alignment on standing lateral radiographs of adult volunteers. *Spine* 2000; 25: 2808-2832.
7. Janssen MM, Drevelle X, Humbert L, Skalli W, Castelein RM. Differences in male and female spino-pelvic alignment in asymptomatic young adults: a three-dimensional analysis using upright low-dose digital biplanar X-rays. *Spine* 2009; 34: E826–E832.
8. Lee CS, Chung SS, Kang KC, Park SJ, Shin SK. Normal patterns of sagittal alignment of the spine in young adults radiological analysis in a Korean population. *Spine* 2011; 36: E1648-E654.
9. Lonner BS, Auerbach JD, Sponseller P, Rajadhyaksha AD, Newton PO. Variations in pelvic and other sagittal spinal parameters as a function of race in adolescent idiopathic scoliosis. *J Spinal Disord Tech* 2009; 22: 551–558.
10. Mac-Thiong JM, Roussouly P, Berthonnaud E, Guigui P. Age- and sex-related variations in sagittal sacropelvic morphology and balance in asymptomatic adults. *Eur Spine J* 2011; 20 Suppl 5: 572–577.
11. Marks MC, Stanford CF, Mahar AT, Newton PO. Standing lateral radiographic positioning does not represent customary standing balance. *Spine* 2003; 28: 1176-1182.
12. Schwab F, Patel A, Ungar B, Farcy JP, Lafage V. Adult spinal deformity-postoperative standing imbalance: how much can you tolerate? An overview of key parameters in assessing alignment and planning corrective surgery. *Spine* 2010; 35: 2224-2231.
13. Sevinc O, Iş M, Barut C, Ozdemir ST, Ayoglu FN. Sagittal alignment of the lumbar spine in a Turkish population. *Neurosciences* 2007; 12(3): 221-225.
14. Tonbul M, Guzelant A, Gokce A, Gökay NS, Yılmaz I, Demirok M. Spinopelvic parameters in a Turkish population: a study on 120 healthy individuals that could facilitate treatment planning. *Turkiye Klinikleri J Med Sci* 2012; 32(3): 670-676.
15. Vialle R, Levassor N, Rillardon L, Templier A, Skalli W, Guigui P. Radiographic analysis of the sagittal alignment and balance of the spine in asymptomatic subjects. *J Bone Joint Surg Am* 2005; 87-A: 260-267.
16. Zhu Z, Xu L, Zhu F, et al. Sagittal alignment of spine and pelvis in asymptomatic adults: norms in Chinese populations. *Spine* 2013; 39: E1–E6.

Volume: 30, Issue: 1, January 2019 pp: 5-12 ORIGINAL ARTICLE

POSTERIOR INSTRUMENTATION AND SPINAL FUSION RESULTS IN SURGICAL TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS

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ABSTRACT

Objective: To define the relationship between radiological and functional outcomes of AIS more than10 years follow-up.

Methods: 22 AIS patients were reviewed retrospectively. Cobb angles were measured from full-length spinal radiography at preoperative, postoperative, mid-term and long-term follow-up.

Correction rate and correction loss rate were calculated. The SRS-30 questionnaire form was filled by the patients at the final follow-up examination. Results were compared with the Mann Whitney U test and unpaired t-test. Non-parametric correlation analytical test was performed with the Spearman test. $p<0.05$ considered as statistically significant.

Results: There were 15 female and 7 male with the mean age of 14.5. The mean follow-up was 35.8 and 134 months for mid-term and final follow-up. The mean fusion levels were 10.4 and the average of last instrumented vertebra was L 1.8. Major curvatures were corrected from 53.1° to 19.7° with a 63.6% correction rate. According to the SRS-30 questionnaire form, the mean pain, function and activity, self-image appearance, mental health, and satisfaction scores were 4.16 ± 0.29, 4.43 ± 0.28, 4.15 ± 0.31, 3.84 ± 0.30, and 4.15 ± 0.44 at mid-term and 3.96 ± 0.52, 4.22 ± 0.38, 4.35 ± 0.22, 4.14 ± 0.36, and 4.10 ± 0.34 at final follow-up, respectively. While the mental health scores improved statistically (p=0.0214), the pain (p=0,043) and the activity (p=0.038) scores deteriorated and the satisfaction score (p=0.64) remained stable in time. A significant relationship was found between the final cobb angle and pain (p = 0.044, Rho = -0.407). When the SRS-30 results were evaluated among themselves, there was a significant correlation between function and self-image (p= 0.005, Rho = 0.547), also function and pain (p= 0.038, Rho = 0.532).

Conclusion: For the surgical treatment of adolescent idiopathic scoliosis, posterior instrumentation and spinal fusion surgery is an efficient and successful method with patient satisfaction, curvature correction, and low complication rates after more than ten years follow-up.

Keywords: Adolescent idiopathic scoliosis; SRS-30; functional results; long-term

Level of evidence: Retrospective clinical study, Level III

INTRODUCTION

Adolescent idiopathic scoliosis is determined as the most common type of scoliosis. In this three-dimensional deformity lateral shift, axial rotation and sagittal lordosis occur. The most common symptoms are a cosmetic deformity, rib hump, shoulder, hip and breast asymmetries [17,19,21].

Treatment options are observation, conservative treatment or surgical treatment according to the magnitude of the curvature, flexibility, progression and patient age. Surgical indications are generally considered to be curvature more than 45°, rapid progression between follow-up, severe back pain, pulmonary, cardiac and psychological serious complaints [10,15].

The goals of the surgical treatment are to correct the three-dimensional deformity, to provide solid fusion, and to balance the head and body on the pelvis [21]. In recent years segmental pedicle screw fixation technique is commonly used to provide a more rigid fixation. With this method,

compression, distraction, translation and rotation forces can be applied intersegmentally, and control of curvature in each segment is possible [8-9,14,21]. Technological advances have much improved the ability of surgeons to safely correct the deformity while maintaining sagittal and coronal balance [12,17,21].

Radiological and functional outcomes of the patients may change over time on extended follow-up. Especially the SRS-30 form is beneficial for monitoring functional results and measuring patient satisfaction [6,20].

Which radiological parameter that most affect the functional results is not a subject that is studied widely in the current literature. However, notice and interest in the parameter that can change patient satisfaction might improve treatment success.

This study aimed to define the relationship between radiological and functional outcomes of AIS more than10 years follow-up.

MATERIALS and METHODS

Adolescent idiopathic scoliosis (AIS) patients who underwent posterior instrumentation and spinal fusion surgery from 1999 to 2006 at Department of Orthopedics and Traumatology clinic were evaluated in this retrospective study (Table-1). Inclusion criteria were **(1)** diagnosed adolescent idiopathic scoliosis and received acceptable correction surgery, **(2)** minimum ten years follow up period after surgery, **(3)** no previous surgery, **(4)** adequate documentation before and after surgery. Twenty-five patients were collected from the thesis study [3] of the first author and twenty-two of 25 patients who met all the criteria were included in this study. We referred to the results of the previously mentioned thesis study as the mid-term (minimum 2 years follow-up). In July and June 2018, 15 female and seven male with the mean age of 14.55 ± 1.53 were examined for last control visit. The mean follow-ups at the mid-term and the final were 35.8 ± 20.58, and 134 ± 11.98 months, respectively. Demographic characteristic of the patients is determined (Table-2).

Table-1. The age, sex, Risser stage, King classification type, follow-up period, Cobb angles, correction ratio, correction loss and SRS-30 results of each patients.

No	Age	Sex	Risser	King Type	Folow-up (month)	Preop Cobb (°)	Postop Cobb (°)	Last Cobb (°)	Correction Ratio (%)	Correction Lost (%)	Pain	Function / Activity	Self Image Appearance	Mental Health	Satisfaction
1	15	K	5	2	20	54	22	24	59,2	3,7	3,8	4	4	3,4	5
2	13	E	2	3	12	50	9	10	82	2	4,2	4,2	4	4,2	4,4
3	15	E	4	5	13	56	20	20	64,2	0	4,6	3,8	4	4	4
4	12	K	2	2	16	60	16	16	73,3	0	4,2	4,2	4	4,2	4,4
5	13	K	3	3	30	48	14	16	70,8	4,1	4,4	4,8	4,6	4,2	4
6	16	E	4	3	40	50	15	16	70	2	4,2	4,6	4,2	4	4,4
7	15	K	3	2	18	52	22	25	57,6	5,7	4,5	4,8	4	4	4
8	17	E	4	2	46	49	14	17	71,4	6,2	4,6	4,2	4,4	4	4,4
9	18	K	5	2	64	54	20	22	62,9	3,7	4	4,4	3,8	3,4	3,6
10	16	E	4	3	78	53	22	23	58,5	1,8	4,2	4,8	4,8	4,2	4
11	14	K	4	2	36	60	32	32	46,6	0	3,8	4,6	4	3,6	4,4
12	15	K	4	1	65	79	30	34	62,5	4,9	4	4,4	4,2	4	5
13	14	K	3	4	90	50	19	23	62	8	3,5	4,2	3,6	3,4	3,6
14	13	K	3	3	26	54	28	28	48,1	0	4,2	4,8	4,4	4	4,4
15	13	K	3	5	20	46	16	18	65,2	4,3	4,6	4,6	4,2	3,8	4
16	15	K	4	1	22	48	20	21	58,3	2,1	4,5	4,8	4,4	4	4,4
17	18	E	4	4	20	52	24	24	53,8	0	4,2	4,6	4,2	3,8	3,6
18	14	K	4	2	24	52	20	22	61,5	3,8	4	4,4	3,8	3,2	3,6
19	21	K	5	2	54	58	40	44	31,1	6,8	3,8	4,2	3,6	3,4	3,6
20	15	E	3	1	46	54	24	26	55,5	3,7	4	4,2	4,4	4	4
21	12	K	2	1	32	50	18	19	64	2	4,2	4,6	4,2	4	4,4
22	16	E	4	2	38	58	20	22	65,5	3,5	4,6	4,8	4,8	4,2	5
23	18	K	5	2	34	54	30	32	44,4	3,7	4,2	4,4	4	3,6	3,6
24	14	K	4	1	24	45	16	18	64,4	4,4	3,8	4,2	4,2	3,8	4
25	15	K	4	2	27	48	18	19	62,5	2,1	4	4,2	4	3,8	4

Table-2. Demographic characteristic of the patients.

Age	14.55 ± 1.53
Female	15 (68.2%)
Male	7 (31.8%)
Age of onset of symptoms	13.1 ±1.82
Risser sign	3.55 ± 0.85
Mid-term follow-up (months)	5.8 ± 20.58
Final (long term) follow-up (months)	134 ± 11.98

All surgeries were performed in the prone position by the same two attending spinal surgeons. Titanium segmental pedicle screws, 6 mm titanium rods and transverse connectors were used in all cases. The stable vertebra was determined to be the last instrumented vertebra. Instrumentation extended proximally to the neutral vertebra. The mean fusion levels were 10.4 (range 8 to 13) while the longest fusion level was between T2 and L3. The last instrumented vertebra level ranged between T12 and L4, with an average of L 1.8.

To correct scoliotic curvature, facetectomies, apical derotation, convex side compression, and concave side distraction maneuvers were applied respectively. In all cases, a wake-up test was performed during surgery. Only posterior segmental spinal instrumentation was applied to all of the cases.

Thoracolumbosacral orthosis (TLSO) was used from postoperative second day to the fourth month to reduce pain and maintain fusion. All patients were mobilized with TLSO on the second day.

The radiographic evaluation of these patients was obtained preoperatively, immediately after surgery, at the mid-term and final follow-up examination by full-length spinal radiography (Figure-1).

Preoperatively, the apical, neutral and stable vertebrae were determined, and the size of curvatures was measured by Cobb method. Nash Moe method was used to measure apical vertebral rotation. Also, pre-operative curvatures were distributed according to the Lenke classification system (Table-3).

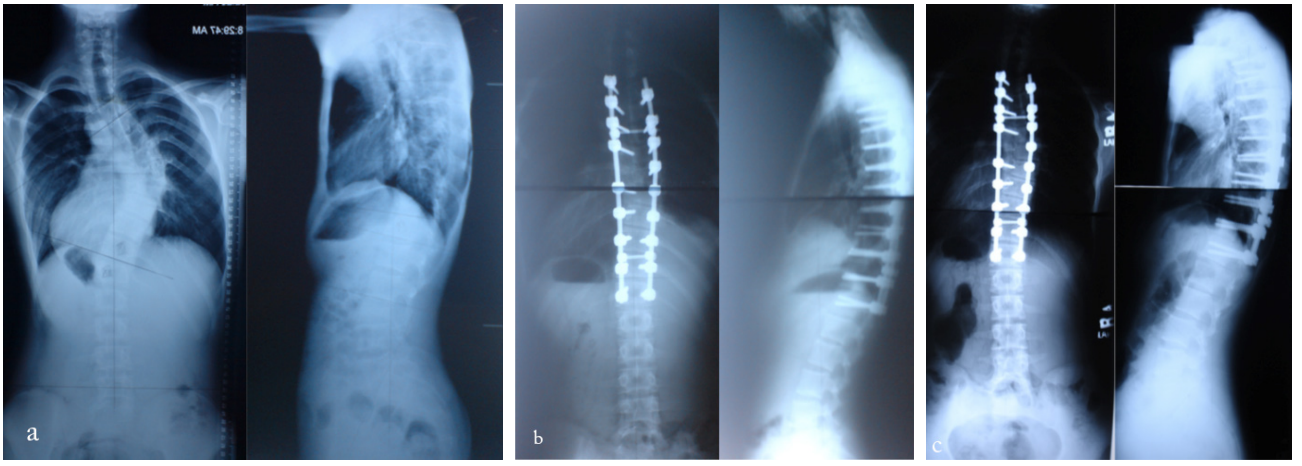

Figure 1 : a) preoperative, **b)** postoperative, and **c)** last follow-up radiographies of 13 years old male. Thoracic major curvature was corrected from 50° to 9° with a 82% correction rate. At the final follow-up on 125th month, 2 % correction loss was seen.

Table-3. Distribution of the all cases according to Lenke classification system.

Curve Type	No (%)	Lomber Spine Modifier			Thoracic Sagittal Profile		
		A	B	C	(-)	N	(+)
I	13 (59.2)	7	5	1	-	13	-
II	2 (9.1)	2	-	-	-	2	-
III	4 (18.2)	-	1	3	-	3	1
IV	1 (4.5)	-	1	-	-	1	-
V	**1 (4.5)**	-	-	**1**	-	**1**	-
VI	**1 (4.5)**	-	-	**1**	-	**1**	-

Correction rate was calculated from the early postoperative radiographs by using the following formula:

Correction rate % = (Pre-op Cobb - Post-op Cobb)*100 / Pre-Op Cobb

From the last follow-up radiographs, the correction loss percentage ratio was calculated:

Correction loss % = (Last Cobb - Post-op Cobb)*100 / Pre-Op Cobb

The Scoliosis Research Society form (SRS-30) was filled by the patients at the final follow-up examination. SRS-30 questionnaire form (encompasses Versions 22 and 24 consists of the five groups and 30 questions with the addition of 6 questions to the SRS-24 after treatment: **(1)** Pain, **(2)** Function and Activity, **(3)** Self Image Appearance, **(4)** Mental Health, **(5)** Satisfaction. Each answer was evaluated out of 5 points (e.g., 5 points for the excellent result while 1 point for poor results), and the average of the groups was recorded (Table-4).

Preoperative, postoperative and follow-up results were compared with the Mann Whitney U test and unpaired t-test. A non-parametric analytical correlation test was performed with the Spearman test by using SPSS software (Version 17.0, SPSS, Inc, Chicago, IL, USA). $p<0.05$ was considered statistically significant.

Table-4. SRS-30 questionnaire

SECTION 1 (All patients)		
1.Which one of the following best describes the amount of pain ou have experienced during the past 6 months?	5-None 4-Mild 3-Moderate 2-Moderate to severe 1-Severe	P
2.Which one of the following best describes the amount of pain you have experienced over the last month?	5-None 4-Mild 3-Moderate 2-Moderate to severe 1-Severe	P
3. During the past 6 months have you been a very nervous person?	5-None of the time 4-A little of the time 3-Some of the time 2-Most of the time 1-All of the time	MH
4. If you had to spend the rest of your life with your back shape as it is right now, how would you feel about it?	5-Very happy 4-Somewhat happy 3-Neither happy nor unhappy 2-Somewhat unhappy 1-Very unhappy	SA
5.What is your current level of activity?	1-Bedridden/wheelchair 2-Primarily no activity 3-Light labor, such as household chores 4-Moderate manual labor and moderate sports, such as walking and biking 5-Full activities without restriction	FA
6.How do you look in clothes?	5-Very good 4-Good 3-Fair 2-Bad 1-Very bad	SA
7. In the past 6 months have you felt so down in the dumps that nothing could cheer you up?	1-Very often 2-often 3-Sometimes 4-Rarely 5-Never	MH
8. Do you experience back pain when at rest?	1-Very often 2-often 3-Sometimes 4-Rarely 5-Never	P
9.What is your current level of work/school activity?	5-100% normal 4-75% normal 3-50% normal 2-25% normal 1-0% normal	FA
10.Which of the following best describes the appearance of your trunk; defined as the human body except for the head and extremities?	5-Very good 4-Good 3-Fair 2-Poor 1-Very poor	SA
11. Which one of the following best describes your medication usage for your back?	5-None 4-Non-narcotics weekly or less 3-Non-narcotics daily 2-Narcotics weekly or less 1-Narcotics daily	P
12. Does your back limit your ability to do things around the house?	5-Never 4-Rarely 3-Sometimes 2-Often 1-Very often	FA
13. Have you felt calm and peaceful during the past 6 months?	5-All of the time 4-Most of the time 3-Some of the time 2-A little of the time 1-None of the time	MH
14. Do you feel that your back condition affects your personal relationships?	5-None 4-Slightly 3-Mildly 2-Moderately 1-Severely	SA
15.Are you and/or your family experiencing financial difficulties because of your back?	1-Severely 2-Moderately 3-Mildly 4-Slightly 5-None	FA
16.In the past 6 months have you felt downhearted and blue?	5-Never 4-Rarely 3-Sometimes 2-Often 1-Very often	MH

17.In the last 3 months have you taken any sick days from work/ school due to back pain, and if so, how many?	5-0 4-1 3-2 2-3 1-4 or more	P
18.Do you go out more or less than your friends?	5-Much more 4-More 3-Same 2-Less 1-Much less	FA
19.Do you feel attractive with your current back condition?	5-Yes, very 4-Yes, somewhat 3-Neither attractive nor unattractive 2-No, not very much 1-No, not at all	SA
20.Have you been a happy person during the past 6 months?	1-None of the time 2-A little of the time 3-Some of the time 4-Most of the time 5-All of the time	MH
21.Are you satisfied with the results of your back management?	5-Very satisfied 4-Satisfied 3-Neither satisfied nor unsatisfied 2-Unsatisfied 1-Very unsatisfied	S
22.Would you have the same management again if you had the same condition?	5-Definitely yes 4-Probably yes 3-Not sure 2-Probably not 1-Definitely not	S
23.On a scale of 1 to 9 , with 1 being very low and 9 being extremely high, how would you rate your self-image? (1 to9)	1-1,2 2-3,4 3-5,6 4-7,8 5-9	SA
SECTION 2 (Postoperative patients)		
24.Compared with before treatment, how do you feel you now look?	5-Much better 4-Better 3-Same 2-Worse 1-Much worse	S
25.Has your back treatment changed your function and daily activity?	5-Increased 3-Not changed 1-Decreased	FA
26.Has your back treatment changed your ability to enjoy sports/ hobbies?	5-Increased 3-Not changed 1-Decreased	FA
27.Has your back treatment _____ your back pain?	1-Increased 3-Not changed 5-Decreased	P
28.Has your treatment changed your confidence in personal relationships with others?	5-Increased 3-Not changed 1-Decreased	SA
29. Has your treatment changed the way others view you?	5-Much better 4-Better 3-Same 2-Worse 1-Much worse	SA
30.Has your treatment changed your self-image?	5-Increased 3-Not changed 1-Decreased	SA

RESULTS

Preoperative major curvatures were measured as a mean of 53.1° ± 7.1 (range 45°-79°) according to Cobb method. The mean postoperative Cobb angle was 19.7° ± 5.3 with a 63.6 % ± 7.8 correction. At the mid-term follow up, the mean correction loss was 3.09 % ± 2.1 and finally 5.06 % ± 2.88 (range 0-12%) for more than 10 years. Preoperative, postoperative and follow-up measurements of the major curvatures, coronal balance and sagittal parameters are compared. In frontal plan, correction of the major curves was important statistically ($p<0.05$), but there was no difference between the postoperative, minimum 2 years follow –up and long-term follow up values. In the other words, loss of correction of the Cobb angles of the major curves were same in the minimum two years and long-term follow-up controls, statistically ($p>0.05$). In all patients physiological normal sagittal contours was obtained postoperatively, in the midterm and long-term follow-up visits. (Table-5).

According to the SRS-30 questionnaire form, at mid-term follow-up the mean pain, function and activity, self-image appearance, mental health, and satisfaction scores were 4.16 ± 0.29, 4.43 ± 0.28, 4.15 ± 0.31, 3.84 ± 0.30, and 4.15 ± 0.44, respectively. At the final follow-up SRS outcomes were 3.96 ± 0.52, 4.22 ± 0.38, 4.35 ± 0.22, 4.14 ± 0.36, and 4.10 ± 0.34, respectively. While the mental health scores improved statistically (p=0.0214), the pain (p=0,043) and the activity (p=0.038) scores deteriorated and the satisfaction score (p=0.64) remained stable in time.

Correlation of the radiological and functional with the Spearman test demonstrated significant relationship was found between cobb angle and pain (p = 0.044, Rho = -0.407). When the SRS-30 results were evaluated among themselves, there was a significant correlation between function and self-image (p= 0.005, correlation coeffective = 0.547), also function and pain (p=0.038, correlation coeffective = 0.417). Comparison of statistically significant data was determined (Table-6).

In the clinical examination, shoulder asymmetry more than 20 mm was detected in 9 patients preoperatively, and 2 cases postoperatively. In these patients self-image and satisfaction scores were statistically lower (p=0.015 and p=0,02).

Table-5. Measurements of the major curvatures, coronal balance and sagittal parameters, and results of the SRS-30 questionnaire.

	Pre-operative	Post-operative	Mid-term follow-up	Final follow-up
Cobb Angle	53.1°	19.7°	21.41°	22.64°
Correction Rate		63.6%		
Correction Loss			3.09 %	5.06 %
Coronal Balance	2.22	1.14	0.98	0.92
Thoracic Kyphosis	14.86	23.6	25.5	26.2
Lumbar Lordosis	44.54	52.18	50.27	49.54
Pain			4.16	3.96
Function and Activity			4.43	4.22
Self-image Appearance			4.15	4.35
Mental Health			3.84	4.14
Satisfaction			4.15	4.10

Table-6. Statistical analysis and results.

Statistical Analysis	Data	Result
Difference	Cobb angle; pre vs post-op	p < 0.001
	Cobb angle; post-op vs mid-term	p =0.24
	Correction loss; mid-term vs final	p = 0.83
	SRS pain; mid-term vs final	p =0.043 (-)
	SRS function and activity; mid-term vs final	p =0.038 (-)
	SRS mental health; mid-term vs final	p = 0.021 (+)
	SRS satisfaction; mid-term vs final	p = 0.64
Correlations	Final Cobb and Pain	p = 0.044 (Rho = - 0.407)
	Final Cobb and Mental Health	p = 0.032 (Rho = - 0.430)
	Correction Ratio and Mental Health	p = 0.080 (Rho = 0.498)
	Function and Self Image	p = 0.005 (Rho = 0.547)
	Function and Pain	p = 0.038 (Rho = 0.417)
	Satisfaction and Self Image	p = 0.024 (Rho = 0.451)
	Satisfaction and Mental Health	p = 0.008 (Rho = 0.521)
	Pain and Self Image	p = 0.006 (Rho = 0.532)
	Self Image and Mental Health	p = 0.001 (Rho = 0.684)

DISCUSSION

The primary goal of the surgical treatment of AIS is to achieve a stable, well-balanced spine with a solid fusion. With the new generation instrumentation systems, surgeons can do more correction with segmenter pedicle screws. Most of the studies with long-term results are related to anterior instrumentation, Harrington, and CD systems [4,19,21].

In many studies, the frontal plane correction results were close to each other. In literature, the first study of long-term results of the TSRH instrumentation, Benli et al. published an average of 64% correction using the TSRH system [4]. Suk et al. reported the mean correction rate as 55% with hooks and 72% with segmental pedicle screws (18,20). In our study, major curvatures were corrected from 53.1° ± 7.1 to 19.7° ± 5.3 with a 63.6% ± 7.8 correction rate.

In a study by King et al., the relationship between the last instrumented vertebra and the postoperative pain was examined [11]. Accordingly, 25% lower back pain was

observed when the last instrumented vertebrae L1 while 82 % in cases where L5 level was included in the instrumentation. They concluded that maintaining the motion segment in the lumbar region as much as possible was critically important [17,22]. In our study, the last instrumented vertebra level ranged between T12 and L4, with an average of L 1.8.

Bartie et al. studied 171 surgically-treated AIS patients with a mean follow-up of 19 years and compared to a control group with the same age and gender [1]. They reported, patients fused to L2, L3, and L4 had slightly more low back pain than controls, but the SF-36 outcomes were equal in patients and controls. Nohara et al. reported 48 % disk degeneration after the 154 months average follow-up time, and L5/S1 was the most common location [14]. However, a relation between low back pain and degeneration was not found. Similar results were reported in the literature [7-9].

The SRS-30 questionnaire form was suggested from Scoliosis Research Society to follow functional outcomes of AIS patients [13]. This form consists of 30 questions and five groups. In the current study, while the mental health scores improved statistically (p=0.0214), the pain (p=0,043) and the activity (p=0.038) scores deteriorated, and the satisfaction score (p=0.64) remained stable in time. Statistically, a significant relationship was found inversely proportional between the final Cobb angles and the pain scores (p = 0.044). A significant correlation between function and self-image (p= 0.005), also function and pain (p=0.038) was evaluated.

Controversies about SRS outcomes and radiologic correlation continue in the current literature. Carreon reported that patient satisfaction with treatment did not change, and other SRS parameters increased significantly [5]. Some studies as the current study found a relationship between pain and Cobb angle, while others showed no significant relation [4-5,8]. However, in these studies, the current conception is satisfaction score generally tends to remain constant or increase with treatment on mid-term and long-term follow-up [4-5,7-8,12].

Bastrom et al reported major complications impact SRS scores [2]. Rodrigues et al evaluated no correlation between functional outcomes and the presence of minor perioperative complications [16]. In our study superficial wound infection was detected in 2 cases and on follow-up functional outcomes were not different from the others. However, in two patients shoulder asymmetry more than 20 mm was detected postoperatively. In these patients self-image and satisfaction scores were statistically lower (p=0.015 and p=0,02).

Limitations of the study were a small patient group, the absence of functional results preoperative and immediate after surgery and retrospective study design. However, most of the cases are still under follow-up and it is planned to publish results more than 20 years.

In conclusion, for the surgical treatment of adolescent idiopathic scoliosis, posterior instrumentation and spinal fusion surgery is an efficient and successful method with patient satisfaction, curvature correction, and low complication rates after more than ten years follow-up.

REFERENCES

1. Bartie BJ, Lonstein JE, Winter RB. Long-term follow-up of adolescent idiopathic scoliosis patients who had harrington instrumentation and fusion to the lower lumbar vertebrae: is low back pain a problem? *Spine* 2009; 34(24): E873-E878.
2. Bastrom TP, Yaszay B, Shah SA, Miyanji F, Lonner BS, Kelly MP, Samdani A, Asghar J, Newton PO. Major complications at two years after surgery impact srs scores for adolescent idiopathic scoliosis patients. *Spine Deformity* 2019; 7(1): 93-99.
3. Bayraktar MK. Posterior instrumentation and fusion results of the surgical treatment of adolescent idiopathic scoliosis. Uzmanlık Tezi, İstanbul, 2008.
4. Benli İT, Ates B, Akalin S, Citak M, Kaya A, Alanay A. Minimum 10 years follow-up surgical results of adolescent idiopathic scoliosis patients treated with TSRH instrumentation. *Eur Spine J* 2007; 16(3): 381-391.
5. Carreon LY, Sanders JO, Diab M, Sturm PF, Sucato DJ. Patient satisfaction after surgical correction of adolescent idiopathic scoliosis. *Spine* 2011; 36(12): 965-968.
6. Danielsson AJ, Hallerman KL. Quality of life in middle-aged patients with idiopathic scoliosis with onset before the age of 10 years. *Spine Deformity* 2015; 3(5): 440-450.
7. Green DW, Lawhorne TW, Widmann RF, Kepler CK, Ahern C, Mintz DN, Rawlins BA, Burke SW, Boachie-Adjei O. Long-term magnetic resonance imaging follow-up demonstrates minimal transitional level lumbar disc degeneration after posterior spine fusion for adolescent idiopathic scoliosis. *Spine* 2011; 36(23): 1948-1954.
8. Harding IJ, Charosky S, Vialle R, Chopin DH. Lumbar disc degeneration below a long arthrodesis (performed for scoliosis in adults) to L4 or L5. *Eur Spine J* 2008; 17(2): 250-254.
9. Iida T, Suzuki N, Kono K, Ohyama Y, Imura J, Ato A, Ozeki S, Nohara Y. Minimum 20 years long-term clinical outcome after spinal fusion and instrumentation for scoliosis: comparison of the SRS-22 patient questionnaire with that in nonscoliosis group. *Spine* 2015; 40(16): E922-E928.
10. Janicki JA, Alman B. Scoliosis: review of diagnosis and treatment. *Paediatr Child Health*. 2007; 12(9): 771-776.
11. King HA, Moe JH, Bradford DS, Winter RB. The selection of fusion levels in thoracic idiopathic scoliosis. *J Bone Joint Surg Am* 1983; 65(9): 1302-1313.
12. Li N, Xu C, Shen M-K, Luo M, Wang J, Xia L. Clinical outcomes of posterior pedicle screw instrumentation without osteotomy in the management of adolescent idiopathic scoliosis. *Medicine (Baltimore)* 2018; 97(36): e12122.

13. Merola AA, Haher TR, Brkaric M, Panagopoulos G, Mothur S, Kohani U, Lowe TG, Lenke LG, Wenger DR, Newton PO, Clements DH, Betz RR. A multicenter study of the outcomes of the surgical treatment of adolescent idiopathic scoliosis using the Scoliosis Research Society (SRS) outcome instrument. *Spine* 2002; 27(18): 2046-2051.

14. Nohara A, Kawakami N, Tsuji T, Ohara T, Saito T, Kawakami K. Intervertebral disc degeneration during postoperative follow-up more than 10 years after corrective surgery in idiopathic scoliosis. Comparison between patients with and without surgery. *Spine* 2018: 10.1097/BRS.0000000000002319 Publish Ahead of Print.

15. Richards BS, Bernstein RM, D'Amato CR, Thompson GH. Standardization of criteria for adolescent idiopathic scoliosis brace studies: SRS Committee on Bracing and Nonoperative Management. *Spine* 2005; 30(18): 2068-2075; discussion: 2076-2077.

16. Rodrigues LMR, Gotfryd AO, Machado AN, Defino M, Asano LYJ. Adolescent idiopathic scoliosis: surgical treatment and quality of life. *Acta Ortopédica Brasil* 2017; 25(3): 85-89.

17. Studer D. Clinical investigation and imaging. *J Children's Orthop* 2013; 7(1): 29-35.

18. Suk S-I, Lee S-M, Chung E-R, Kim J-H, Kim S-S. Selective thoracic fusion with segmental pedicle screw fixation in the treatment of thoracic idiopathic scoliosis: more than 5-year follow-up. *Spine* 2005; 30(14): 1602-1609.

19. Tambe AD, Panikkar SJ, Millner PA, Tsirikos AI. Current concepts in the surgical management of adolescent idiopathic scoliosis. *Bone Joint J* 2018; 100-B(4) :415-424.

20. Theologis AA, Crawford M, Diab M. Ethnic variation in satisfaction and appearance concerns in adolescents with idiopathic scoliosis undergoing posterior spinal fusion with instrumentation. *Spine Deformity* 2018; 6(2): 148-155.

21. Weinstein SL, Dolan LA, Cheng JC, Danielsson A, Morcuende JA. Adolescent idiopathic scoliosis. *The Lancet* 2008; 371(9623): 1527-1537.

Volume: 30, Issue: 1, January 2019 pp: 13-16 ORIGINAL ARTICLE

THE EFFECT OF THE USAGE OF CELL-SAVER AND TRANEXAMIC ACID ON THE AMOUNT OF INTRAOPERATIVE ALLOGENIC BLOOD TRANSFUSION WHILE MANAGING BLOOD LOSS IN ADOLESCENT IDIOPATHIC SCOLIOSIS SURGERY

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ABSTRACT

Background Data: Reconstructive adolescent idiopathic scoliosis surgery performed by applying pedicle screw system with posterior approach is a major surgical procedure. Allogenic blood transfusion is one of the oldest known method for volume loss during this surgery. In order to reduce the amount of intraoperative and postoperative blood transfusion, methods such as cell-saver (CS) and tranexamic acid (TXA) have been used. Our study was performed to assess the efficacy and safety of these two methods.

Materials and Methods: In our hospitals spine surgery clinic, between 2012 and 2018, a total of 58 patients whom met the inclusion criteria, were divided into 3 groups and these two methods (CS and TXA groups) were compared with the patients who underwent surgery without applying any blood loss reduction procedure. Group 1 consisted of patients whom we applied cell-saver only (n: 19), group 2 consisted of patients whom we applied tranexamic acid only (n: 19) and group 3 consisted of the patients whom had undergone surgery without applying any other blood loss reduction procedure (n: 20). Gender, age, screwing levels, how many units allogenic blood transfusion were performed except than autogenic blood transfusion by CS during the operation were respectively determined in all three groups. Also complications related to blood loss reduction procedures intraoperatively and postoperatively were evaluated.

Results: When all 3 groups were considered together, the statistical difference was significant in terms of the amount of blood transfusion (p.0). While there was no significant difference in the amount of blood transfusion between group 1 and group 2 (p.4), there was significantly less amount of blood transfusion between group 1 & group 3 and between group 2 & group 3 (p.0 and p.0, respectively). None of the patients had major or minor complications related with managing blood loss.

Conclusions: The usage of cell-saver and/or tranexamic acid during reconstructive adolescent idiopathic scoliosis surgery significantly reduces the amount of intraoperative allogenic blood transfusion. Especially we think about that 10mg/kg bolus and 1mg/kg/hour maintenance doses of tranexamic acid are effective and safe.

Key Words: Adolescent idiopathic scoliosis, Tranexamic acid, Cell-saver.

Level of Evidence: Retrospective Clinical Study, Level III

INTRODUCTION

In reconstructive scoliosis surgery with posterior spinal instrumentation systems; wide surgical incisions, long surgical periods and spongious bone structure of the spine cause large amounts of blood loss [16]. As all major surgeries, various methods are used to manage this excessive blood loss in scoliosis surgery. The methods that are used to avoid the possible side effects of perioperative allogenic blood transfusion which are most commonly used in spinal surgery are cell-saver (CS) and IV & topical tranexamic acid (TXA) [1,12,15].

The use of TXA as an antifibrinolytic agent in order to reduce the amount of intraoperative blood loss has become

increasingly widespread in the 1990's. TXA (trans-4-aminomethyl-cyclohexane-1-carboxylic acid) is a synthetic lysine analogue. It shows its effect by binding to the lysine receptors on plasminogen molecules, inhibits the activation of plasminogen to plasmin and blocks fibrinolysis [15]. CS is a method that can be explained as a sequence of processes. First of all we collect the lost blood in the intraoperative period. Then the blood is anticoagulated, washed, filtered and given back to the patient respectively [13].

There are studies in the literature that both methods reduce the amount of intraoperative blood transfusion. Especially the cell-saver method is a more expensive method that is indicated as a disadvantage [10].

In our study, we aimed to compare these two methods used in adolescent idiopathic scoliosis (AIS) surgery performed with posterior approach with the patients who underwent surgery without applying any blood loss reduction procedure, retrospectively. Our hypothesis was to investigate whether these two methods were effective or not.

MATERIALS AND METHODS

Patients who underwent spinal surgery with only a posterior approach between 2012 and 2018 in the spinal surgery clinic of our hospital were identified and file records were checked.

The patients with the diagnosis of AIS, whose file records which were completely written (gender, age, anesthesia application forms), whom we applied pedicle screws only, whom we gave TXA dose 10 mg/kg bolus and 1 mg/kg/hour infusion and in which cases intraoperative blood loss management procedure (amount of CS or how many units allogenic blood transfusion) were exactly clear, were included in the study. The exclusion criteria of our study were; in which cases hybrid fixation methods were used, the patients whom we performed revision surgery, patients who had any osteotomy, whom we gave the TXA dose other than the aforementioned values and in which cases the amount of intraoperative blood transfusion were not clear.

A total of 58 patients who met the inclusion criteria were divided into 3 groups. Group 1 consisted of patients whom we applied cell-saver only (n: 19), group 2 consisted of patients whom we applied tranexamic acid only (n: 19) and group 3 consisted of the patients who had undergone surgery without applying any other blood loss reduction procedure (n: 20). Gender, age, screwing levels, how many units allogenic blood transfusion were performed except than autogenic blood transfusion by CS during the operation were respectively determined in all three groups. Also complications related to blood loss reduction procedures intraoperatively and postoperatively were evaluated.

Statistical Analysis

Kolmogorov Smirnov test was used to evaluate the distribution of continuous variables. Kruskal-Wallis analysis was performed to evaluate the difference between the groups. Tamhane's Posthoc analysis was applied to determine the difference between the groups. $p < 0.05$ was significant.

RESULTS

The mean age of the patients was 16 (±4) in group 1, 15 (±3) in group 2 and 14 (±4) in group 3. There was no statistically significant difference between the ages ($p = .24$). When the screwing levels were examined, the mean was 12 (±1) in group 1 and 10 (±2) in group 2, and 11 (±2) in group 3. Although there was a statistically significant difference between these three groups in terms of screwing levels (p.01), we think that this difference is not clinically significant.

The amount of allogenic blood transfusion during the operation was determined as 1.37 (±1) units in group 1, 1.7 (±.5) units in group 2 and 2.7 (±.8) units in group 3. When all 3 groups were considered together, the statistical difference was significant in terms of the amount of blood transfusion (p.0). While there was no significant difference in the amount of blood transfusion between group 1 and group 2 (p.4), there was significantly less amount of blood transfusion between group 1 & group 3 and between group 2 & group 3 (p.0 and p.0, respectively). None of the patients had major or minor complications related with managing blood loss.

DISCUSSION

Blood loss management is one of the most challenging subjects for the surgeons and anesthetists in spinal surgery as in all other major surgeries. Allogenic blood transfusion is the oldest known procedure to prevent the hypovolemic condition caused by high amounts of blood loss during surgery [6]. However; for the allogenic blood transfusion, the source is exhaustible and it is an increasingly costly method. There is also a risk of infection in allogenic transfusion. Although the rates of viral infections are relatively low, the risk of postoperative bacterial infection has been increased in several studies [14].

Reducing the amount of intraoperative blood loss consequently decreases blood transfusion which is an intended condition for the safety of the spinal surgery. For this reason, CS which is used to make autogenic blood transfusion and antifibrinolytic agents, have been increasingly used in major surgeries. [12,15].

Both methods can be performed as separate procedures or can be used together. We applied these methods separately in our study.

There are studies which suggest that the use of CS in spinal surgery decreases the need for blood transfusions, but there are also studies that provide a low benefit or nothing at all as well [3,7]. This difference is closely related to the surgical procedure performed and the number of instrumented levels. Charles et al. stated in their study that usage of CS in patients with adult lumbar fusion showed a significant difference but they also stated that this difference was not as much as they expected. Another outcome in the same study is that the CS group is more expensive than the control group [3]. Similarly, in the study of Gause et al. unlike us, patients who underwent lumbar laminectomy and fusion in the postoperative period were divided into two groups with and without CS, and a significant increase in the number of blood transfusions was detected in the CS group [5].

In an another study demonstrating the efficacy of CS in the intraoperative period, Bowen et al. reported that usage of CS significantly reduced allogenic blood transfusion, especially in scoliosis surgery lasting longer than 6 hours and in patients with blood loss greater than 30 % of total blood volume [2]. Based on this study, we can interpret that usage of CS would be advantageous especially in cases where long segment instrumentation will be performed and amount of blood loss is expected to be high.

In our study, patients whom we gave CS group 1 needed less intraoperative blood transfusion than patients whom had undergone surgery without applying any other blood loss reduction procedure group 3. Also group 1 consisted of patients whom underwent a prolonged surgery like AIS in which long segment instrumentation was performed. The most important drawback for the usage of CS is the higher costs. Although we do not have any data in this study about this, we think that it is worth research.

Another method used in blood loss management is the usage of pharmacological agents. Some of these agents whose antifibrinolytic properties are used, include tranexamic acid, aprotinin, and aminocaproic acid. TXA is an agent that can be used safely in most major surgeries [4,15]. In the meta-analysis of Li et al.; they found that intravenous administration of TXA, particularly at high doses (≥ 15 mg/kg) reduced the need for blood transfusion and did not increase the risk of deep vein thrombosis (DVT), but they pointed out that the quality of evidence for the publications included in the study was not high [11].

Jones et al. found that in 36 AIS patients whom were divided in two groups (TXA used and unused) in a similar way to our study, TXA showed a significant reduction in total blood loss. They also detected that an estimated amount of blood loss less than 6 % in TXA group compared to the other group [9]. In the same study about the levels of instrumentation; they also reported that the efficacy of TXA in 9 or less level instrumentation was worth investigating. In our study, TXA was used in the patients in group 2. These patients had a significant difference in blood transfusion, compared to whom had undergone surgery without applying any other blood loss reduction procedure. The mean fusion level of this group was 10 (±2).

In a multicenter, prospective and double-blind study, Colomina et al. compared the TXA with placebo. As a result, TXA did not significantly reduce transfusion requirements, but they noted that perioperative blood loss was significantly reduced in adults with major spinal surgery [4]. In the editorial interpretation of the same study, "intraoperative tranexamic acid reduces blood loss and transfusion under certain conditions, but its effectiveness is not clear in major spine surgery" is noted.

For the administration dose of TXA, although different studies have shown different opinions, it has been reported that usage of high dose (at least 10mg/kg bolus followed by more than 1mg/kg/hour) reduces the intraoperative blood loss, the requirement for blood transfusion and shortens the operation time generally [8].

The adverse effects of the usage of TXA are deep venous thrombosis, pulmonary embolism, myocardial infarction, hypersensitivity reaction, renal insufficiency, and rarely seizures [8-9,15]. In the meta-analysis of Hui et al. postoperative thromboembolic risk does not increase with TXA. These effects were mostly reported as case reports [8]. In our study, we did not encounter any adverse effects in the intraoperative or postoperative period.

Limited sample size, the surgeries performed by different surgeons, lack of knowledge about the exact amount of intraoperative blood loss and the lack of cost analysis for CS were the limitations of our study.

CONCLUSION

The usage of cell-saver and/or tranexamic acid during reconstructive adolescent idiopathic scoliosis surgery which is considered to be among the major spinal surgeries, significantly reduces the amount of intraoperative allogenic blood transfusion. Cost-effective study of the CS method may be beneficial in terms of total patient cost. Especially we think about that 10 mg/kg bolus and 1mg/kg/hour maintenance doses of tranexamic acid are effective and safe.

Conflict of interest: None

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REFERENCES

1. Behrman MJ, Keim HA. Perioperative red blood cell salvage in spine surgery. A prospective analysis. *Clin Orthop Relat Res* 1992; 278: 51–57.
2. Bowen RE, Gardner S, Scaduto AA, Eagan M, Beckstead J. Efficacy of intraoperative cell salvage systems in pediatric idiopathic scoliosis patients undergoing posterior spinal fusion with segmental spinal instrumentation. *Spine* 2010; 15; 35(2): 246–251.
3. Charles A, Reitman M, William C, Watters MD, Walter R, Sassard MD The Cell Saver in adult lumbar fusion surgery. *Spine* 2004; 29(14): 1580–1584.
4. Colomina MJ, Koo M, Basora M, Pizones J, Mora L, Bago J. Intraoperative tranexamic acid use in major spine surgery in adults: a multicentre, randomized, placebo-controlled trial. *Br J Anaesth* 2017; 118: 380-390.
5. Gause PR, Siska PA, Westrick ER, Zavatsky J, Irrgang JJ, Kang JD. Efficacy of intraoperative cell saver in decreasing postoperative blood transfusions in instrumented posterior lumbar fusion patients. *Spine* 2008; 33(5): 571-575
6. Glance L, Dick A, Mukamel D, Fleming F, Zollo R, Wissler R, Salloum R, Meredith UW, Osler TM. Association between intraoperative blood transfusion and mortality and morbidity in patients undergoing non-cardiac surgery. *Anesthesiology* 2011; 114: 283-292.
7. Goulet JA, Bray TL, Timmerman LA, Benson DR, Bargar WL .Intraoperative autologous transfusion in orthopedic patients. *J Bone Joint Surg* 1989; 71-A(1): 3–8.
8. Hui S, Xu D, Ren Z, Sheng L, Zhuang Q, Li S. Can tranexamic acid conserve blood and save operative time in spinal surgeries? A meta-analysis. *Spine J* 2018; 8: 1325-1337.
9. Jones KE, Butler EK, Barrack T, Ledonio CT, Forte ML. Tranexamic acid reduced the percent of total blood volume lost during adolescent idiopathic scoliosis surgery. *Int J Spine Surg* 2017; 11: 27.
10. Kolawole AJ, Aaron JB, Edward MD, Peter LZ, Zhou PL, Vasquez-Montes D, Goldstein JA, Bendo JA.The use of cell saver in spinal surgery: a value-based utilization analysis. *Spine J* 2017; 10: 201.
11. Li Z-J, Fu X, Xing D, Zhang H-F, Zang J-C, Ma X-L. Is tranexamic acid effective and safe in spinal surgery? A meta-analysis of randomized controlled trials. *Eur Spine J* 2013; 22(9): 1950-1957.
12. Neilipovitz DT, Murto K, Hall L, Barrowman NJ, Splinter WM. A randomized trial of tranexamic acid to reduce blood transfusion for scoliosis surgery. *Anesthe Analg* 2001; 93: 82–87.
13. Regan F, Taylor C. Blood transfusion medicine. *BMJ 2002;* 325(7356): 143-147.
14. Schreiber GB, Busch MP, Kleinman SH, Korelitz JJ. The risk of transfusion transmitted viral infections. The retrovirus epidemiology donor study. *N Engl J Med* 1996; 334: 1685-1690.
15. Sethna NF, Zurakowski D, Brustowicz RM, Bacsik J, Sullivan LJ, Shapiro F. Tranexamic acid reduces intraoperative blood loss in pediatric patients undergoing scoliosis surgery. *Anesthesiology* 2005; 102: 727–732.
16. Tate DE, Friedman RJ. Blood conservation in spinal surgery review of current techniques. *Spine* 1992; 17(12): 1450–1456.

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ANESTHESIA MANAGEMENT IN PEDIATRIC SCOLIOSIS PATIENTS: A RETROSPECTIVE CLINICAL STUDY

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ABSTRACT

***Introduction*:** Neurological, cardiovascular and respiratory system pathologies are frequently accompanied by pediatric scoliosis surgery. The aim of this retrospective clinical study was to evaluate the demographic characteristics, operation characteristics, and complications associated with anesthesia and surgery in pediatric patients undergoing scoliosis surgery.

Material and Methods: In this study, 33 pediatric patients undergoing elective scoliosis surgery were reviewed retrospectively. Demographic characteristics, surgical procedure data, complications related anesthesia or surgery were examined in terms of anesthesia management. Medications, concomitant diseases, laboratory values, postoperative service and intensive care unit records were obtained from the university database.

Results: The mean age of thirty-three patients was 13.09 ± 2.98 years. Three patients had meningomyelocele and one had neuromuscular disease. 72.7 % of patients (24 patients) have thoracolumbar scoliosis. The duration of anesthesia and surgery was 241.21 ± 55.55 min and 214.84 ± 54.55 min, respectively. The mean number of instrumented level was 10.78 ± 3.54. Blood transfusion was performed in 97 % of the patients (32 patients). All patients were transferred to the intensive care unit in the postoperative period. In each two patients, bradycardia and hypotension were observed. In the perioperative period, the mean blood loss of the patients was 843.93 ± 246.14 mL.

Conclusion: Pediatric scoliosis surgery; is an important orthopedic procedure which may results in serious intraoperative blood loss and postoperative pain and can be accompanied by syndromes, difficult airway management, serious respiratory and circulatory system complications during perioperative and postoperative period. Evaluation of localization and the extent of curvature, length of surgery, concomitant diseases and congenital anomalies are important for the management of anesthesia in patients undergoing pediatric scoliosis surgery.

Key words: Anesthesia management, Pediatric scoliosis, Spinal surgery, Kyphoscoliosis

INTRODUCTION

The curvature of the spine is measured by the Cobb angle and the curvature of more than 10° is considered as scoliosis [(2)]. It is often seen with rotation and causes anatomical changes in the thorax over time. This structural disease is a complex condition that causes rotation of the spine in its axis, so the deformity is not only in the coronal plane but also in axial and sagittal planes. Scoliosis is the most common deformity of the spine. About 80 % of the structural coronal deformities are idiopathic scoliosis. Prevalence of scoliosis is 4 % in the population. It is 4 times more in females [(13)]. Lok et al reported that scoliosis prevalence rate is 1.3-1.5 % in Turkey [(7)].

Neurological, cardiovascular and respiratory system pathologies are frequently associated with pediatric patients undergoing scoliosis surgery. Difficult airway management, invasive arterial and central venous monitoring difficulties, long-term surgery, intraoperative blood loss, neurologic deficits secondary to surgery and severe postoperative pain are challenging both anesthesiologists and surgeons during surgery [(3)]. Due to the accompanying comorbidities, preoperative evaluation,

perioperative follow-up and postoperative care are important and serious in this patient group. The aim of this retrospective clinical study was to evaluate the demographics, operation characteristics, and complications related to the anesthesia and surgery in pediatric patients undergoing scoliosis surgery.

MATERIAL AND METHODS

In this study, 33 pediatric patients undergoing elective scoliosis surgery between January 2015 and January 2018 in Inonu University Medical Faculty operating room were reviewed retrospectively. Demographic characteristics, surgical procedure data, complications related to anesthesia or surgery and hospital records were reviewed. Medications, comorbid diseases and treatments, laboratory values, service and intensive care follow-up information were obtained from the university patient database. This study was prepared with the guidelines of the CONSORT study group [9].

Pediatric patients under the age of 18 undergoing scoliosis surgery were included in the study. Patients with uncontrolled diabetes mellitus, lung disease or cerebrovascular disease and patients without written informed consent or lack of preoperative anesthesia evaluation were excluded from the study.

Premedication was performed with midazolam for all patients except the ones with difficult airway. After the patients were taken to the operation room, heart rate (HR), noninvasive blood pressure (NIBP), electrocardiogram (ECG), peripheral oxygen saturation (SpO2), body temperature measurement and bispectral index (BIS) were performed. Because of the high intraoperative blood loss risk, preoperative blood samples were drawn before the surgery for each patient.

A standard general anesthesia protocol was applied to all patients by an experienced anesthesiologist. After pre-oxygenation (100 % 4 L / min O2, at least 3 min), intravenous (IV) anesthesia induction was performed with propofol (0.5–2 mg / kg), rocuronium (0.4–0.6 mg / kg), and fentanyl (1 µg / kg). After the orotracheal intubation, the patients were ventilated with Dräger Primus anesthesia device (Dräger AG, Lübeck, Germany) with 8 mL / kg tidal volume, 10-24 breathing frequency and 5 mmHg positive end-expiratory pressure (PEEP). End-tidal carbon dioxide (EtCO2) monitoring was performed after intubation. Tidal volume and respiratory frequency were adjusted so that the partial pressure of EtCO2 was between 35-45 mmHg in arterial blood gas analysis. Patients were given 50 % oxygen in the oxygen-air mixture. Since neuromonitoring was applied to scoliosis patients, maintenance of anesthesia was provided by total intravenous anesthesia (TIVA) with propofol and remifentanil infusion at appropriate doses.

Foley catheterization, at least 2 large intravenous catheterization, invasive arterial monitoring to the radial artery, central venous catheterization to the internal jugular or subclavian vein was performed to all patients. Arterial blood gas analysis and hemogram were performed at frequent intervals. Patients were transferred to the intensive care unit with orotracheal intubation after surgery. Postoperative analgesia management of all patients was provided by multimodal analgesia technique with appropriate doses of paracetamol (20 mg / kg, IV) and tramadol (0.5-1 mg / kg, IV).

The duration of anesthesia was defined as the time from admission in operating room until the transfer of the patient to the intensive care unit. The duration of the surgery was defined as the time from the first skin incision until the closure of last skin suture. Mortality indicates the mortality rate associated with anesthesia or surgery during the patient's stay in the hospital.

Data were analyzed using SPSS (Statistical Package for Social Sciences Statistics for Windows, Version 22.0 Software. Armonk, NY: IBM Corp.). Quantitative data were expressed as mean and standard deviation, and qualitative data was expressed as number and percentage. P value less than 0.05 was considered significant.

RESULTS

The mean age of the 33 patients was 14.09 ± 1.98 years. 42.4 % of the patients were male (14 patients) and 57.6% were female (19 patients). ASA scores were I in 51.5 % (17 patients) and II in 48.5 % (16 patients). The Mallampati classification was I in 75.8 % (25 patients) and II in 24.2% (8 patients). Mean hemoglobin value was 12.75 ± 0.66 mg / dL and mean hematocrit value was 37.90 ± 3.50 %. Of the patients, 9.1 % (3 patient) had meningomyelocele and 3 % (1 patient) had neuromuscular disease. Demographics are shown in Table-1.

The scoliosis was at thoracic spine in 24.2 % (8 patients), at lumbar spine in 3 % (1 patient) and at thoracolumbar spine in 72.7 % (24 patients). The duration of anesthesia and surgery was 241.21 ± 55.55 min and 214.84 ± 54.55 min, respectively. The mean number of instrumented level was 12.78 ± 3.54. All of the patients undergoing surgical procedure were followed by invasive arterial monitoring, central venous catheterization, nasogastric catheterization, bladder catheterization with foley catheter and bispectral index (BIS) monitoring to measure the depth of anesthesia. The total consumptions of crystalloid and colloid were 1854 ± 403 mL and 393 ± 102 mL, respectively. Blood transfusion was performed in 97% of the patients (32 patients). All patients were transferred to the intensive care unit in the postoperative period. No mortality occurred during

the hospital stay. The surgical procedure data of the patients are shown in Table-2.

Table-1. Demographics

	Range	Mean±SD
Age (years)	11 – 17	14.09 ± 1.98
Gender (M/F)	-	14/19
ASA, I/II/III/IV, n	-	17/16/0/0
Mallampati Score, I/II/III/IV, n	-	25/8/0/0
Medication, n	-	0
Habits, n	-	0
Hemoglobin, mg/dl	12 – 14	12.75 ± 0.66
Hematocrit, %	26 – 42	37.90 ± 3.50
Comorbid Disease		
Meningomyelocele, n (%)	-	3 (9.1%)
Neuromuscular disease, n (%)	-	1 (3%)

ASA: American Society of Anesthesiology, n: number

Table 2. Surgical procedure data.

	Range	Mean±SD
Scoliosis classification		
Thoracic, n (%)	-	8 (24.2%)
Lumbar, n (%)	-	1 (3%)
Thoracic + Lumbar, n (%)	-	24 (72.7%)
Duration of anesthesia (min)	150 – 420	241.21 ± 55.55
Duration of surgery (min)	140 – 400	214.84 ± 54.55
Instrumented Level, n	7 – 16	12.78 ± 3.54
Invasive arterial monitoring, n (%)	-	33 (100%)
Central venous catheter, n (%)	-	33 (100%)
Nasogastric tube, n (%)	-	33 (100%)
Foley catheter, n (%)	-	33 (100%)
Bispectral Index, n (%)	-	33 (100%)
Total consumption of crystalloid, mL	800 – 2800	1854 ± 403
Total consumption of colloid, mL	200 – 500	393 ± 102
Blood transfusion, n (%)	-	32 (97%)
Admission to the intensive care unit, n (%)	-	33 (100%)
In-Hospital mortality, n (%)	-	0

When the patients were examined in terms of complications, 6.1 % (2 patients) had bradycardia and 6.1 % (2 patients) had hypotension. In the perioperative period, 843.93 ± 246.14 mL bleeding was observed. None of the patients developed hypoxia, neurological deficits and surgical complications. Complications of patients are shown in Table-3.

Table-3. Complications.

	Range	Mean±SD
Bradycardia, n (%)	-	2 (6.1%)
Hypotension, n (%)	-	2 (6.1%)
Hypoxia, n (%)	-	0
Neurological deficit, n (%)	-	0
Blood loss, mL	300 – 1400	843.93 ± 246.14
Surgical complication, n	-	0

DISCUSSION

In this study, demographics, surgical procedure data, and complications related to anesthesia and surgery were reviewed in pediatric patients with scoliosis surgery. In the results obtained from this study; the mean age of the patients was 13, the rate of females was higher, the majority of patients had thoracic or thoracolumbar scoliosis, the duration of anesthesia and surgery were long, the consumptions of crystalloid and colloid were high and almost all patients required serious blood transfusion.

In pediatric patients undergoing scoliosis surgery, respiratory, cardiovascular and neurological systems should be evaluated in detail. In addition to the general airway assessment recommended by ASA, airway evaluation should be performed more carefully due to the anatomic changes in this patient group for difficult intubation. Difficult intubation is frequently accompanied by syndromes, especially in pediatric scoliosis patients [5]. For difficult airways, supraglottic airway vehicles such as video-laryngoscopy, fiberoptic intubation and, if necessary, laryngeal mask airway should be available. ECG should be evaluated with echocardiography due to the restriction effects of the thoracic cage in the preoperative evaluation [6]. In this study, we observed that although the mallampati scores were lower in the preoperative evaluation, detailed airway evaluation was performed for each patient.

Pediatric scoliosis surgery is a long-time surgery and serious blood loss can occur. In addition to standard monitoring, invasive arterial monitoring, central venous catheterization, nasogastric tube, bladder catheterization and BIS monitoring are indispensable in this patient group [3,11]. In addition, arterial blood gas analysis and hemograms should be taken at frequent intervals; blood loss, metabolic status and electrolyte balance provides very important information in the follow-

up [14]. In this study, we observed that all patients undergoing pediatric scoliosis surgery needs extensive monitoring.

In scoliosis surgery, when the main curvature is at the thoracic level, the respiratory system and its functions are severely affected. In particular, anatomical defects occurring in the ribcage cause restriction in lung volume and pulmonary functions [8]. The vital capacity, functional residual capacity and total lung capacity of the respiratory system of pediatric scoliosis patients are decreasing [4]. As the curvature increases, the chest cavity narrows. Especially in curves containing 8 or more thoracic vertebrae, the respiratory system is severely affected [12]. For this reason, pulmonary function tests and arterial blood gas analysis should be performed preoperatively. It will be useful to see the hypoxemia that may occur especially in the perioperative and postoperative periods. In this study, pulmonary function tests and arterial blood gas analysis were performed in all patients and evaluated in detail in terms of respiratory system.

In scoliosis surgery, the incidence of complications in the perioperative and postoperative periods is higher than others. Especially after the surgical interventions of congenital scoliosis, high degree curves or anterior-posterior approaches; severe respiratory system complications such as atelectasis, pleural effusion, and pulmonary edema occur. Prone positioning of patients, prolongation of the intervention time, hypotension, bleeding, acidosis and postoperative analgesia management should be noted [10]. In this study; bradycardia and hypotension were observed in four patients. None of the patients developed hypoxia and neurological deficits. Especially postoperative analgesia management is very important for increasing the quality and comfort of postoperative care [1].

This study has some limitations. First of all this study was based on the data obtained from the anesthesia records and the hospital database. Secondly, all patients consist of cases in a single center. And finally some parameters which is important for anesthesia management could not be reached.

CONCLUSION

Pediatric scoliosis; is an important orthopedic disease that can be accompanied by syndromes, with difficult airway management, with serious respiratory and circulatory system complications during perioperative and postoperative period, which may result in serious intraoperative blood loss and postoperative pain. In patients undergoing pediatric scoliosis surgery, the localization and the extent of curvature, length of surgery, concomitant diseases and congenital anomalies are important for the management of anesthesia.

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REFERENCES

1. Chidambaran V, Subramanyam R, Ding L, Sadhasivam S, Geisler K, Stubbeman B, Sturm P, Jain V, Eckman MH. Cost-effectiveness of intravenous acetaminophen and ketorolac in adolescents undergoing idiopathic scoliosis surgery. *Paediatr Anaesth* 2018; 28(3): 237-248.
2. Cobb JR. Outline for the study of scoliosis. In: Ann Arbor MI, Edwards JW (eds). *Instructional Course Lectures,* American Academy of Orthopaedic Surgeons, New York 1948; pp: 261–275.
3. Hassan N, Halanski M, Wincek J, Reischman D, Sanfilippo D, Rajasekaran S, Wells C, Tabert D, Kurt B, Mitchell D, Huntington J, Cassidy J. Blood management in pediatric spinal deformity surgery: review of a 2-year experience. *Transfusion* 2011; 51(10): 2133-2141.
4. Kafer ER. Respiratory and cardiovascular functions in scoliosis and the principles of anesthetic management. *Anesthesiology* 1980; 52: 339-351.
5. Karacaer F. Anesthetic management of scoliosis surgery. *Arch Med Rev J* 2014; 23(3): 519-533.
6. Liu L, Xiu P, Li Q, Song Y, Chen R, Zhou C. Prevalence of cardiac dysfunction and abnormalities in patients with adolescent idiopathic scoliosis requiring surgery. *Orthopedics* 2010; 1: 21-28.
7. Lök V, Önçağ H, Yüce N. Türkiye hakkında skolyoz insidensi. *6. Milli Türk Ortopedi ve Travmatoloji Kongre Kitabı*, Ankara 1980; pp: 86-90.
8. Mackel CE, Jada A, Samdani AF, Stephen JH, Bennett JT, Baaj AA, Hwang SW. A comprehensive review of the diagnosis and management of congenital scoliosis. *Childs Nerv Syst* 2018; 34(11): 2155-2171.
9. Schulz KF, Altman DG, Moher D; CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *Int J Surg* 2011; 9(8): 672-677.
10. Schur MD, Blumstein GW, Seehausen DA, Ross PA, Andras LM, Skaggs DL. Intraoperative hypothermia is common, but not associated with blood loss or transfusion in pediatric posterior spinal fusion. *J Pediatr Orthop* 2018; 38(9): 450-454.
11. Seol TK, Han MK, Lee HJ, Cheong MA, Jun JH. Bispectral index and their relation with consciousness of the patients who receive desflurane or sevoflurane anesthesia during wake-up test for spinal surgery for correction. *Korean J Anesthesiol* 2012; 62(1): 13-18.
12. Wilton N, Anderson B. Orthopedic and spine surgery. In: Cote CJ, Lerman J, Todres ID (eds). *Practice of Anesthesia in* İnfants *And Children*. 4th edition. Elsevier, Philadelphia 2009: 633-655.

13. Yaman O, Dalbayrak S. İdiopatik Skolyoz. *Türk Nöroşirürji Dergisi* 2013; 23 (2): 37-51.
14. Zuccaro M, Zuccaro J, Samdani AF, Pahys JM, Hwang SW. Intraoperative neuromonitoring alerts in a pediatric deformity center. *Neurosurg Focus* 2017; 43(4): E8.

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ANESTHESIA MANAGEMENT IN ADULT SCOLIOSIS PATIENTS

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ABSTRACT

Introduction: Adult scoliosis surgery management is challenging procedure for both orthopedic surgeons and anesthetists because of the long duration of surgery, difficulties in cannulation and intubation and serious bleeding. In this retrospective study, the anesthesia records of 25 adult patients who underwent scoliosis surgery under general anesthesia between 2010 and 2013 were evaluated in the light of current literature.

Material and Methods: Twenty-five adult patients who underwent scoliosis surgery between January 2010 and December 2013 were included in the study. Demographic data, American Society of Anesthesiologists (ASA) classification, Mallampati (MP) score, duration of anesthesia, duration of operation, amount of blood loss data were recorded.

Results: The mean age of 25 patients who underwent scoliosis surgery was 26.6 ± 8.80 years. 2 (8 %) of the patients were classified as ASA I, 19 (76 %) ASA II and 4 (4 %) ASA III. MP score was I in ten (40 %) patients, and was recorded as II in 10 (40 %) patients and III in 5 (20 %) patients. The mean duration of anesthesia was 289.80 ± 81.01 minute, the mean amount of blood loss was recorded as 1162 ± 466.72 ml. Twenty (88 %) patients underwent peroperative blood transfusion.

Conclusion: Anesthesia management is important in scoliosis surgery due to many complications that may develop especially because of blood loss. Detailed preoperative evaluation should be performed and appropriate preparations should be planned before surgery.

Key words: Anesthesia management, adult scoliosis, spinal surgery, kyphoscoliosis

Level of evidence: Retrospective clinical study, Level III.

INTRODUCTION

Scoliosis is a disease that progresses with age, shows abnormal angulation of a spinal segment sideways or backwards, and has clinically significant results [(7)]. It is more common in female than male [(2)]. The incidence of scoliosis in Turkey was reported to be 1.3 % [(6)]. Scoliosis surgery is often performed by multiple levels of instrumentation and correction of spinal curve. Although most of the scoliosis are idiopathic, many diseases such as mesenchymal disorders, trauma, surgery and infection can cause scoliosis. Patients should be evaluated in terms of airway difficulties, respiratory, cardiovascular and neurological system disorders in the preoperative evaluation [(3)]. Particular attention should be paid to important cardiac problems and congenital anomalies. Cardiac pathologies such as atrial septal defect (ASD) may be most common [(5)].

Because of the long duration of surgery, difficulties in cannulation and intubation and serious bleeding, anesthesia management is important in scoliosis surgery. Increasing the number of instrumented levels increases both the duration and the complications of surgery such as bleeding. In these patients, in addition to standard anesthesia monitoring (electrocardiography, noninvasive blood pressure, end-tidal carbon dioxide pressure, peripheral oxygen saturation, temperature) invasive interventions (radial artery cannulation, central vein cannulation, bladder probe) and neurophysiological monitoring (depth of anesthesia and spinal

cord functions) techniques are applicable. Intermittent blood count and blood gas analysis can be used to assess the acid base balance and the need for blood. In this retrospective study, the anesthesia records of 25 adult patients who underwent scoliosis surgery under general anesthesia between 2010 and 2013 were evaluated in the light of current literature.

MATERIAL AND METHODS

After the approval of the University Ethics Committee, 25 patients who underwent scoliosis surgery under general anesthesia in the central operating room of our hospital between January 2010 and December 2013 were included in the study. Demographic data (age, gender, weight, height, body mass index (BMI)), American Society of Anesthesiologists (ASA) classification, Mallampati (MP) score, duration of anesthesia, duration of operation, amount of blood loss, history of medication and operation, comorbid systemic diseases, the number of instrumented levels, Cobb angle of curves, amount of blood transfusion and mortality data were recorded.

SPSS (Statistical Package for the Social Sciences Inc., Chicago IL, USA) 22.0 package program was used for statistical analysis. Number, percentage, mean and standard deviation values were used to define the data. The recorded data were obtained by complete counting sampling.

RESULTS

The mean age of 25 patients who underwent scoliosis surgery was 26.6 ± 8.80 years, the male / female ratio was 11/14 (44 % / 56 %), the average body weight was 68.16 ± 7.88 kg, the mean height was 164.16 ± 8.47 cm, and the mean BMI was 25.24 ± 2.10 kg / m^2. Two (8%) of the patients were classified as ASA I, 19 (76 %) ASA II and 4 (4 %) ASA III. MP score was I in ten (40 %) patients, and was recorded as II in 10 (40 %) patients and III in 5 (20 %) patients (Table-1).

Table-1. Demographic data of the patients. (mean ± SD)

Gender (M/F) (n,%)	11(%44) / 14 (%56)
Age (years)	26.6 ± 8.80
Weight (kg)	68.16 ± 7.88
Height (cm)	164.16 ± 8.47
BMI (kg/m^2)	25.24 ± 2.10
ASA I/II/III (n,%)	2(%8) / 19(%76) / 4(%4)
Mallampati score (I/II/III)	10(%40) / 10(%40) / 5(%20)

SD; standard deviation, M; male, F; female, BMI; Body Mass Index, ASA: American Society of Anesthesiology, n;number.

The mean duration of anesthesia was 289.80 ± 81.01 min, and the mean operation time was 313.20 ± 81.54 min. The mean amount of blood loss was recorded as 1162 ± 466.72 ml. While 3 (12 %) patients had a history of medical drug use, 21 (84 %) patients had a history of previous surgery. When systemic diseases were evaluated, 2 (% 8) patients had ASD, 1 (4 %) had Arnold-Chiari syndrome, 1 (4 %) had epilepsy, 1 (4 %) had asthma and 3 (12 %) had hypertension. The mean number of instrumented vertebrae was 11.26 ± 4.74. Thoracolumbar surgery was performed in 22 (88 %) patients, thoracic in 2 patients (8 %) and lumbar in 1 (4 %) patient. The mean Cobb angle was 78.5 ± 9.1°. Twenty (88 %) patients underwent peroperative blood transfusion. No mortality occurred in any patient during hospital stay (Table-2).

Table-2. Surgical procedure data.

Anesthesia time (min)	289.80 ± 81.01
Surgery time (min)	313.20 ± 81.54
Blood loss (ml)	1162 ± 466.72
Medication history (n,%)	3 (%12)
Operation history (n,%)	21 (%84)
Systemic diseases (n,%)	
ASD	2 (%8)
Arnold-Chiari Syndrome	1 (%4)
Epilepsy	1 (%4)
Asthma	1 (%4)
Hypertension	3 (%12)
Instrumented Level	11.26 ± 4.74
Surgical Zone (T/L/TB) (n,%)	2(%8) / 1 (%4) / 22 (%88)
Cobb angle (°)	78.5 ± 9.1
Blood transfusion (n,%)	22 (%88)
Mortality (n,%)	0 (%0)

ASD; atrial septal defect, T; thoracic, L; lumbar, TB; thoraco-lumbar

In this study, total intravenous anesthesia (propofol and remifentanil infusion) was chosen as anesthesia management and inhalation anesthetics were not preferred [8]. Surgery was applied prone position with posterior approach in all patients. Neuromonitoring (Somatosensory Evoked Potentials and Motor Evoked Potentials) and bispectral index (BIS) monitoring were performed. No Wake Up test (intraoperative wake-up test) was performed. All patients were admitted to the intensive care unit postoperatively and were extubated one day later. An epidural catheter was placed and postoperative analgesia was provided with local anesthetic infusion.

DISCUSSION

Anesthesia management is important because of anatomical defects and surgical difficulties in scoliotic patients. According to many anesthesiologists, blood transfusion due to serious blood loss and related complications are the most important problems [3]. In addition to hemodynamic changes, changes in bleeding diathesis are changes that may lead to an increase in mortality [4,9]. Increased number of vertebrae surgery and prolongation of these surgery may increase the amount of bleeding. Therefore, careful surgical technique and alternative strategies to reduce the amount of bleeding (correct patient position, controlled hypotension, preoperative autologous blood transfusion, acute normovolemic hemodilution, preoperative erythropoietin administration, tranexamic acid application) must be selected in these patients. In recent years, cell-saver methods, which provide the reuse of blood after bleeding, have also gained popularity [1]. In our cases, the mean amount of bleeding was around 1200 ml. In two patients, the amount of bleeding was over 2500 ml, which is an indication of the extent of the bleeding. For this reason, it is important to make preoperative blood preparation and to ensure peroperative bleeding control. According to our clinical experience, the application of methods that can reduce bleeding, such as controlled hypotension, by experienced anesthesiologists especially helps to reduce the complications due to blood transfusion. The studies on the effect of different doses of tranexamic acid on bleeding have been continuing in our clinic.

Scoliosis surgery is a long-term surgical treatment and anesthesia management is difficult due to duration of surgery. It can make it more difficult to have additional diseases. As seen in our study, blood transfusion was required in most of the cases due to the high amount of bleeding. The mean surgical instrumented vertebral level was 11, which led to an increase in the amount of peroperative bleeding and the duration of surgery. Considering that many of these cases were operated previously due to scoliosis, drugs used in anesthesia management and methods to reduce bleeding would be necessary. In addition, it should be kept in mind that difficult airway may be seen in these cases because of high MP score and the fact that neck movements may be restricted and alternative airway vehicles such as laryngeal mask airway (LMA), fiberoptic bronchoscope or videolaryngoscope should be available to provide airway if necessary [5]. The patients who were included in our study did not develop difficult airway and all patients were intubated at one attempt with orotracheal route.

In addition to the clinical features of scoliosis surgery patients, it may be necessary to provide advanced monitoring methods as it is a long-term and bleeding surgery. In these patients, in addition to standard anesthesia monitorization (electrocardiography, noninvasive blood pressure, end-tidal carbon dioxide pressure, peripheral oxygen saturation, temperature), invasive monitoring techniques (radial artery cannulation, central vein cannulation, bladder catheter) are almost always necessary [1]. In addition, near-infread spectroscopy (NIRS) and BIS monitoring may be preferred to evaluate cerebral oxygen saturation and the depth of anesthesia, repectively.

CONCLUSION

Due to the fact that scoliosis surgery is a major surgical procedure, anesthesia management is important in scoliosis surgery due to many complications that may develop especially for bleeding. In these cases, a detailed preoperative evaluation should be performed and appropriate preparations should be planned for bleeding. Care must be taken because of difficult airway and interventional procedures. The presence of an experienced anesthesia team in scoliosis surgery may help to reduce complications and accelerate postoperative recovery. This can be achieved by coordinated work by the orthopedist, anesthesiologist and intensive care professional.

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REFERENCES

1. Bowen RE, Gardner S, Scaduto AA, Eagan M, Beckstead J. Efficacy of intraoperative cell salvage systems in pediatric idiopathic scoliosis patients undergoing posterior spinal fusion with segmental spinal instrumentation. *Spine* 2010; 15: 246-251.
2. Farber NE, Pagel SP, Warltier DC. Pulmonary pharmacology of inhaled anaesthetics. In: Miller RD (ed.) *Anesthesia*. 5th ed. Churchill Livingstone. Philadelphia 2000; pp:125-146.
3. Gürkan Y, Eroğlu A, Kelsaka E, Kürşad H, Yılmazlar A. Skolyoz Cerrahisinde Anestezi. *Turk J Anaesth Reanim* 2013; 41: 88-97.
4. Lentschener C, Cottin P, Bouaziz H, Mercier FC, Wolf M, Aljabi Y et al. Reduction of blood loss and transfusion requirement by aprotinin in posterior lumbar spine fusion. *Anesth Analg* 1999; 89: 590–597.
5. Liu L, Xiu P, Li Q, Song Y, Chen R, Zhou C. Prevalence of cardiac dysfunction and abnormalities in patients with adolescent idiopathic scoliosis requiring surgery. *Orthopedics* 2010; 1: 21-28.
6. Lök V, Önçağ H, Yüce N. Türkiye hakkında skolyoz insidensi. *6. Milli Türk Ortopedi ve Travmatoloji Kongre Kitabı*. 1980 Ankara; pp: 86-90.

7. McMaster MJ, Glasby MA, Singh H, Cunningham S. Lung function in congenital kyphosis and kyphoscoliosis. Spinal Disord Tech 2007; 20 (3): 203-208.

8. Sutter M, Deletis V, Dvorak J, Eggspuehler A, Grob D, Macdonald D, Sala F, Tamaki T. Current opinions and recommendations on multimodal intraoperative monitoring during spine surgeries. *Eur Spine J* 2007; 16: 232-233.

9. Tzortzopoulou A, Cepeda MS, Schumann R, Carr DB. Antifibrinolytic agents for reducing blood loss in scoliosis surgery in children. *Cochrane Database Syst Rev* 2008; 16: CD006883.

Volume: 30, Issue: 1, January 2019 pp: 27-32 ORIGINAL ARTICLE

THE EFFECT OF POSTURAL KINESIOTAPING IN THE TREATMENT OF THORACIC KYPHOSIS

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ABSTRACT

Purpose: The purpose of this study is to find out whether postural kinesio taping (KT) contributes to decreasing kyphosis angle in adolescents who have increased thoracic kyphosis. Within this context, our purpose was to contribute to treatment of thoracic kyphosis as an additional method.

Material and Method: 50 adolescents between 10 and 18 years of age who referred to Orthopedics and Traumatology Polyclinic and who were diagnosed with thoracic kyphosis after required examinations participated in the study voluntarily. The patients were randomly grouped in two. One of the groups was exercise group (Ex), while the other was both exercise and taping (Ex-KT) group. At the beginning of the study, thoracic kyphosis values of all the patients in the study were measured by an orthopedist based on Cobb method. The groups consisted of 25 patients. Consent was taken from all participants with pediatric informed consent form. The same exercises were given to both groups. The patients were asked to make two types of exercises daily. The first exercise was 20 body hyperextensions in prone position. The second exercise was a rhythmic swimming movement done as if diving into the water and coming out of the water. This swimming movement would be done 5 minutes each day. The exercises were followed daily under the supervision of a physiotherapist. Only these exercises were given to Ex group. After Ex-KT group made the exercises, KT was applied on their upper backs. KT application was renewed each week. The participants were referred to the orthopedist again for measurement following a 6-week program. Final measurement results the orthopedist conducted with Cobb method were compared with the first measurement results.

Results: No statistically significant difference was found between the average pre-treatment and post-treatment kyphosis degrees of males and females in the Ex group ($p > 0,05$). Statistically significant difference was found between the average pre-treatment and post-treatment kyphosis degrees of males and females in the Ex-KT group ($p < 0,05$).

Conclusion: In the present study, it was found that KT technique had positive results in terms of decreasing increased thoracic kyphosis. We are of the opinion that it will be useful to apply KT technique with other treatment protocols in the treatment of increased thoracic kyphosis. We believe that the results of this study will be a reference for future studies. We are of the opinion that studies with longer periods of time should be conducted to have a clear idea about the effects of KT on thoracic kyphosis.

Key Words: Kinesio taping, Thoracic kyphosis, Cobb method

Level of evidence: Retrospective clinical study, Level III

INTRODUCTION

Kyphosis is the forward curving that occurs mostly in the thoracic area as a result of the increase of convexity of column vertebrae from posterior. In kyphosis, there is shortening on the anterior column of column vertebrae and increase in the posterior column. Kyphosis, which is a posture disorder, is excessive curvature of the thoracic area in the spine. In a healthy person, there is a normal kyphosis angulation in the thoracic and sacral areas in the sagittal plane. Since the sacral area is more stable, pathological conditions generally occur in the thoracic area [10,14,20]. It is of primary importance to decide whether the kyphosis is pathological or not. Patients generally refer to clinics

by complaining about their physical appearance. Pain and neurological problems are other complaints of the patients [19,27]. Radiological examinations are of primary importance in kyphosis assessment. Physiological kyphosis of column vertebrae should not be ignored depending on the age [3].

Kyphosis of the thoracic area is thought to develop due to higher posterior edges of vertebra forms as a result of the natural curve from fetal period [3]. Physiological thoracic kyphosis is necessary for cardiopulmonary system organs to work in harmony [11]. The degree of thoracic kyphosis is determined according to Cobb measurement method. According to Cobb method, the value of the angle that the straight lines which intersect each of the parallel lines passing from superior end plate of T1 to inferior end plate of T12 gives the thoracic kyphosis angle. Some researchers have chosen the upper point in different ways from T2 to T5 as the reference point [7,9,17]. The value of physiological kyphosis is between 20° and 40° and with advancing age, it is accepted as normal up to 50° [17,23].

While kyphosis can develop after a trauma, it can also occur depending on congenital developmental anomalies. Degenerative disc diseases, inflammatory diseases, infectious reasons, muscular and neuromuscular diseases, muscular dystrophy, spinal muscular atrophy, myelomeningocele, neurofibromatosis, vertebra fractures, Paget's disease and spinal vertebra tumors can be listed among kyphosis etiologies [2].

Thoracic kyphosis can result from bad position of trunk, congenital kyphosis, Scheuermann kyphosis, paralytic kyphosis, and due to developmental and metabolic reasons [2]. Scheuermann kyphosis is the type of kyphosis which was first defined by Danish radiologist Holger Werfel Scheuermann. It is the rigid kyphosis mostly seen in young adults as a result of the osteochondritis of the secondary ossification centers. Scheuermann stated that due to being a rigid deformity, the kyphosis deformity that occurred was differentiated from postural kyphosis and was a different clinical picture [4,26]. In Scheuermann kyphosis, a kyphotic deformity of 75° and higher, presence of progressive deformity, cardiopulmonary problems, pain, progressive neurological deficit and cosmetic disorders are accepted as surgical treatment indications [1].

Kinesiology Taping technique was developed in 1973 by Dr. Kenzo Kase. Kinesiology Taping has recently begun to be used as a method to support treatment in physiotherapy, orthopedics and sports injury. Kinesiology Taping technique can be used for supporting the painful tissue, providing ease to move and for protection. It is frequently used by athletes to decrease the myofascial tension of the muscle. It is also used for many purposes in orthopedic and neurological cases [5-6,8,18]. The objective of this study is to find out whether postural kinesio taping (KT) contributes to decrease in kyphosis angle in adolescents who have increased thoracic kyphosis. In this regard, we wanted to contribute to the thoracic kyphosis treatment protocol as an additional method.

MATERIAL AND METHOD

50 adolescent patients between 10 and 19 years of age who referred to Medical Center Orthopedics and Traumatology Polyclinic and who were diagnosed with thoracic kyphosis after required examinations participated in the study voluntarily. *The study was conducted with permission numbered 2015/89 from Malatya Clinical Researches Ethical Board.*

The patients were randomly grouped in two as exercise (Ex) group and exercise and kinesio taping (Ex-KT) group. At the beginning of the study, thoracic kyphosis values of all the patients in the study were measured by an orthopedist based on Cobb method. The groups consisted of 25 people. Consent was taken from the parents of all participants in the study with pediatric informed consent form. The patients whose anamnesis included spine surgery, osteoporosis, cardiac arrhythmia, scoliosis, gibosity, musculoskeletal deformities, and the patients who were physically disabled, who were doing sport professionally or as an amateur, those who had vertebral fracture and those who were allergic to KT material were excluded from the study. During the study, 3 patients from the Ex group and 2 patients from the Ex-KT group discontinued the study for various reasons. New participants were included in the study in place of these participants in line with the criteria. X-Rays of individuals in both groups were taken for control both before and after the study and their kyphosis degrees were measured by an orthopedist with Cobb method. All Ex-KT group patients were informed about taping. Patient information forms which included the demographic information of the participants, kyphosis type, anamnesis and family history were filled in.

Treatment

The same exercises were given to both groups. There were two types of exercises the patients were asked to make daily. The first exercise was a rhythmic swimming movement done as if diving into the water and coming out of the water. In this rhythmic swimming movement, the patient's head, arms and the body starting from the upper part of T4 level would hang from outside the bed and thus the arms and the upper body would become lower than the lower extremities and diving move would be made. While doing this rhythmic swimming move, the patients' arms would be positioned forward and

downward while the head would get in between the arms (Figure-1.a).

After this diving position, the shoulder would be retracted with head hyperextension and body hyperextension, the elbows would be flexed and the arms would be adjacent to the body as much as possible, fingers adjoined and the patient would get up behind until the palms would look down. The exercise of diving into the water and coming out of water would be done for five minutes each day in the form of a rhythmical swimming move (Figure-1.b).

For patients who could not complete this 5 minute period without stopping, breaks were made and these resting times were decreased from the total time. The second exercise was 20 body hyperextensions in two sets while in prone position. The point that the patients had to pay attention to during body hypertension was to have maximum hyperextension while getting up and getting minimum support from the arms (Figure-1.c).

The exercises were followed daily under the supervision of a physiotherapist. Only these exercises were made in the Ex group, as treatment. In the Ex-KT group, KT was applied on the back following the same exercises. Taping started from C6 spine level, continued paravertebrally until T12 level and ended at T12 level obliquely from the acromion line in the form of V. While taping, the patients were asked to keep an upright position as much as possible and to keep the head low to the back (Figure-2).

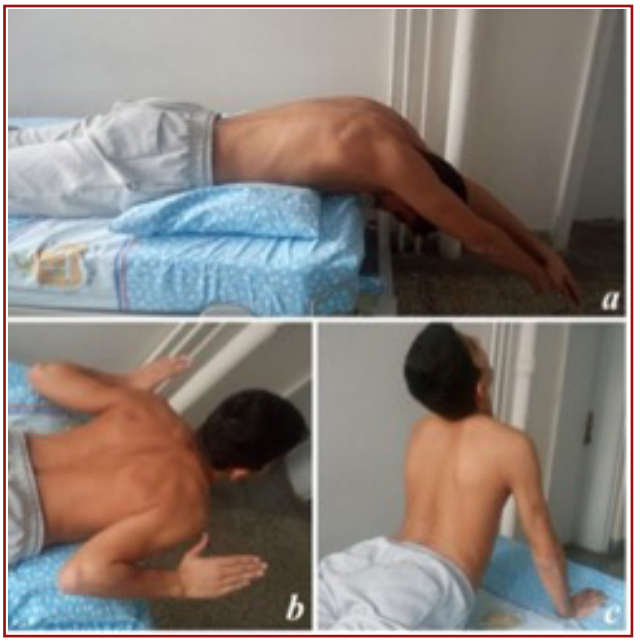

Figure-1. Back exercises given to groups; ***a:*** Diving to water, ***b:*** Rising from water, ***c:*** Body hyperextension exercise

The tapes had zero stress on both ends and about 40 % stress in the middle parts. Taping was not taken off for four days. After day four, it was taken off and the skin was rested for two days. Taping application was repeated on day 7. The patients were told that KT was water-resistant, thus, they could easily have bath and they were also told the situations that they had to take care of. The tapes of patients which went bad or which wore off somehow were renewed during the week. The patients in the Ex-KT group were followed for six weeks. At the end of six weeks, X-rays of all patients were taken again and the final kyphosis degrees were measured by the same orthopedist with Cobb method. Final measurement results the orthopedist conducted with Cobb method were compared with the first measurement results.

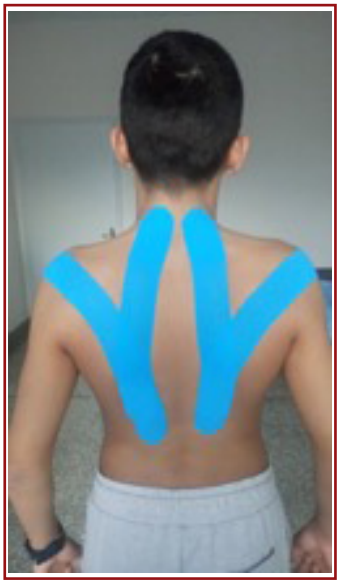

Figure-2. Kinesio taping

Statistical Analysis

Shapiro-Wilk test was conducted to find out if the data were normally distributed and it was found that the data did not have a normal distribution. Wilcoxon analysis was conducted on the data to assess the pre-treatment and post-treatment kyphosis degrees. Median and min and max values were given for the data which were not normally distributed. $p<0.05$ was considered as statistically significant. IBM SPSS Statistics 22.0 program was used for analysis.

RESULTS

29 females (16 in the Ex group, 13 in the Ex-KT group) and 21 males (9 in the Ex group, 123 in the Ex-KT group) participated in the study. Among the girls, the median value of the ages of children was 14 years in the Ex group and 15 years

in the Ex-KT group; the median value of the boys was 14 years both in the Ex group and in the Ex-KT group. Among the girls, the median value of the heights of children was 164.5 cm in the Ex group and 160 cm in the Ex-KT group; the median value of the boys was 164 cm in the Ex group and 167 cm in the Ex-KT group. Among the girls, the median value of the mass of children was 74 kg in the Ex group and 52 kg in the Ex-KT group; the median value of the boys was 50 kg in the Ex group and 56.5 kg in the Ex-KT group. Among the girls, the median value of the BMI of children was 20.76 kg/m^2 in the Ex group and 19.57 kg/m^2 in the Ex-KT group; the median value of the boys was 19.37 kg/m^2 in the Ex group and 19.05 kg/m^2 in the Ex-KT group (Table-1).

In girls in Ex group, pre-treatment kyphosis degree median value was 63.5º, while post-treatment kyphosis degree median value was 63º. In girls in Ex-KT group, pre-treatment kyphosis degree median value was 62º, while post-treatment kyphosis degree median value was 57º. In boys in Ex group, pre-treatment kyphosis degree median value was 60º, while post-treatment kyphosis degree median value was 57.5º. According to the results of Wilcoxon analysis conducted, statistically significant difference was found in Ex-KT group between pre-treatment and post-treatment kyphosis degrees of both girls and boys ($p<0.05$), (Table-2).

When females and males were assessed under one group, pre-treatment kyphosis degree median value was 63º in Ex group, while post-treatment kyphosis degree median value was 64º. Pre-treatment kyphosis degree median value was 62º in Ex-KT group, while post-treatment kyphosis degree median value was 57º. According to Wilcoxon analysis results, statistically significant difference was found between pre-treatment and post-treatment kyphosis degrees in Ex-KT group ($p<0.05$), (Table-3).

DISCUSSION

In patients with Scheuermann and postural kyphosis, conservative treatment is considered initially. Several practices such as physiotherapy, medical treatment, exercise treatment, orthesis and corset are applied in combination. In cases who do not respond to conservative treatment and whose kyphosis degrees increase (Cobb >75˚), surgical treatment is considered appropriate. In literature review, there are few KT practices for the treatment of thoracic kyphosis. We are of the opinion that this study will make up this deficiency in the literature.

Table-1. Median (min-max) values of age, height, weight and BMI in girls and boys in Ex and Ex-KT groups.

Variable	Females		Males		P value
	Ex (n=16)	***Ex-KT (n=13)***	***Ex (n=9)***	***Ex-KT (n=12)***	
Age	14 (12-18)	15 (11-18)	14 (10-18)	14 (10-18)	0.804
Height (cm)	164.5 (158-175)	160 (152-171)	164 (155-180)	167 (125-185)	0.168
Mass (kg)	74 (42-74)	52 (36-69)	50 (40-65)	56.5 (22-74)	0.193
BMI	20.8 (15.67-26.53)	19.6 (14.98-26.95)	19.4 (15.63-20.81)	19.1 (12.89-22.84)	0.290

Table-2. Changes in pre-treatment and post-treatment kyphosis values of boys and girls and Wilcoxon analysis results

Group	Females			Males		
	pre-treatment	***post-treatment***	***p***	***pre-treatment***	***post-treatment***	***p***
Ex	63.5º (46º -81º)	63º (35º -71º)	0.315	60º (41º -71º)	67º (43º -77º)	0.573
Ex-KT	62º (52º -75º)	57º (44º -67º)	0.023	64º (54º -78º)	57.5º (43º -74º)	0.012

Table-3. Changes in pre-treatment and post-treatment kyphosis degrees of all children and Wilcoxon analysis results

Group	pre-treatment	post-treatment	*p*
Ex	63º (41º -81º)	64º (35º -77º)	0.782
Ex-KT	62º (52º -78º)	57º (43º -74º)	0.001

Greig et al. divided 15 patients with osteoporotic vertebral fractures into three groups as KT, placebo taping and no taping. Thoracic kyphosis angles were repeated before test and before application. Body muscle electromyography activity was measured during three different static standing positions and the balance parameters from strength platform were

examined. KT application was found to have a statistically significant effect on thoracic kyphosis; however, it was not found to be associated with EMG measurements or balance parameters. Greig et al. thought that the mechanic balance provided by taping was responsible for the muscle activity not to change although thoracic kyphosis decreased [13].

Sastre et al. used FED (fixation-elongation-derotation) device on 30 patients with Scheuermann kyphosis [21]. This device has been designed 3-D in a way to apply a force up to 100 kg from the apex point and to force the vertebra to a smooth line with adverse effect mechanism for abnormal curvatures. In the same study, they recommended home exercises to patients in order to maintain lumbar area flexibility. Following a 4-month-long treatment and follow-up, they observed that the initial average value of the thoracic angle decreased to 45° from 53° with FED device and that backache due to thoracic hyperkyphosis was found to disappear. As shown by this study, the results of which are similar to our results, we are of the opinion that the reason why both FED device and KF decreased hyperkyphosis is that they increased proprioceptive sense development and bodily awareness. In addition, the fact that FED device is more costs in terms of application makes our study more advantageous. Still, further studies are needed to advocate the thought that thoracic hyperkyphosis and vertebral deformities can be fixed with postural awareness and postural education.

Weiss et al. applied kyphologic brace orthosis to patients with Scheuermann kyphosis and found positive results [25]. In this study which included patients who had been getting orthosis treatment and physiotherapy for a period of a long time such as 20 months, thoracic kyphosis values were examined and compared with pre-treatment values. The fact that thoracic kyphosis values were observed in a longer period than our study can show that this study is more advantageous than ours; however, we believe that KT is a much more advantageous method in terms of ease of use and comfort.

In a study conducted with Milwaukee orthosis in patients with Scheuermann kyphosis, the orthosis was found to decrease thoracic kyphosis during its period of use [15]. While Milwaukee brace gave positive results, the ease of use that KT material has brings it one step ahead of orthosis.

While assessing patients with thoracic hyperkyphosis before treatment, the other sagittal curvatures of the vertebra should also be examined. Flexibility of lumbar extensor, hip flexor and hamstring muscles are primary factors that affect the posture of the vertebra. Thus, since there are many factors affecting the balance of the body and the development of the vertebra, these points should be taken into consideration during the treatment. In patients with Scheuermann kyphosis, the shortness of knee flexor muscles, which are called the hamstring muscle group, is thought to influence the thoracic kyphosis and vertebra biomechanics negatively [16]. Thus, we believe that extension exercises to lumbar extensor muscles and hamstring muscles should always be among exercises applied in the treatment of thoracic hyperkyphosis treatment. The fact that the head positions of patients with thoracic hyperkyphosis are bent forward is thought to cause an increase in the degree of kyphosis [28]. In this study, the patients were told that they had to pay attention to their head positions as much as possible in their daily lives in order to increase their postural awareness.

In patients with postural hyperkyphosis, there are studies which state that even only exercise can be enough to fix increased kyphosis [22]. In a study about yoga, postural exercises were found to decrease hyperkyphosis [12]. These studies bring forward the idea that exercises should be varied and they should be presented to patients as an alternative.

The results of our study show that combining KT technique with exercises in the treatment of Scheuermann kyphosis or postural kyphosis causes positive results in the treatment. It was observed clearly that KT technique was effective on increased thoracic kyphosis. However, since the development of vertebra still continues in adolescence, we believe that the results of KT practice should be observed in a longer period. We are of the opinion that our study will be a reference to future studies.

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REFERENCES

1. Arlet V, Schlenzka D. Scheuermann's kyphosis: surgical management. *Eur Spine J* 2005; 14: 817-827.
2. Aufdenmaur E. Juvenil kyphosis (Scheuermann's disease) radiography, histology and pathogenesis. *Clin Orthop Relat Res* 1981; 154: 166-174.
3. Bernhardt M, Bridwell KH. Segmental analysis of the sagittal plane alignment of the normal thoracic and lumbar spines and thoracolumbar junction. *Spine* 1989; 14: 717-721.
4. Bezalel T, Carmeli E, Been E, Kalichman L. Scheuermann's disease: current diagnosis and treatment approach. *J Back Musculoskelet Rehabil* 2014; 27(4): 383-390.
5. Birrer RB, Poole B. Athletic taping, part 4: the shoulder and elbow: added support enables the athlete to remain active. *J Musculoskel Med* 1996; 1: 52-57.
6. Drottning M, Staff PH, Sjaastad O. Cervicogenic headache (CEH) after whiplash injury. *Cephalalgia* 2002; 22: 165-171.
7. Edmondston SJ, Singer KP. Thoracic spine: anatomical and biomechanical consideration for manual therapy. M*an Ther* 1997; 3: 132-147.

8. Eichberger A, Darok M, Steffan H, Leinzinger PE, Bostrom O, Svensson MY. Pressure measurements in the spinal canal of post-mortem human subjects during rear-end impact and correlation of results to the neck injury criterion. *Accid Anal Prev* 2000; 32: 251-260.
9. Gelb DE, Lenke GL, Bridwell KH, Balanke K, McEnery KW. An analysis of sagittal spinal alignment in 100 asymptomatic middle and older aged volunteers. *Spine* 1995; 20(12): 1351-1358.
10. Goldstein LA, Waugh TR. Classification and terminology of scoliosis. *Clin Orthop* 1973; 93: 10-22.
11. Gray H. Anatomy of the human body. 2000; Available from: http://www.bartleby.com/107.
12. Greendale GA, Huang MH, Karlamangla AS, Seeger L, Crawford S. Yoga decreases kyphosis in senior women and men with adult onset hyperkyphosis: results of a randomized controlled trial. *J Am Geriatr Soc* 2009; 57(9): 1569-1579.
13. Greig AM, Bennell KL, Briggs AM, Hodges PW. Postural taping decreases thoracic kyphosis but does not influence trunk muscle electromyographic activity or balance in women with osteoporosis. *Man Ther* 2008; 13: 249-257.
14. Haher TR, Bergman M, O'Brrien M. The effect of the three columns of the spine on the instantaneous axis of rotation in flexion and extension. *Spine* 1991; 16: 312-318.
15. Hefti F, Jani L. The treatment of Scheuermann's kyphosis with the Milwaukee brace. *Z Orthop Ihre Grenzgeb* 1981; 119 (2): 185–192.
16. Hosman AJ, Kleuver M, Anderson PG, Limbeek JV, Langeloo DD, Veth RP, Slot GH. Scheuermann kyphosis: the importance of tight hamstrings in the surgical correction. *Spine* 2003; (28)19: 2252–2259.
17. Korovesis PG, Stamatakis MV, Baikousis AG. Reciprokal angulation of verteberal bodies in the sagittal plane in an asymptomatic Greek population. *Spine* 1998; 23(6): 700-705.
18. Lewis JS, Wright C, Green A. Subacromial impingement syndrome: the effect of changing posture on shoulder range of movement. *J Orthop Sports Phys Ther* 2005; 35: 72-87.
19. Milet A, Pannier S, Vialle R, Glorion C. Kyphosis and kyphotic posture in children and adolescents. *Rev Prat* 1996; 56(2): 157-164.
20. Panjabi MM, White AA. Basic biomechanics of the spine. *Neurosurgery* 1980; 7(1): 76-93.
21. Sastre S, Lapuente JP, Barrios JP. Benefits of F.E.D. Treatment in Scheuermann's Disease. *Stud Health Technol Inform* 2002; 88: 270-278.
22. Seidi F, Rajabi R, Ebrahimi I, Alizadeh MH, Minoonejad H. The efficiency of corrective exercise interventions on thoracic hyper-kyphosis angle. *J Back Musculoskelet Rehabil* 2014; 27(1): 7-16.
23. Singer KP, Edmondston SJ, Day RE, Breidahl WH. Computer- assisted curvature assessment and Cobb angle determination of the thoracic kyphosis. An in vivo and in vitro comparison. *Spine* 1994; 19(12): 1381-1384.
24. Weiss HR, Turnbull D, Bohr S. Brace treatment for patients with Scheuermann's disease - a review of the literature and first experiences with a new brace design. *Scoliosis* 2009; 4: 22.
25. Wenger DR, Frick SL. Scheuermann kyphosis. *Spine* 1999; 24: 2630-2639.
26. White AA, Panjabi MM, Thomas CL. The clinical biomechanics of kyphotic deformities. *Clin Orthop Relat Res* 1977; 128: 8-17.
27. Yoon TL, Cynn HS, Choi SA, Lee JH, Chio BS. Effect of the craniocervical brace on craniocervical angle, thoracic kyphosis angle, and trunk extensor muscle activity during typing in subjects with forward head posture. *Work* 2016; 55(1): 163-169.

Volume: 30, Issue: 1, January 2019 pp: 33-40 ORIGINAL ARTICLE

TRANS-SACRAL EPIDUROSCOPIC LASER DECOMPRESSION FOR LUMBAR DISC HERNIATION

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ABSTRACT

Background Data: Back or leg pain is common in all lumbar disc herniation including the patients who had surgery or not. Trans-Sacral Epiduroscopic Laser Decompression, a new, minimally invasive therapeutic technique, may be useful in many patients with lumbar disc herniation. We investigated the clinical outcomes of this procedure for chronic low back pain and radicular pain in lumbar disc herniation with the comparison between the patients who had surgery and who did not.

Materials – Methods: Patients with lumbar disc herniation (n=144, median age 42,64±10,24 yr) were divided into two groups: a group without any operations and those who have had back surgery. Each patient, in whom relevant findings were present on MR images, was submitted to Trans-Sacral Epiduroscopic Laser Decompression. The patients with motor weakness, spinal stenosis and spondylolisthesis were excluded from the study. Outcomes of the patients were assessed with Visual Analogue Scale score and Oswestry Disability Index. The same procedure was performed in all patients under local anesthesia and sedation. We analyzed the clinical data, median age, symptom duration, radiological findings, and outcome scores. Statistical analysis was performed using appropriate statistical tests.

Results: Significant improvement in low back and lower limb pain was observed on the first day after the procedure. The outcome scores after 6 months and 2 years in both groups were significantly decreased as well.

Conclusion: From these findings, we suggest that Trans-Sacral Epiduroscopic Laser Decompression could be a safe and effective treatment modality for Lumbar Disc Diseases in selected cases.

Key Words: Trans-sacral; epiduroscopic; laser; disc decompression

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Interventional treatments in the spine field have become quiet important recently. For, conservative treatment may fail in many cases and surgery is often considered as the last option [8]. Epiduroscopic approach to disc herniation seems to be one of the most promising method of minimal invasive procedures for spinal pathologies.

We can define Epiduroscopy as a technique that permits direct endoscopic visualization of the epidural space. When compared with conventional surgical techniques, the advantages of Trans-Sacral Epiduroscopic Laser Decompression (SELD) include less invasiveness, reduced operating time, needlessness of general anesthesia, cooperation with the patient during the procedure and repeatability.

First epiduroscopic observations in autopsy cases were reported by Blomberg in 1985 [2]. Then the introduction of flexible endoscopes accelerated the progression of development in epiduroscopy [6,15].

In 1998, Choy had reported his results of percutaneous laser disc decompression [4]. A large series of patients with herniated disc disease was documented with success rate ranged from 75 % to 89 % with a complication rate of less than 1 %. However, to make an attempt directly to the disc from via epidural space seemed to be more difficult for many physicians.

Since then, epiduroscopic techniques have become more popular for treatment of radicular pain caused by especially adhesions or fibrosis in the epidural space. As instruments have become advanced, pain physicians began to apply the laser during the epiduroscopic procedure for the treatment of low back pain and/or radicular pain caused by herniated lumbar disc, adhesions or fibrosis in the epidural space [5,13].

The authors have performed this procedure after a long time experience of microdiscectomy and the other open surgical techniques. According to the data of epiduroscopic procedures of 144 cases, we suggest that trans-sacral epiduroscopic laser disc decompression appears to be a preferable treatment modality for low back pain or radicular pain.

MATERIALS AND METHODS

This study was conducted using retrospective findings from 144 patients who underwent Trans-Sacral Epiduroscopic Laser Decompression (SELD) procedure between October 2013 and May 2016 at a single institution. An informed consent, describing the details and probable complications of the procedure was obtained from all patients. The mean age of the patients was 42.64 ± 10.24 years and 54.9 % (n=79) of them were women while 45.1 % (n=65) were men. (Table-1).

They were divided into two groups: one is the group of patients without any operations (Group-A, n=96), and the other is the group of patients who have had back surgery (Group-B, n=48) (Table-2).

Each patient in whom relevant findings were present on MR images, was submitted to SELD after receiving medical and physical therapy for >2 weeks before the procedure. The patients with motor weakness, spinal stenosis and spondylolisthesis were excluded from the study. The level of lesions were mostly at L4-5 and L5-S1 with high percentages which were 57.6 % and 36.1 % respectively (Fig.-1).

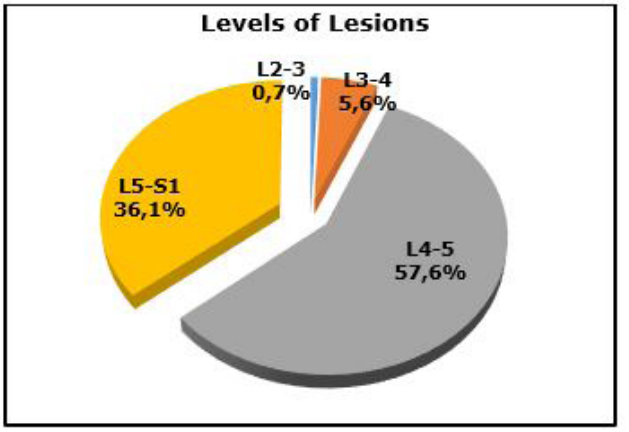

Figure-1. Distribution of lesions according to levels

Table-1. Demographic Characteristics of the Patients

		Min-Max	Mean±Sd
Age (years)		19 – 70	42,64±10,24
Duration of symptom before SELD (months)		0,17 – 48,0	7,17±7,16
		n	**%**
Sexuality	**Female**	79	54,9
	Male	65	45,1

Table-2. Demographic Characteristics according to Groups

		Group A (n=96)	Group B (n=48)	*p*
Age (years)	*Mean±Sd*	41,51±10,37	44,90±9,69	[a]***0,061***
	Min-Max (Median)	19-69 (40,0)	28-70 (44,0)	
		n (%)	**n (%)**	
Sexuality	**Female**	50 (52,1)	29 (60,4)	[b]***0,441***
	Male	46 (47,9)	19 (39,6)	

[a]*Student-t Test* [b]*Yates Continuity Correction Test*

The same procedure was performed in all patients under local anesthesia with mild sedation. Each patient was placed in prone position with spacer placed under the hips to decrease lumbosacral lordosis. After the identification of sacral hiatus with the aid of C-arm fluoroscope in a latero-lateral view, the sacrococcygeal ligament was punctured with a Tuohy needle. A guide wire, dilator and finally steerable video guided catheter were inserted into the sacrococcygeal ventral epidural space respectively. The position of the catheter in the ventral epidural space was verified in anterior/posterior and lateral views by fluoroscope. The first epidurogram was taken under A-P and L-L views administering radio-opaque dye in order to show filling defects and margins of herniation (Fig.-2.a).

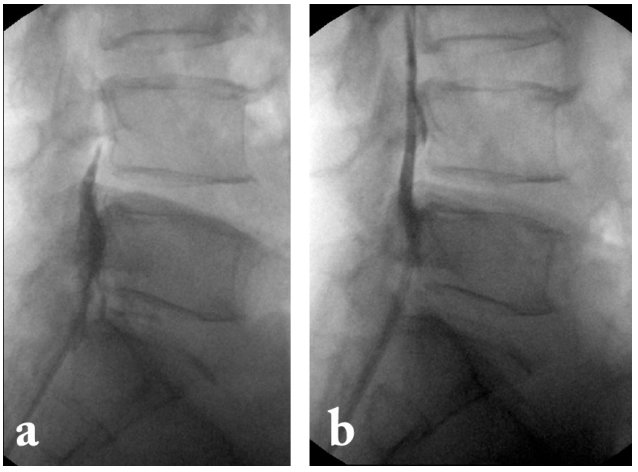

Figure-2. Fluoroscopic Images During Procedure **a.** The first epidurogram demonstrating the filling defects under L-L views administering radio-opaque dye **b.** Final epidurogram demonstrating flattened outline of herniation and decompression of the neural tissue

Direct visualization of the disc and neural tissue was provided by epiduroscope that was advanced into the end of the catheter and leveling of the epidural space was achieved by irrigation of physiological solution (Fig.-3.a). By using fiber optic scope, herniated disc was identified in patients of Group A (Fig.-3.b). Adhesions and mass effect of fibrotic tissue was also localized in group-B likewise. Adhesiolysis, degradation of granulation tissue and the shrinkage of herniated disc were rendered by the use of Ho:YAG laser. To prevent the complications of increased pressure, the total volume of irrigation water was restricted less than 200 cc. At the end of the operation, decompression of nerve root was observed by epiduroscope (Fig.-3.c) and a final epidurogram was performed using the same amount of contrast medium in order to demonstrate flattened outline of herniation and decompression of the neural tissue (Fig.- 2.b). We did "not" use corticosteroids and analgesic drugs except for very few patients who had severe leg pain and impatience during the procedure.

Pain scores were measured by the visual analog scale (VAS) for low back pain. Disability was evaluated by the Oswestry Disability Index (ODI). Efficacy was prospectively evaluated by an independent neurosurgeon at follow-up interviews on the first day and 6 months and 2 years after the operation. We analyzed the clinical data, median age, symptom duration, radiological findings, VAS and ODI scores. Statistical analysis was performed with NCSS (Number Cruncher Statistical System) 2007 Statistical Software (NCSS LLC, Kaysville, Utah, USA). Data were evaluated with definitive statistical methods.

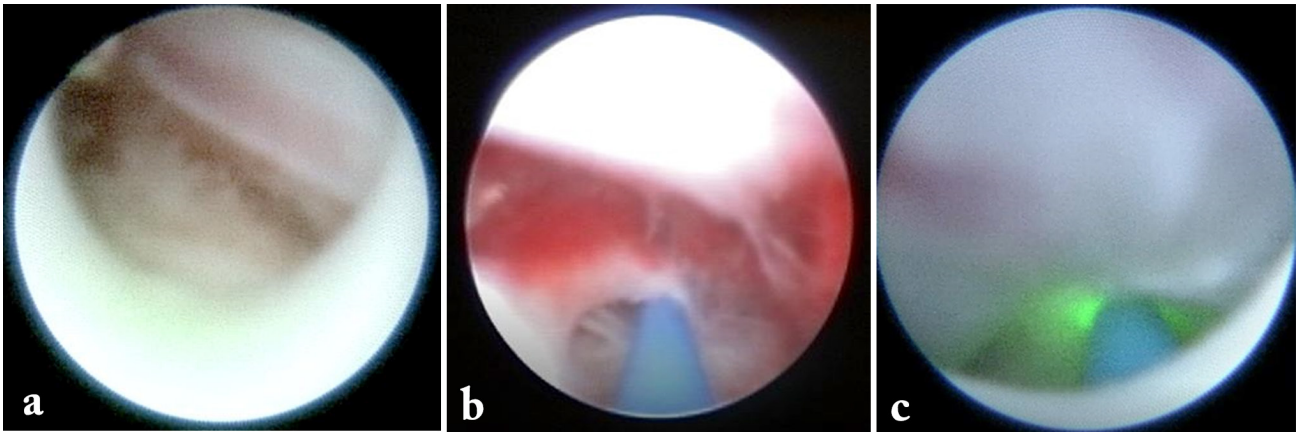

Figure-3. Epiduroscopic View **a:** Identification of herniated disc by epiduroscope **b:** Shrinkage of herniated disc by the use of Ho:YAG **c:** Decompressed root after the procedure

Student t test was used in comparison of variants of normal distribution between the groups. Variants, which do not show normal distribution, were analyzed with Mann Whitney U test in comparing the groups while Wilcoxon Signed Ranks test was used to evaluate the variants of same group. Yates Continuity Correction and Fisher Freeman Halton test were used in comparison of qualitative data. P value <0.05 was considered statistically significant.

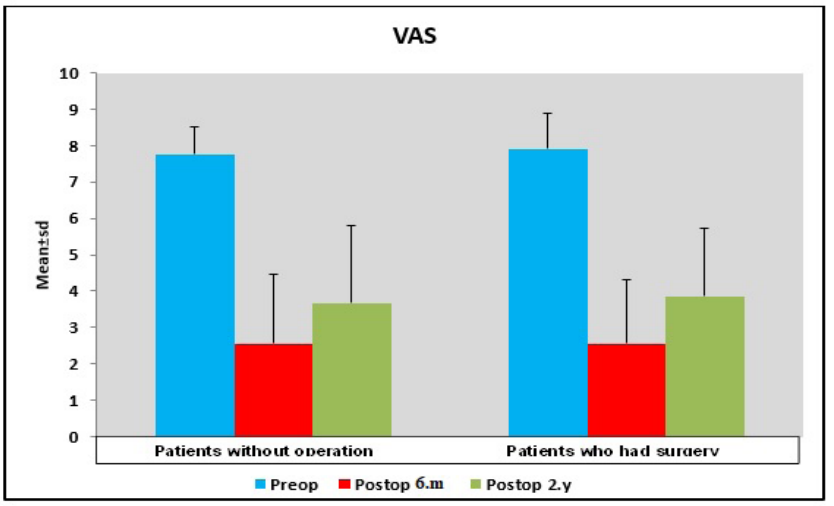

Figure-4. VAS Scores of patients in Group A and Group B

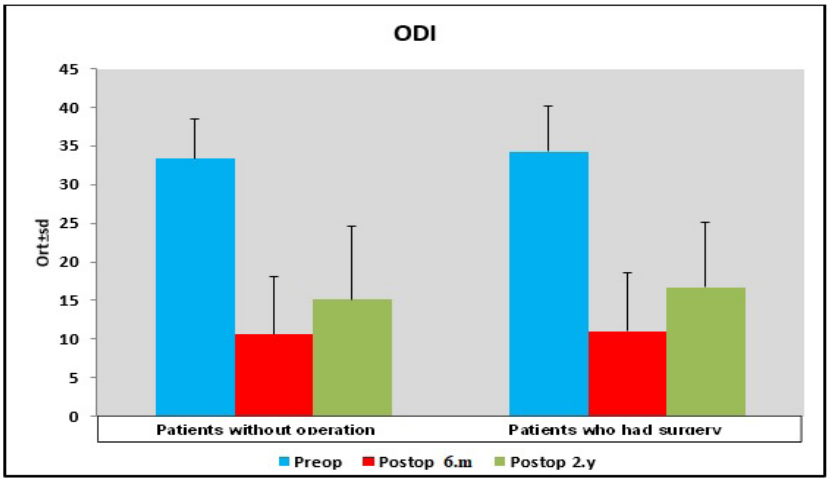

Figure-5. ODI Scores of patients in Group A and Group B

RESULTS

Patients were kept in bed for at least 4 hours after the intervention. For a postoperative observation period of 24 hours, all patients were admitted to the hospital. Significant improvement in low back and lower limb pain was observed on the first day after the procedure and all patients were discharged on the 1st day postoperatively.

Considering both groups, preoperative VAS scores ranged from 6 to 10 while postoperative VAS scores ranged from 0 to 9 on 6th month and 1 to 9 on 2nd year. During follow up, on 6th month after the procedure, there were significant decreases in both groups with regard to the VAS scores. The mean VAS score for Group A decreased to 2.55 ± 1.89 from 7.76 ± 0.76 (p<0.01), and for Group B, it has decreased from 7.92 ± 0.96 to 2.56 ± 1.75 (p<0.01) On the 2nd year, the mean VAS score was detected as 3.67 ± 2.13 for Group-A and 3.85 ± 1.86 for Group-B. The decreases after 2 years were also evaluated as significant (p<0.01) (Table-3, Fig.-4).

Median decrease in VAS scores for Group A and Group B were 5.21 ± 1.96 and 5.35 ± 1.77 on 6th month and 4.09 ± 1.68 and 4.07 ± 1.55 on 2nd year respectively and these data revealed statistical significance (p=0,001; p<0,01). VAS scores were not statistically different when compared between Group-A and Group-B (p>0,05).

Decreases in the average ODI scores were detected for both groups as well; from 33.33 ± 5.13 to 10.56 ± 7.47 on 6th month and 15.08 ± 9.51 on 2nd year in Group-A and from 34.23 ± 5.99 to 11.02 ± 7.65 on 6th month and 16.71 ± 8.39 on 2nd year in Group B. Mean decrease in ODI scores for Group A and Group B were 22.77 ± 8.69 and 23.21 ± 9.53 on 6th month and 18.25 ± 10.71 and 17.52 ± 9.53 on 2nd year respectively. The difference between the preoperative and postoperative ODI scores were also statistically significant on 6th month and 2nd year after the procedure (p=0,001; p<0,01). There was no statistical difference in ODI scores between two groups (p>0,05) (Table-4, Fig.-5).

Between two groups, there were also no statistical differences in composition of sex, age, mean duration of illness and levels of lesions (p>0,05).

Decompression of nerve root and decrease in mass effect of herniated disc were demonstrated with postoperative MRI (Fig.-6 and 7).

Eleven of the patients showed deterioration of motor or sensory deficits requiring surgery during the follow-up period. One patient presented urinary incontinence temporarily that recovered totally within 3 months. Three of them had headache and neck pain after the operation. We experienced dural puncture in 3 patients during procedure. It was relatively easy to introduce the epiduroscope via sacral hiatus in all patients except for 4 of them.

Table-3. Evaluation of VAS Scores according to Groups

VAS		Group A (n=96)	Group B (n=48)	[c]p
Preop	*Mean±sd*	7.76±0.76	7.92±0.96	**0.419**
	Median (min, max)	8 (6, 10)	8 (6, 10)	
Postop 6.m	*Mean±sd*	2.55±1.89	2.56±1.75	**0.758**
	Median (min, max)	2 (0, 8)	2.5 (0, 9)	
Postop 2.y	*Mean±sd*	3.67±2.13	3.85±1.86	**0.355**
	Median (min, max)	3 (1, 9)	4 (1, 9)	
	[e]p	**<0.001****	**<0.001****	
Preop-Postop 6.m	**Difference**	-6 (-9, 1)	-6 (-9, 2)	**0.694**
	[f]p	**<0.001****	**<0.001****	
Preop-Postop 2.y	**Difference**	-5 (-8, 2)	-4 (-9, 2)	**0.655**
	[f]p	**<0.001****	**<0.001****	
Postop 6.m-Postop 2.y	**Difference**	1 (-1, 4)	1 (-2, 3)	**0.107**
	[f]p	**<0.001****	**<0.001****	

[c]Mann-Whitney U Test *[e]Friedman test* *[f]Wilcoxon signed-ranks test* ***p<0.01*

Table-4. Evaluation of ODI Scores according to Groups

ODI		Group A (n=96)	Group B (n=48)	[c]p
Preop	*Mean±sd*	33.33±5.13	34.23±5.99	**0.468**
	Median (min, max)	34 (20, 46)	34 (24, 49)	
Postop 6.m	*Mean±sd*	10.56±7.47	11.02±7.65	**0.575**
	Median (min, max)	8 (0, 36)	10 (0, 40)	
Postop 2.y	*Mean±sd*	15.08±9.51	16.71±8.39	**0.146**
	Median (min, max)	11 (4, 42)	16 (4, 42)	
	[e]p	**<0.001****	**<0.001****	
Preop-Postop 6.m	**Difference**	-24 (-42, 3)	-24.5 (-38, 16)	**0.606**
	[f]p	**<0.001****	**<0.001****	
Preop-Postop 2.y	**Difference**	-21 (-38, 15)	-20 (-45, 18)	**0.368**
	[f]p	**<0.001****	**<0.001****	
Postop 6.m-Postop 2.y	**Difference**	4 (-7, 17)	6 (-8, 18)	**0.013***
	[f]p	**<0.001****	**<0.001****	

[c]Mann-Whitney U Test *[e]Friedman test* *[f]Wilcoxon signed-ranks test*
**p<0.05* ***p<0.01*

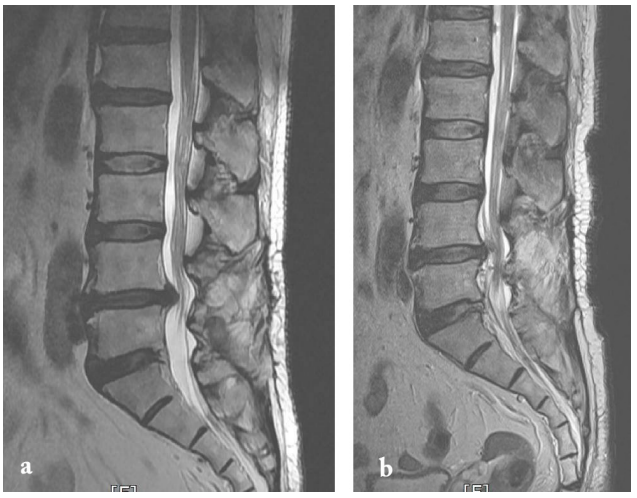

Figure-6. a, b. Sagittal MRI demonstrating the herniation before and after the procedure respectively

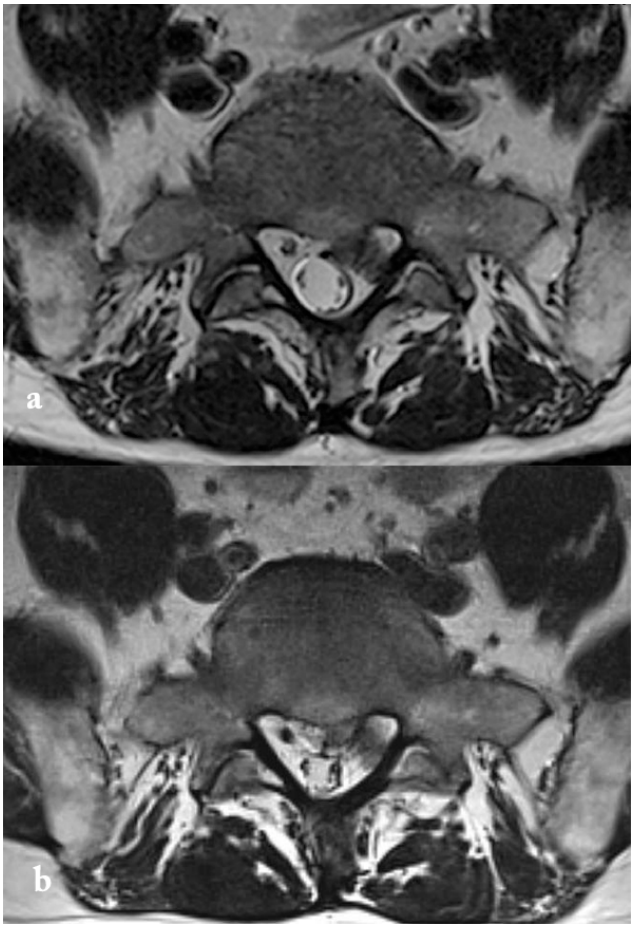

Figure-7.a, b. Axial MRI demonstrating the herniation before and after the procedure respectively

DISCUSSION

In recent years, several minimal invasive procedures have been developed and reported with varying success [7]. With each passing day, new instruments and techniques provide more alternatives for conservative procedures.

Spine surgery presents as a complicated system overlaps with anatomy, physiology, statics, mechanics etc. Many disciplines work together in an area. When we deal with the spine, it is important to imagine new relationships between anatomical structures.

Anatomy does not examine only the tissues just lined up in order to make up different layers; it studies on what they do with each other and which combinations they form. Trans-Sacral Epiduroscopic Laser Decompression originates from different ways of thinking anatomy and mechanics of the spine. It offers a totally different way to cure lumbar disc herniation. Its main goal is to use anatomy for searching "natural pathways" to reach the disease.

Sacral hiatus provides an extraordinary way to reach disc pathologies through epidural space allowing longitudinal approach [12]. Since discal pathologies typically occur within epidural space, epiduroscopy seems to be a preferable approach in this manner.

Several studies have demonstrated the results of epiduroscopic disc decompression in recent years. There are two important clinical series of epiduroscopic procedure using laser. One of them is a report of 154 cases reviewed at 8 participating centers [11]. The other one is a recent prospective case series study that reviews the clinical outcomes of 250 patients [10]. Both of these reports have revealed the technical details of epiduroscopic laser decompression for herniated discs. Generally, we have followed the same methodology in our cases. We have observed significant improvement in low back pain and lower limb pain in our patients with regard to the VAS and ODI scores after the procedure.

Previously, epiduroscopic procedures have been considered to be indicated generally for peridural fibrosis following spinal procedures and not a primary alternative for disc herniation [16]. As time passed by and experience enlarged, epiduroscopic laser disc decompression have become a relatively popular method for most cases. It was reported that epiduroscopic laser neural decompression provided satisfaction (more than 85 %) for patients with chronic low back pain and/or leg pain regardless of previous back surgery history [8]. In our study, there were no statistically significant differences between two groups as well.

However, it is obvious that this method has some limitations. It is not possible to remove herniated disc totally, as we do

via microdiscectomy. Postoperative MRI usually reveals residual disc herniation (Figure-7.d). Despite the favorable statistical results, during the follow-up period, we had to do microdiscectomy for 11 patients who showed deterioration of motor or sensory deficits. It is well known that patients may require surgery again even after open procedures. Nevertheless, 11 patients of 144 seems to be significantly higher when compared with microdiscectomy. We hope that there will always be such cases and some other advancing instruments in near future could resolve the problem of residual or recurrent disc herniation.

Lee et al. have reported that have removed sequestrated herniated nucleus pulposus using 1 mm forceps [10]. It seems to be a novel method which could be a part of SELD application after particular experience.

Avellanal et al. have systematically reviewed the complications and side effects of epiduroscopy [1]. They have reported that dural puncture and overpressure due to fluid injection were the main causes of complications. Complications related to epiduroscopy were usually minor and mostly transient neurological symptoms like headache, neck pain, dizziness, etc. Also some rare complications such as iatrojenic intradural lumbosacral cyst were reported following epiduroscopy [14].

In our cases, we have performed epiduroscopy under light sedation to detect these symptoms immediately. However, we had patients with headache and dural puncture who had uneventful recovery with conventional analgesics. Moreover, one patient had urinary incontinence because of neurogenic bladder and he recovered within 3 months. We have experienced that anatomical orientation through epiduroscope and confirmation of the tissues is not always easy. One of the main goals of SELD is the combination of epiduroscopy and fluoroscopy. The images provided by these two techniques lead to a much more comprehensive evaluation of spinal pathologies. However, it was suggested that there could be marked discrepancies between imaging and intraoperative findings of epiduroscopy [13]. Magnetic resonance imaging of this patient with urinary incontinence revealed no newly developed lesions, such as residual/aggravated disc herniation, hematoma or infection. After investigating all factors, based on the results of the clinical evaluation, we have concluded that the patient had probably micro injury in the sacral nerve roots during laser firing. In a report of cadaver study, it was suggested that laser usage during epiduroscopy might increase the potential for unwanted complications because of the ablative effect on nerve tissue even at the lowest laser power [9]. Another possibility for this patient was thought to be the mechanical injury by steerable catheter in the epidural space [3].

CONCLUSIONS

No description of scientific method could possibly be broad enough to encompass all the approaches and methods used by spinal surgeons. There are no useful and exception-free methodological rules governing the progress of surgery. For SELD is a relatively new procedure, we consider that further studies revealing the results of long-term follow-up are needed. We conclude that for selected cases of lumbar disc herniation, SELD appears to be a preferable treatment modality for low back pain or radicular pain.

Conflict of Interest: No potential conflict of interest relevant to this article was reported.

Informed Consent: Informed consent was obtained from all individual participants included in this study.

REFERENCES

1. Avellanal M, Diaz-Reganon G, Orts A, Gonzalez-Montero L, Ares JDA. Epiduroscopy: Complications and Troubleshooting. *Tech Reg Anesth Pain Manag* 2014; 18: 35-39.
2. Blomberg R. A method for epiduroscopy and spinaloscopy. Presentation of preliminary results. *Acta Anaesthesiol Scand* 1985; 29: 113–116.
3. Chang MC. Sacral root injury during trans-sacral epiduroscopic laser decompression: A case report. Medicine (Baltimore) 2017; 96(42): e8326.
4. Choy DS. Percutaneous laser disc decompression (PLDD): twelve years' experience with 752 procedures in 518 patients. *J Clin Laser Med Surg* 1998; 16: 325-331.
5. Hayek SM, Helm S, Benyamin RM, Singh V, Bryce DA, Smith HS. Effectiveness of spinal endoscopic adhesiolysis in post lumbar surgery syndrome: a systematic review. *Pain Physician* 2009; 12: 419-435.
6. Heavner JF, Cholkhavatia S, Kizelshteyn G. Percutaneous evaluation of the epidural and subarachnoid space with the flexible fiberscope. *Reg Anesth* 1991; 15S1: 85.
7. Hussain NS, Perez-Cruet MJ. Complication management with minimally invasive spine procedures. *Neurosurg Focus* 2011; 31: E2.
8. Jo D, Kim ED, Oh HJ. The comparison of the result of epiduroscopic laser neural decompression between FBSS or not. *Korean J Pain* 2014; 27(1): 63-67.
9. Jo D, Lee DJ. The extent of tissue damage in the epidural space by ho /yag laser during epiduroscopic laser neural decompression. *Pain Physician* 2016; 19(1): E209-214.
10. Lee SH, Lee SH, Lim KT. Trans-sacral epiduroscopic laser decompression for symptomatic lumbar disc herniation: a preliminary case series. *Photomed Laser Surg* 2016; 34(3):121-129.
11. Richter EO, Abramova MV, Cantu F, DeAndres J, Lierz P, Manchiaro PL, Van Buyten JP, Kim JD, Jang JH, Jung GH, Kim JY, Jang S, Salgado H, Salgado P, Alo KM.. Anterior epiduroscopic neural decompression: Eight-center experience in 154 patients. *Eur J Pain Supp* 2011; 5: 401–407.

12. Richter EO, Abramova MV, Mussell J. Current trends in minimally invasive spinal surgery. *J Neurosurg Rev* 2011; 1(Suppl.-1): 1–13.
13. Ruetten S, Meyer O, Godolias G. Epiduroscopic diagnosis and treatment of epidural adhesions in chronic back pain syndrome of patients with previous surgical treatment: first results of 31 interventions. *Z Orthop Ihre Grenzgeb* 2002; 140: 171-175.
14. Ryu KS, Rathi NK, Kim G, Park CK. Iatrogenic intradural lumbosacral cyst following epiduroscopy. *J Korean Neurosurg Soc* 2012; 52(5): 491-494.
15. Schütze G, Kurtze H. Percutaneous investigation of the epidural space using a flexible endoscope: a contribution to epiduroscopy. *Reg Anesth* 1993; 18(1S): 24.
16. Shim KW, Park EK, Kim DS, Choi JU. Neuroendoscopy current and future perspectives. *J Korean Neurosurg Soc* 2017; 60(3): 322-326.

Volume: 30, Issue: 1, January 2019 pp: 41-45 ORIGINAL ARTICLE

THE EFFICACY OF TRANSFORAMINAL EPIDURAL STEROID INJECTION (TFESI) IN SINGLE LEVEL LUMBAR DISC HERNIATION

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ABSRACT

Purpose: Aim of our study is to evaluate the effectiveness of transforaminal epidural steroid injection (TFESI) in patients who have radicular leg pain due to single level lumbar disc herniation and whose complaints did not regress with conservative treatment methods and do not require surgery.

Materials and Methods: 378 patients who were applied TFESI for radicular leg pain between March 2017 and May 2018 were analyzed retrospectively.

Results: The beginning VAS scores of patients were 8.35 ± 0,75. The VAS score regressed to 4.02±1.77, and 3.89±1,85 in third week and third month respectively after injection. ODI scores of patients regressed from the beginning value of 51.60 ± 6.14 to 28.22 ± 14.57 third week value after injection.

Conclusion: TFESI shows effective outcomes in pain reduction and functional improvement in patients with radiculopathy which is caused by lumbar disc herniation at short and middle-term follow-up period.

Keywords: Low back pain, radicular leg pain, transforaminal epidural steroid injection, epidural steroid injection

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Low back and radicular leg pain due to lumbar disc herniation are serious health problems can affect daily physical activities. Most of these patients respond to conservative methods like bed rest, anti-inflammatory drugs, muscle relaxants, physioterapy and corset. 5-8 % of the patients do not respond to these conservative methods [5,24].

Epidural steroid injection (ESI) is a minimal invasive treatment method for patients who did not get benefit from conservative treatments and do not require surgery [3]. Different methods can be applied for epidural steroid injection such as caudal, transforaminal or interlaminar. Transforaminal route is the most preferred one because of anatomical closeness to affected nerve root and need less medication dose [2]. Transforaminal epidural steroid injection (TFESI) is an effective treatment method that enables delivering medications to anterior epidural space via a spinal needle with guideless of fluoroscopy [6,13-14,16,21,23].

In this study, we aimed to evaluate the effectiveness of TFESI in patients who have radicular leg pain due to single level lumbar disc herniation and whose complaints did not regress with conservative treatment methods and do not require surgery.

Materials&Methods

378 patients who were applied TFESI for radicular leg pain between March 2017 and May 2018 at our clinic were analyzed retrospectively. The age of the patients was between 21 and 85. Written informed constents of all patients were taken before the procedure.

Patient Inclusion Criterias

Patients who have radicular leg pain at least one month and pain does not relieve

with conservative methods like medical and physical therapy, have single level disc herniation as bulging or protrusion at lumbar MRI scan and do not have neurological deficit are included to study.

Patients who have multiple level and extrude or sequester disk herniation's at lumber MRI scan, have neurological deficit in examination and need surgical intervention, have contraindicated situations like pregnancy, sepsis, coagulopathy, anticoagulant and antitrombositic drug use, have infection at needle entrance area, have lumbar disc surgery story and allergy story to drugs we use during treatment, have received this injection treatment before were not included to study.

TFESI Procedure

After venous cannulation, patients were taken prone position on operation table. After monetarization of blood pressure, pulse oximeter and ECG, lumbar procedure entrance area is covered following sterility rules after cleaning with iodine based antiseptic solution. After vertebra level determination with anterior-posterior (A-P) positioned C-armed fluoroscopy (GE Brivo OEC 785, Beijing, China), the fluoroscope was brought into an approximate 15-20 degree oblique position to obtain an image of intervertebral foramina at the level. At the same time care was taken to vertebral end plates are seen like one line. Then local anesthesia (1 mg, %1 lidocaine) was applied to entrance skin and subcutaneous region. TFESI was performed by using preganglionic approach which was described by Lee et al. [13-14].

After passing skin and subcutaneous tissues, quince 22 G 90 mm spinal needle (Egemen International, İzmir, Turkey) was guided into the intervertebral foramen. Fluoroscope was positioned laterally to confirm needle is in foramen. When sufficient depth had been reached and it was decided that the point of needle was in suitable position at the foramen fluoroscope was positioned A-P and 0,5 cc contrast solution (Omnipaque 300; iohexol, 300mg iodine/ml, Amsterdam Health, Princeton, NJ, USA) was injected to check typical anterior epidural spread (Figure 1).

When the contrast distribution to anterior epidural space was suspicious, needle was positioned again because of the possibility of intravascular injection. Procedure was stopped when contrast distribution was not appropriate again at the second injection. Mix solution of 40 mg (1 ml) methylprednisolone acetate (Depo-Medrol, Pfizer Ilac Ltd Sti, Luleburgaz, Kırklareli, Turkey) and 10 mg (2 ml) bupivacaine hydrochloride (Marcaine %0.5, Astra Zeneca, Istanbul, Turkey) were given slowly in 1-2 minutes to appropriate contests distributed patients. Patients were monitored 1-2 hours in the recovery room for the early signs of complications. Then the patients were discharged from hospital with control suggestions.

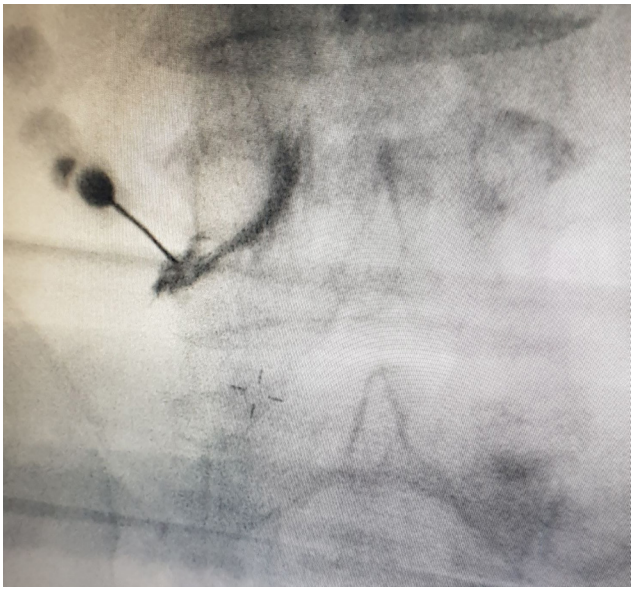

Figure-1. Contrast distrubition at anterior epidural space for showing nerve root trace.

Assessment protocol

Visual analog scale (VAS) of patients were assessed for pain score. VAS is a 100 mm straight horizontal line. The ends are defined as the extreme limits with 0 representing no pain and 10 representing the worst pain imaginable. Restriction changes of patients in daily routine activities were assessed with Oswestry Disability Index (ODI).

In this study we investigated the effectiveness of TFESI in single level lumbar disc herniation's with radicular leg pain by comparing VAS and ODI scores between pre-injection (VAS-0) (ODI-0), third week (VAS-3w) (ODI-3w), third month (VAS-3m) (ODI-3m) and sixth month (VAS-6m) (ODI-6m) after injection.

Statistical Analysis

Descriptive statistics were used for continuous variables (mean, standard deviation, minimum, maximum, median). The paired t-test was used to compare the pre-injection and post-injection results of average pain. A probability (p) value of <0.05 was considered statistically significant. All statistical analyses were performed using the IBM, SPSS Statistics version 22 (IBM corp. 2013).

RESULTS

378 patients were involved to our study in 14 months. 13 patients required surgery because of neurogical deterioration

during the follow-up period. 3 patients were removed from the study due to suspicion of intravascular injury by needle malposition and 25 patients did not come to control. Demographic datas and beginning VAS and ODI scores did not show statistically significant difference between study group and the patients who were removed from study. A total of 337 patients were included in the study. 138 (% 40.9) of the patients were male, 199 (% 59.1) of the patients were female and the mean age was 46,28 ± 11,67 years. Lumbar disc herniation was detected at L4-5 level most frequently (Table-1). There was no significant difference in VAS/ODI scores according to the level of lumbar disc herniation.

Table-1. Demographics and clinical data of study population (n=337)

		Male (n=138, 40.9 %)	Female (n=199, 59.1 %)
Age		45.33 ± 11.5	47.11 ± 11.7
Level	**L3-L4**	6 (4.34 %)	6 (3.01 %)
	L4-L5	77 (55.79 %)	139 (69.84 %)
	L5-S1	55 (39.85 %)	54 (27.13 %)

Evaluation after TFESI

VAS and ODI scores at the beginning and 3 week, 3 months, 6 months after injection were assessed. These VAS and ODI scores are shown at **Table-2**. We found that the beginning VAS scores of patients were 8.35±0,75. The VAS score regressed to 4.02±1.77, and 3.89±1,85 in third week and third month respectively after injection. This regression in VAS score was found to be statistically significant (p=0.001).

At the same time, it was shown that ODI scores of patients regressed from the beginning value of 51,60±6,14 to 28,22±14,57 third week value after injection. This regression between this time period was statistically significant (p=0.001). In contrast to the third month VAS score, the third month ODI score was found to be minimally increased when compared to the third week results (Table-2). But this ODI changes between 3 week and 3 month wasn`t found to be statistically significant (p=0.073).

DISCUSSION

In our study, the regression of third week and third month VAS and ODI scores were found statistically significant than pre-injection scores. Sixth month VAS and ODI scores were seen close to pre-injection scores. These results showed that, TFESI is an effective treatment at short and middle term but the efficacy of TFESI is decreasing at long term.

Generally, it is considered that radicular leg pain is related with direct nerve root pressure by herniated intervertebral disc in lumbar disc herniations [22,25]. Although mechanical press to nerve root leads to local axonal injury and ischemia, disc damage related inflammatuar mediator releases are important impacts which were shown in many studies [10]. Degenerated disc especially nucleus pulposus is biologically active tissue and can trigger inflammatory process [11]. After inflammatory mechanisms are shown to be play an important role in the radicular leg pain pathophysiology in lumbar disc herniations as well as mechanical nerve root press, the reason of ESI is explained [1]. Because of being minimal invasive rather than surgery, epidural steroid injections are used in treatment of appropriate patients who don't answer conservative methods [4,16,18,20].

Although TFESI is a minimal invasive treatment, it is not totally safe because of side effects and complications. Major complications are death, paraplegia, discitis, nerve injury, spinal cord infarct, dural sac injury and intrathecal or vascular injection [4,7,9,15]. In addition, minor complications are increasing headache, dizziness, nausea and vomiting [8,17]. In our study we did not see any major complications but dizziness, nausea and vasovagal reaction were detected in 18 patients in our study.

Table-2. Comparison of the results of TFESI between pre-post injection. VAS: visual analog scale, ODI: Ostwestry disability index

	Pre-Injection	**Post-Injection**			**p**
		3 weeks	**3 months**	**6 months**	
VAS	8.35(0.75)	4.02 (1.77)	3.89 (1.85)	7.2 (0.94)	0,001
ODI	51.3 (6.14)	29.09 (14.36)	30.69 (12.76)	48.65 (5.69)	0,001

The effectiveness of TFESI differs at some studies. Although there are some studies which show TFESI is effective more than 6 month [19, 23], some of the other studies show TFESI is effective in first 3 months and then rebound effect starts [12]. In our study, we observed this treatment is effective up to 3 months, but the effect of TFESI decreases in 3-6 months period by looking VAS and ODI scores. So there was similar rebound effect like some other studies.

Our study had some limitations. The study was not prospective and there was no control group. Only lumbar disc herniation patients were included to study. The other reasons of radicular leg pain like spinal stenosis, spondylolisthesis and multilevel disc herniation could be included study for more effective results. Further studies will be needed for these. But we consider we gave important information's about the effectiveness of TFESI in a wide patient population.

Conclusion

Our study found that; TFESI shows effective outcomes in pain reduction and functional improvement in patients with radiculopathy which is caused by lumbar disc herniation at short and middle-term follow-up period.

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REFERENCES

1. Al-Zain F, Lemcke J, Killeen T, Meier U, Eisenschenk A. Minimally invasive spinal surgery using nucleoplasty: a 1-year follow-up study. *Acta Neurochir (Wien)* 2008; 150(12): 1257-1262.
2. Atcheson SG, Dymeck T. Rapid resolution of chronic sciatica with intravenous infliximab after failed epidural steroid injections. *Spine* 2004; 29: E248–E250.
3. Benyamin RM, Manchikanti L, Parr AT, Diwan S, Singh V, Falco FJ, et al. The effectiveness of lumbar interlaminar epidural injections in managing chronic low back and lower extremity pain. *Pain Physician* 2012; 15(4): E363-404
4. Buenaventura RM, Datta S, Abdi S, Smith HS. Systematic review of therapeutic lumbar transforaminal epidural steroid injections. *Pain Physician* 2009; 12(1): 233-251.
5. Carey TS, Garrett JM, Jackman AM. Beyond the good prognosis. Examination of an inception cohort of patients with chronic low back pain. *Spine* 2000; 25(1): 115- 20.
6. Gajraj NM. Selective nerve root blocks for low back pain and radiculopathy. *Reg Anesth Pain Med* 2004; 29(3): 243-256.
7. Gharibo CG, Fakhry M, Diwan S, Kaye AD. Conus medullaris ınfarction after a right L4 transforaminal epidural steroid injection using dexamethasone. *Pain Physician* 2016; 19: E1211-1214.
8. Glaser SE, Shah RV. Root cause analysis of paraplegia following transforaminal epidural steroid injections: the 'unsafe' triangle. *Pain Physician* 2010; 13(3): 237-244.
9. Goodman BS, Posecion LW, Mallempati S, Bayazitoglu M. Complications and pitfalls of lumbar interlaminar and transforaminal epidural injections. *Curr Rev Musculoskelet Med* 2008; 1(3-4): 212-222.
10. Hamamoto H, Miyamoto H, Doita M, Takada T, Nishida K, Kurosaka M. Capability of nondegenerated and degenerated discs in producing inflammatory agents with or without macrophage interaction. *Spine* 2012; 37: 161-167.
11. Heyse-Moore GH. A rational approach to the use of epidural medication in the treatment of sciatic pain. *Acta Orthop Scand* 1978; 49: 366-370.
12. Karppinen J, Malmivaara A, Kurunlahti M, Kyllönen E, Pienimäki T, Nieminen P, Tervonen O, Vanharanta H. Periradicular infiltration for sciatica: a randomized controlled trial. *Spine* 2001; 26(9): 1059-1067.
13. Lee JW, Kim SH, Choi JY, Yeom JS, Kim KJ, Chung SK, Kim HJ, Kim C, Kwack KS, Kwon JW, Moon SG, Jun WS, Kang HS. Transforaminal epidural steroid injection for lumbosacral radiculopathy: preganglionic versus conventional approach. *Korean J Radiol* 2006; 7(2): 139-144.
14. Lee JW, Kim SH, Lee IS, Choi JA, Choi JY, Hong SH, Hong SH, Kang HS. Therapeutic effect and outcome predictors of sciatica treated using transforaminal epidural steroid injection. *AJR Am J Roentgenol* 2006; 187(6): 1427-1431.
15. Makkar JK, Singh PM, Jain D, Goudra B. Particulate vs non-particulate steroids for transforaminal epidural steroid ınjections: Systematic review and meta-analysis of the current literature. *Pain Physician* 2016; 19: 327-340.
16. Manchikanti L. Transforaminal lumbar epidural steroid injections. *Pain Physician* 2000; 3(4): 374-398.
17. Manchikanti L, Cash KA, Pampati V, Damron KS, McManus CD. Evaluation of lumbar transforaminal epidural injections with needle placement and contrast flow patterns: a prospective, descriptive report. *Pain Physician* 2004; 7(2): 217-223.
18. Manchikanti L, Datta S, Gupta S, Munglani R, Bryce DA, Ward SP, et al. A critical review of the American Pain Society clinical practice guidelines for interventional techniques: part 2. Therapeutic interventions. *Pain Physician* 2010; 13(4): E215-264.
19. Riew KD, Park JB, Cho YS, Gilula L, Patel A, Lenke LG, et al. Nerve root blocks in the treatment of lumbar radicular pain. A minimum five-year follow-up. *J Bone Joint Surg Am* 2006; 88(8): 1722-1725.
20. Rosenberg SK, Grabinsky A, Kooser C, Boswell MV. Effectiveness of transforaminal epidural steroid injections in low back pain: a one year experience. *Pain Physician* 2002; 5(3): 266-270.
21. Sitzman BT. Epidural injections. In: Fenton DS, Czervionke LF (Eds.). *Image-Guided Spine Intervention*. Saunders, Philadelphia 2003; pp: 99-126.
22. Spaccarelli KC. Lumbar and caudal epidural corticosteroid injections. *Mayo Clin Proc* 1996; 71: 169-178.

23. Vad VB, Bhat AL, Lutz GE, Cammisa F. Transforaminal epidural steroid injections in lumbosacral radiculopathy: a prospective randomized study. *Spine* 2002; 27(1): 11-16.

24. van Zundert J, van Kleef M. Low back pain: from algorithm to cost-effectiveness? *Pain Pract* 2005; 5(3): 179-189.

25. Wang JC, Lin E, Brodke DS, Youssef JA. Epidural injections for the treatment of symptomatic lumbar herniated discs. *J Spinal Disord Tech* 2002; 15: 269-72.

Volume: 30, Issue: 1, January 2019 pp: 47-53 ORIGINAL ARTICLE

TRANSFORAMINAL LUMBAR INTERBODY FUSION AS REVISION SURGERY FOR PATIENTS PREVIOUSLY TREATED BY DISCECTOMY OR INSTRUMENTATION OF THE LUMBAR SPINE

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ABSRACT

Purpose: Transforaminal lumbar interbody fusion (TLIF) is a surgical method that allows stable fusion of the anterior spinal column and restoration of disc height and lumbar lordosis. The aim of this study was to evaluate the clinical and radiological data of the patients who underwent lumbar discectomy, posterior instrumentation and laminectomy or TLIF surgery and who applied to our clinic with the complaint of discogenic back or leg pain and investigate the effectiveness of procedure.

Material and Methods: Between the years 2012-2016, patients who underwent TLIF procedure were analyzed retrospectively. Inclusion criteria; patients undergone surgery due to any disc pathology from the lumbar region, complaints that did not respond to a minimum of 6 weeks of conservative treatment, patients undergoing revision surgery with two levels or more TLIF procedure with posterior instrumentation and a follow-up period longer than 2 years. Radiological and clinical data of 13 patients who met these criteria were examined for the study.

Results: The study group consisted of 11 women and 2 men. The mean follow-up period was 39.3 months (range 26-58). The mean age was 62.2 (range 56-71). 7 patients had previously undergone lumbar discectomy, 4 patients had posterior instrumentation and laminectomy, 2 patients had posterior instrumentation and TLIF procedure. The dominant complaint was back pain in all patients. There were also complaints of varying rates of radicular pain and combinations of neurological deficit. Indications for revision surgery; lumbar degenerative disc disease, recurrent lumbar disc herniation, lumbar spinal canal stenosis, segmental instability and spondylolisthesis with two levels and higher. A total of 77, mean 5.9 (±1.4) pedicle screws were placed. A total of 32, average 2.4 (±0.5) levels of TLIF were applied. In 8 (61.5%) patients, pedicle screws was augmented with cement. The mean operative time was 378.8 min, and the mean amount of blood loss was 684.6 ml. The mean amount of autotransfusion and allogeneic blood transfusion was 569.2 ml. Mean duration of hospital stay was 4.6 days. One patient had dural tear during the operation. In one patient, the wound drainage that started in the postoperative 10. day was healed with wound debridement and antibiotic treatment. None of the patients had proximal or distal adjacent segment fracture, implant failure, nonunion or loss of correction during the follow-up. Complete neurological recovery was observed in all patients except the patient who was admitted with a 6-month history of foot drop.

Conclusions: TLIF is a safe and effective procedure for the treatment of spinal pathologies in revision surgery. Elimination of spinal stenosis and instability, decompression of nerve roots, restoration of intervertebral disc heights, restoring lumbar lordosis, neutralization of global spinal balance and pain relief are possible.

Key words: Interbody fusion, TLIF, low back pain, spinal stenosis, complications

Level of evidence: Retrospective clinical study, Level III.

INTRODUCTION

Transforaminal lumbar interbody fusion (TLIF) is a method that allows stable fusion of the anterior spinal column and restoration of disc height and lumbar lordosis. It has been successfully applied in the treatment of symptomatic spinal diseases, especially degenerative disc disease (DDD) and spondylolisthesis for approximately 30 years [(3)]. The need for interbody fusion arose from the importance of the anterior spine column instability. In each spine segment, 80 % of compression, torsion and distraction loads

are delivered through the anterior column. Therefore, in order to increase the quality and stability of segmental fusion, the anterior column must be included in the fusion [23].

The TLIF procedure is also used as a revision surgery in patients who have had lumbar discectomy or decompression for some reason and have new or remaining complaints after surgery [24]. Because, circumferential fusion is more prominent in patients with previous laminectomy for stability and bony fusion. The aim of this study was to evaluate the clinical and radiological data of the patients who underwent lumbar discectomy, posterior instrumentation and laminectomy or TLIF surgery and who applied to our clinic with the complaint of discogenic back and leg pain and investigate the effectiveness of procedure.

MATERIAL AND METHODS

Between the years 2012-2016, patients who underwent TLIF procedure were evaluated retrospectively. The inclusion criteria were: patients who had undergone surgery due to any disc pathology from the lumbar spine, patients who did not respond to a minimum of 6 weeks of conservative treatment, patients undergoing revision surgery with two levels or more TLIF procedure with posterior instrumentation and a follow-up period longer than 2 years. The content of conservative treatment was considered as the use of physical therapy, lifestyle activation and anti-inflammatory, analgesic and antidepressant drugs. Indications for revision surgery; lumbar degenerative disc disease, recurrent lumbar disc herniation, lumbar spinal canal stenosis, segmental instability and spondylolisthesis. Patients who underwent primary surgery, Patients who underwent primary surgery, surgery using interbody fusion techniques other than TLIF, TLIF for the reasons other than the indicated indications (trauma, tumor, etc.) and those who received single level TLIF were not included in the study. One of the 18 patients who met the inclusion criteria was lost in follow-up, and 4 patients were excluded from the study because the follow-up period was less than 2 years. Radiological and clinical data of the remaining 13 cases were examined for the study.

Lumbar anteroposterior (AP), lateral and dynamic lateral X-rays, magnetic resonance imaging (MRI) and computed tomography (CT) were performed routinely for preoperative radiological examination. Neurological examination and lower extremity EMG were performed for neurological status evaluation. The evaluation of segmental instability was made according to the criteria described by White and Panjabi on lateral dynamic radiographs [25]. Accordingly, > 3mm shift, > 3mm translation or > 10degree angulation was accepted as unstable.

All surgical procedures were performed by the senior author (MT). Six patients had different degrees of neurological deficits in preoperative physical examination. Preoperative dual energy x-ray absorptiometry (DXA) and bone density measurements (bone mineral density, BMD) were performed in all patients with osteoporosis on preoperative radiographs. Patients with a T-score of -2.5 and below in the anterior-posterior and lateral images were accepted as osteoporotic and pedicle screws were augmented with cement at all or selected levels. In all instrumented levels, bilateral pedicle screws (Legacy, Medtronic, Memphis, TN) were placed.

The TLIF approach was performed with a midline posterior open incision. The fascia was incised, the paravertebral muscles were dissected with the help of Cobb elevator and electrocautery. The appropriate level was determined by fluoroscopy. All implants were removed in patients who had previously undergone posterior instrumentation. Bilateral pedicle screws were placed at all levels. Laminectomy and bilateral facetectomies were completed. Total discectomy was performed. The disc distance was distracted and local autogenous bone graft and interbody cage were placed into the level. After hemostasis and irrigation wound was closed. A more detailed description of the technique has been made in many studies in the literature [12,14,26].

All patients were mobilized in the first postoperative day. Intermittent pneumatic compression cuffs were used for the first three days. AP and lateral radiographs were taken at 6 weeks, 6 months and 2 years after discharge. All radiographs were examined for loss of correction, nonunion, adjacent segment disease and screw loosening or fracture. The presence of 1 mm or more radiolucent area on the screw bone interface was considered screw loosening. The formation of trabecular bone bridges, lack of implant failure, and less than 3 degrees of segmental movement were considered as definitive fusion indications. [16]. All patients were evaluated with Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) at 6 weeks, 6 months and 2 years.

Statistical analysis was performed using IBM SPSS (IBM Corp., Armonk, NY) for Windows. The mean VAS score, ODI score and standard deviations were calculated using the Friedman test and the Wilcoxon Sign test and compared with each other. $P < 0.05$ was considered as statistically significant.

RESULTS

The study group consisted of 11 women and 2 men. The mean follow-up period was 39.3 months (range 26-58). The mean age was 62.2 years (range 56-71). 7 patients underwent lumbar discectomy, 4 patients underwent posterior instrumentation and laminectomy, 2 patients underwent

posterior instrumentation and TLIF procedure. The dominant complaint in all patients was low back pain. There were also complaints of varying rates of radicular pain, back pain, and combinations of neurological complaints. The mean time from revision surgery to primary surgery was 42.3 months (range 11-83). In addition to lumbar DDD, spinal stenosis was detected in 9 (69.2 %) patients, segmental instability in 5 (38.4 %) patients, recurrent disc herniation in 5 patients (38.4 %) and spondylolisthesis in 4 (30.7 %) patients. The demographic data of the patients are summarized in Table-1.

A total of 77, mean 5.9 (±1.4) levels posterior instrumentation were performed. A total of 32, an average of 2.4 (±0.5) levels TLIF procedure was applied (Table-2).

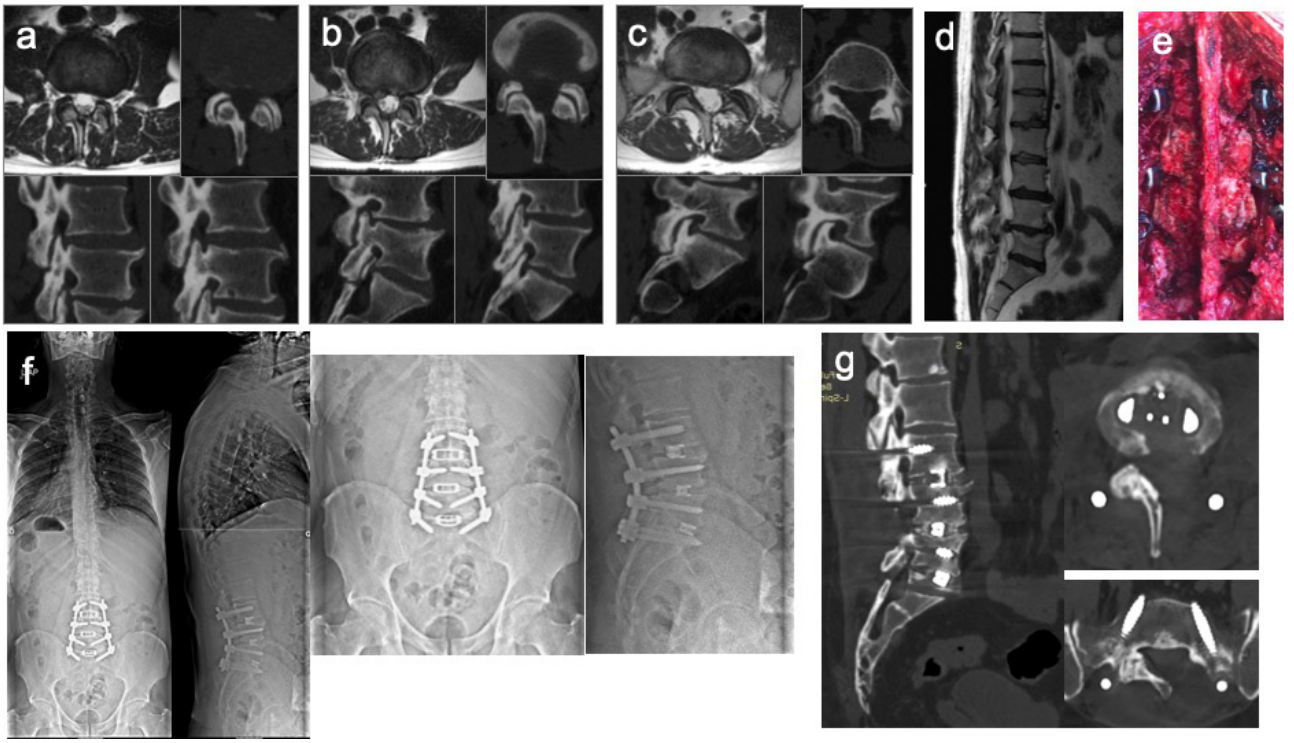

Figure-1. 48 years old male patient. Two years ago, a consecutive three-level laminectomy was performed at L3-L4 **(a)**, L4-L5 **(b)** and L5-S1 **(c)**. Sagittal MRI images shows the degenerative disc disease and herniations **(d)**. Facet joint hypertrophy in the laminectomy levels are seen in clinical view **(e)**. Follow-up AP **(f)** and Lateral **(g)** X rays of the patient. TLIF procedure was performed for three consecutive levels. The fused segments are seen on CT images in follow up **(g)**.

Table-1. Patients demographic data.

Gender F/M (%)	11 (%84), 2 (%16)
Mean age (years)	62.2 ± 4.7
Duration after previous sugery (months)	42.3 ± 18.8
Follow up (months)	39.3 ± 9.8
Pervious surgeries:	
Lumbar discectomy	7 (%53,8)
Posterior instrumentation and laminectomy	4 (%30,7)
Posterior instrumentation and TLIF	2 (%15,3)
Revision Diagnosis:	
Spinal stenosis	9 (%69,2)
Segmental instability	5 (%38,4)
Recurran disc hernia	5 (%38,4)
Spondilolisthesis	4 (%30,7)

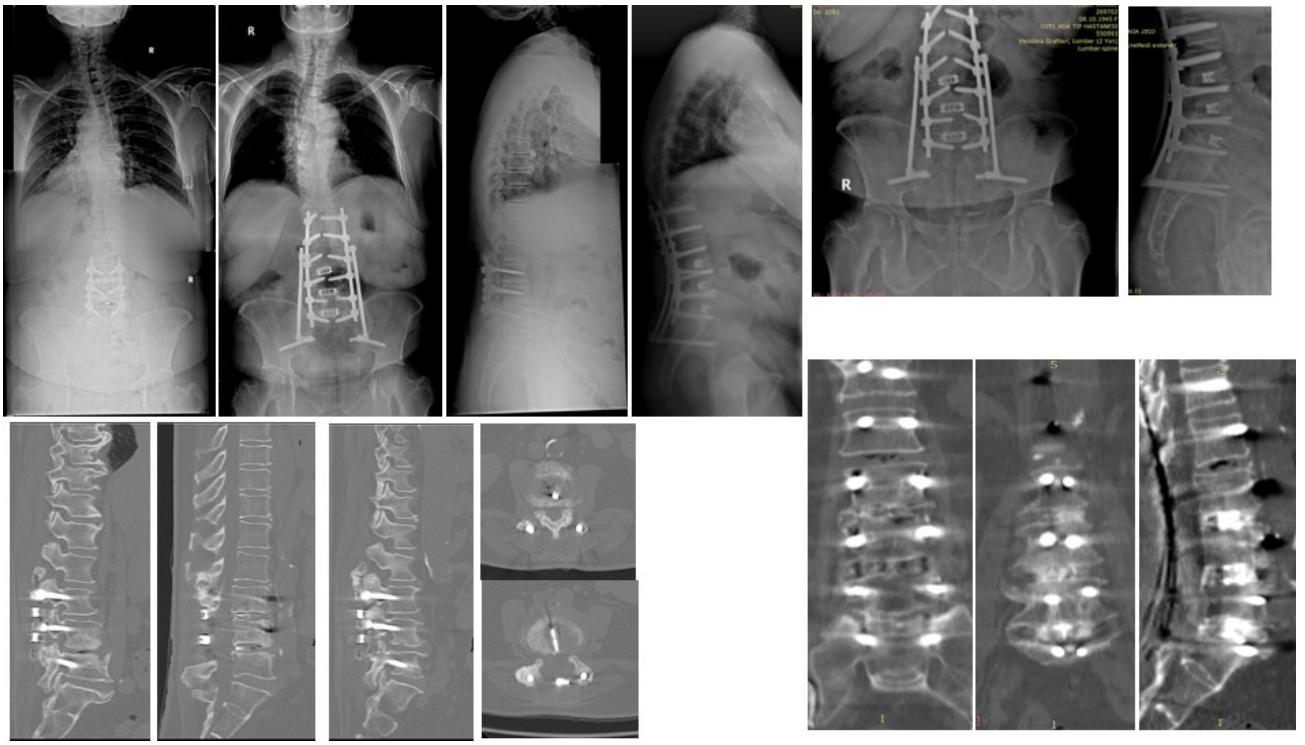

Figure-2. 68 years old female patient. She had a pervious TLIF surgery at L3-L4 and L4-L5 levels. Loss of lumbar lordosis and sagittal spinal balance are seen on preoperative X rays. TLIF procedure was performed at L3-L4, L4-L5 and L5-S1 levels. The fused segments are seen on CT images in follow up.

Table-2. Posterior instrumentation and TLIF levels.

Patient no	Posterior instrumentation	TLIF
1	L2-iliac	L4-L5, L5-S1
2	L3-S1	L3-L4, L4-L5, L5-S1
3	L2-L5	L3-L4, L4-L5
4	T10- iliac	L3-L4, L4-L5, L5-S1
5	L1-L5	L2-L3, L3-L4, L4-L5
6	L1-S1	L4-L5, L5-S1
7	L1- S1	L3-L4, L4-L5, L5-S1
8	L2- iliac	L4-L5, L5-S1
9	L1- iliac	L3-L4, L4-L5, L5-S1
10	L2-S1	L3-L4, L4-L5
11	L2- iliac	L3-L4, L4-L5, L5-S1
12	L1-S1	L4-L5, L5-S1
13	L2- iliac	L4-L5, L5-S1

In 8 (61.5 %) patients, screws were augmented with cement. The mean operative time was 378.8 min, and the mean amount of blood loss was 684.6 ml. The mean amount of autotransfusion and allogeneic blood transfusion was 569.2 ml. The mean duration of hospital stay was 4.6 days (Table-3).

The VAS score was 8.2 (7-10) preoperatively, and it was 2.6 (1-4) at the postoperative 6th week, 2.1 (0-4) at the end of the 6th month and 1.9 (0-4) at the last follow-up. ODI was 46 % (32-64 %) preoperatively, 24.8 % (0-38 %) at the end of the postoperative 6th week, 22.9% (0-34%) at the end of the 6th month, 23.2 % (0-36 %) at the last follow-up. There was a statistically significant decrease in preoperative and final follow-up VAS and ODI scores (P <0.0001) (Table-4).

Table-3. Patients clinical data.

Operating time (min)	373,8 ± 78
Intraoperative blood loss (ml)	684,6 ± 339,9
Amount of transfusion (ml)*	569,2 ± 256,2
Duration of hospital stay (day)	4.6 ± 1.1
Complications	
Dural tear	1 (%7,6)
Wound infection	1 (%7,6)

* Sum of autotransfusion and allogenic blood transfusion.

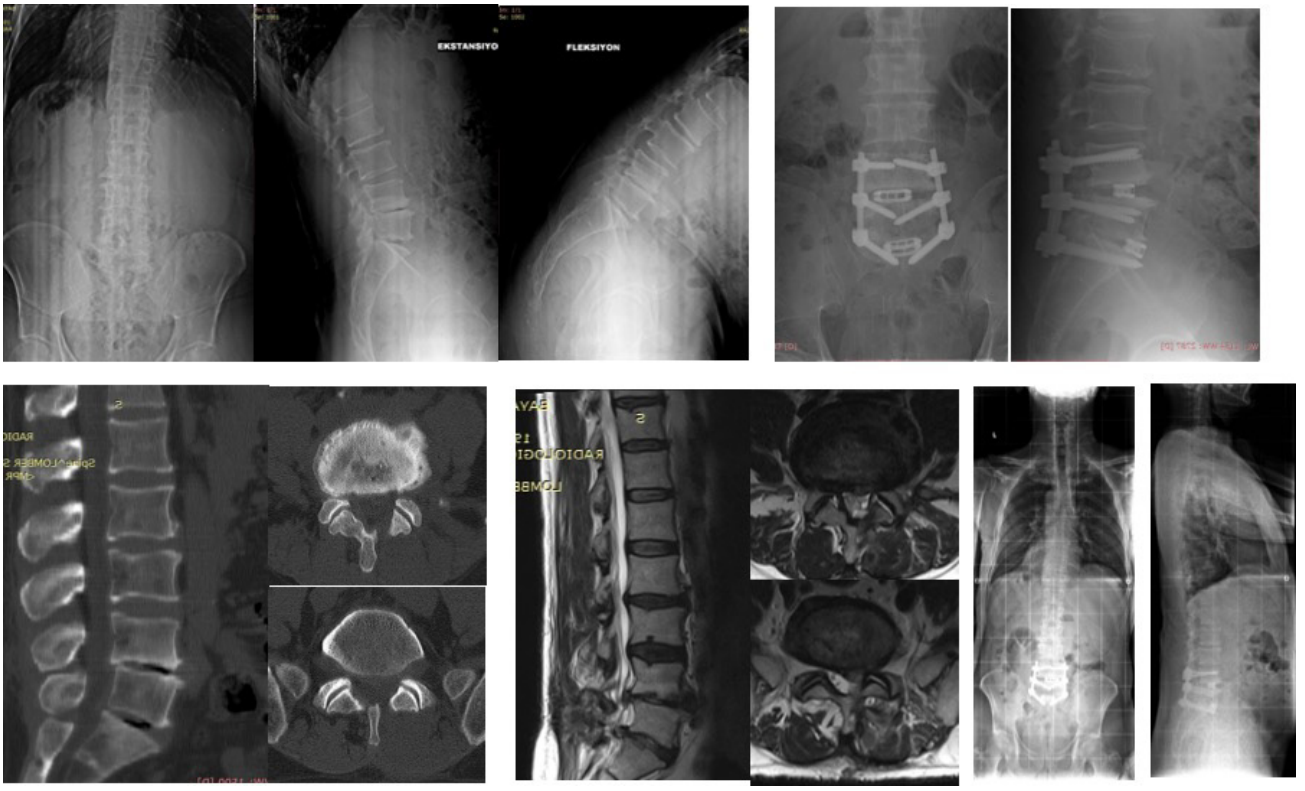

Figure-3. 59 years old male patient. He had a pervious lumbar discectomy surgery at L4-L5 and L5-S1 levels. MRI shows reherniations at same levels. TLIF procedure was performed at L4-L5 and L5-S1 levels.

Tablo-4. Preoperative and postoperative VAS ve ODI scores.

VAS	
Preoperative	8.2 (7-10)
Postoperative 6th week	2.6 (1-4)
Postoperatif 6 th month	2.1 (0-4)
Latest	1.9 (0-4)
ODI	
Preoperative	%46 (%32-64)
Postoperative 6th week	%24,8 (%0-38)
Postoperatif 6th month	%22,9 (%0-34)
Latest	%23,2 (%0-36)

Complete neurological recovery was observed in all patients except the patient who was admitted with a 6-month history of drop foot in the preoperative period. This patient was mobilized with an ankle foot orthosis.

One patient had dural tear during the operation. Fascia graft was used for primary repair with 5-0 nonabsorbable suture, fibrin glue was placed and closed. The patient was taken to bed rest for 3 days and no postoperative leakage or wound complications were observed. In one patient, a wound drainage occurred in the postoperative tenth day. Methicillin resistant S. aureus was detected in the culture. Wound debridement was performed and the infection was completely healed after 3 months of treatment with appropriate antibiotics. Radiographic examinations revealed solid bone fusion in all patients. Proximal or distal adjacent segment fracture, nonunion, implant failure or loss of correction were not observed.

DISCUSSION

In this study, we evaluated the clinical and radiological results of 13 patients who underwent surgical revision with two or more levels of TLIF procedure. In spinal revision surgery, circumferential fusion is the most precise method to achieve stability and bony fusion. For this reason, especially in revision surgeries, TLIF stands out as a salvage procedure. The aim of our study is to investigate the effectiveness of TLIF method in clinical and radiological terms.

With circumferential fusion, a more clinically stable bony fusion mass is obtained when compared with anterior or posterior fusion alone [19]. Today, many techniques are used to obtain interbody fusion. The most commonly used TLIF procedure was first described by Harms and Rolinger [8]. As an alternative to posterolateral fusion (PLF) and posterior lumbar interbody fusion (PLIF), it has begun to be used in increasing rates and has become widespread [1,9,20]. Compared with PLIF, TLIF procedure has many advantages; it provides a larger bone fusion area, a complete approach for medial and lateral decompression and restores the intervertebral height [2]. In addition, the complication rates are lower compared to PLIF procedure, because retraction of the dural sac and nerve roots is not necessary, does not form an epidural scar, and the amount of intraoperative blood loss is less [5,7,21].

Scheufler et al. analyzed the patients who had percutaneous TLIF procedure due to degenerative lumbar instability. They reported good results in single or multi-level applications [15]. Hsieh et al. compared the anterior lumbar fusion with the TLIF procedure, found that ALIF was better than for TLIF in providing foraminal height, restoration of local disc angle and lumbar lordosis, but at the end of two years there was no clinically significant difference between the two groups ($p < 0.05$) [10]. In a study by Starkweather et al. comparing posterior lumbar fusion with TLIF, it was found that pain was significantly decreased in TLIF patients at sixth week compared to the other group. In the same study, interleukin IL-6, which is an indicator of nerve regeneration and recovery in the TLIF group, was found to be high [18]. Ploumis et al. compared ALIF and TLIF and did not detect biomechanical differences between the two techniques [13]. Chen et al. have detected fusion in all patients in whom TLIF procedure was augmented for recurrent lumbar disc hernias [4].

With the technologic development of instrumentation techniques and medical devices, TLIF procedure has been applied with minimally invasive technique and in the literature, this technique has advantages such as less blood loss, less soft tissue damage, smaller wound incision and shorter hospital stay [3]. However, although similar fusion rates have been reported, the duration of the operation is longer with minimally invasive technique, higher radiation exposure occurs and a higher rate of neurological deficit is observed due to the learning curve [11,17,22]. Since the patients in this series have had previous surgeries with one or more lumbar levels, open surgical technique is preferred by the senior author in our clinic. In patients who are scheduled for revision surgery with two or more levels of TLIF whether they are discectomy-related hemilaminectomy, or instrumentation and total laminectomy, access to the discectomy site is more limited, and the risk of dura injury and iatrogenic neurological deficit is higher.

Revision surgery may be defined as secondary operations in patients who have previously been operated with one of the same level or levels as discectomy, hemilaminectomy, laminectomy, posterior instrumentation and fusion. All patients in our series had previous surgeries in another center consisted of lumbar discectomy, laminectomy, posterior instrumentation or TLIF. Lumbar degenerative disc disease and accompanying spinal stenosis, instability, adult scoliosis and spondylolisthesis were detected in radiological investigations due to discogenic and radicular symptoms. In all patients, interbody fusion with TLIF was performed in the lumbosacral zone, depending on the disc pathologies in the relevant segments of the patient, resulting in adequate bony fusion from both anterior and posterior column. It has been shown in the literature that pedicle screws with cement augmentation in osteoporotic spine increases attachment and stability in screw bone interface [6]. In this study, the screw augmentation of 8 patients were performed with cement. We think that the absence of adjacent segment fracture, implant failure, nonunion or loss of correction in our series is also related with pedicle screw augmentation with cement in osteoporotic patients. Complete neurological recovery was observed in all patients except the patient who was admitted with a 6-month history of drop foot. Neurological recovery rates indicates the effectivity of the procedure on the decompression of neural structures.

The most important limitation of this study is the lack of a control group and retrospective design. The second limitation is relatively few patients and the short follow-up period. Randomized prospective controlled trials with large series with longer follow-up are needed.

CONCLUSION

The results of this study indicates that TLIF is a safe and effective procedure for the treatment of spinal pathologies in revision surgery. Elimination of spinal stenosis and instability, decompression of nerve roots, restoration of intervertebral disc heights, restoring lumbar lordosis, neutralization of global spinal balance and relieving pain can be achieved. In addition providing circumferential fusion with avoiding anterior surgery is an important advantage.

Conflicts of interest: There are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

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REFERENCES

1. Blume HG. Unilateral posterior lumbar interbody fusion: simplified dowel technique. *Clin Orthop Relat Res* 1985; 193: 75–84.
2. Branch CL. The case for posterior lumbar interbody fusion. *Clin Neurosurg* 1996; 43: 252–267.
3. Brodano GB1, Martikos K, Lolli F, Gasbarrini A, Cioni A, Bandiera S, Silvestre MD, Boriani S, Greggi T. Transforaminal lumbar interbody fusion in degenerative disk disease and spondylolisthesis grade i: minimally invasive versus open surgery. *J Spinal Disord Tech* 2015; 28(10): E559-564.
4. Chen Z, Zhao J, Liu A, Yuan J, Li Z. Surgical treatment of recurrent lumbar disc herniation by transforaminal lumbar interbody fusion. *Int Orthop* 2009; 33(1): 197-201.
5. Di Paola CP, Molinari RW. Posterior lumbar interbody fusion. *J Am Acad Orthop Surg* 2008; 16: 130–139.
6. Erdem MN, Karaca S, Sarı S, Yumrukcal F, Tanli R, Aydogan M. Application of cement on strategic vertebrae in the treatment of the osteoporotic spine. *Spine J* 2017; 17(3): 328-337.
7. German JW, Foley KT. Minimal access surgical techniques in the management of the painful lumbar motion segment. *Spine* 2005; 30: S52–59.
8. Harms J, Rolinger H. A one-stager procedure in operative treatment of spondylolistheses: dorsal traction-reposition and anterior fusion (author's transl). *Z Orthop Ihre Grenzgeb* 1982; 120: 343–347.
9. Harms JG, Jeszenszky D. Die posteriore, lumbale, interkorporelle fusion in unilateraler transforaminaler technik. *Oper Orthop Traumatol* 1998; 10: 90–102.
10. Hsieh PC, Koski TR, O'Shaughnessy BA, Sugrue P, Salehi S, Ondra S, Liu JC. Anterior lumbar interbody fusion in comparison with transforaminal lumbar interbody fusion: Implications for the restoration of foraminal height, local disc angle, lumbar lordosis, and sagittal balance. *J Neurosurg Spine* 2007; 7: 379-386.
11. Park Y, Ha YW. Comparison of one-level posterior lumbar interbody fusion performed with a minimally invasive approach or a traditional open approach. *Spine* 2007; 32: 537–543.
12. Peng CW, Yue WM, Poh SY, Yeo W, Tan SB. Clinical and radiological outcomes of minimally invasive versus open transforaminal lumbar interbody fusion. *Spine* 2009; 34: 1385–1389.
13. Ploumis A, Wu C, Fischer G, Mehbod AA, Wu W, Faundez A, Mehbod AA, Wu W, Faundez A, Transfeldt EE. Biomechanical comparison of anterior lumbar interbody fusion and transforaminal lumbar interbody fusion. *J Spinal Disord Tech* 2008; 21: 120-125.
14. Potter BK, Freedman BA, Verwiebe EG, Hall JM, Polly DW Jr, Kuklo TR. Transforaminal lumbar interbody fusion: clinical and radiographic results and complications in 100 consecutive patients. *J Spinal Disord Tech* 2005;18: 337–346.
15. Scheufler KM, Dohmen H, Vougioukas VI. Percutaneous transforaminal lumbar interbody fusion for the treatment of degenerative lumbar instability. *Neurosurgery* 2007; 60(5): 203-12.
16. Schwender JD, Holly LT, Rouben DP, Foley KT. Minimally invasive transforaminal lumbar interbody fusion (TLIF): technical feasibility and initial results. *J Spinal Disord Tech* 2005; 18: 1-6.
17. Shunwu F, Xing Z, Fengdong Z, Xiangqian *F*. Minimally invasive transforaminal lumbar interbody fusion for the treatment of degenerative lumbar diseases. *Spine* 2010; 35: 1615–1620.
18. Starkweather AR, Witek-Janusek L, Nockels RP, Peterson J, Mathews HL. The multiple benefits of minimally invasi ve spinal surgery: results comparing transforaminal lumbar interbody fusion and posterior lumbar fusion. *J Neurosci Nurs* 2008; 40: 32-39.
19. Suk SI, Lee CK, Kim WJ, Lee JH, Cho KJ, Kim HG. Adding posterior lumbar interbody fusion to pedicle screw fixation and posterolateral fusion after decompression in spondylolytic spondylolisthesis. *Spine* 1997; 22(2): 210-219.
20. Taneichi H, Suda K, Kajino T, Matsumura A, Moridaira H, Kaneda K. Unilateral transforaminal lumbar interbody fusion and bilateral anterior-column fixation with two Brantigan I/F cages per level: clinical outcomes during a minimum 2-year follow-up period. *J Neurosurg Spine* 2006; 4: 198–205.
21. Villavicencio AT, Burneikiene S, Roeca CM, Nelson *EL*, Mason A. Minimally invasive versus open transforaminal lumbar interbody fusion. *Surg Neurol Int* 2010; 1: 12.
22. Voor MJ, Mehta S, Wang M, Zhang YM, Mahan *J*, Johnson JRl. Biomechanical evaluation of posterior and anterior lumbar interbody fusion techniques. *J Spinal Disord* 1998; 11: 328–334.
23. Wang J, Zhou Y, Zhang ZF, Li CQ, Zheng WJ, Liu J. Minimally invasive or open transforaminal lumbar interbody fusion as revision surgery for patients previously treated by open discectomy and decompression of the lumbar spine. *Eur Spine J* 2011; 20(4): 623-628.
24. White AA III, Panjabi MM. Clinical biomechanics of the spine, 2nd ed. Lippincott, Philadelphia 1990.
25. Yucesoy K, Yuksel KZ, Baek S, Sonntag VK, Crawford NR. Biomechanics of unilateral compared with bilateral lumbar pedicle screw fixation for stabilization of unilateral vertebral disease. *J Neurosurg Spine* 2008; 8: 44–51.
26. Xiao Y, Li F, Chen Q. Transforaminal lumbar interbody fusion with one cage and excised local bone. *Arch Orthop Trauma Surg* 2010; 130: 591–597.

Volume: 30, Issue: 1, January 2019 pp: 55-58 ORIGINAL ARTICLE

POSTERIOR LUMBAR INTERBODY FUSION: ASSESMENT OF COMPLICATIONS

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ABSTRACT

Objective: The aim of study is to investigate the complications of surgeries which were operated with instrumentation and posterior lumbar interbody fusion with the diagnosis of spinal stenosis.

Materials and Method: Sixty patients who were diagnosed as lumbar stenosis were investigated for the study. The patients that operated with instrumentation and posterior lumbar interbody fusion technique was selected. All patients were investigated from the files and radiology archive retrospectively. Vertebrae fractures, spondylolisthesis and neoplastic operations excluded from the study.

Results: A total of 60 patients were included in this study. Mean age of the patients was 54.3 ± 11.1 years. Forty-four patients (73.3 %) were females and 16 were males (26.7 %). All patients had spinal stenosis. Most frequent operation applied to patients was L3-4-5 Instrumentation and PLIF in 32 patients (53.3 %), followed by L2-3-4-5 Instrumentation and PLIF in 14 patients (23.3 %). Forty-three patients had no complication after the procedure (71.7 %), 6 patients had bilateral numbness (10 %), 4 patients had tural tear (6.7 %), 3 patients had bilateral radicular pain (5 %), 2 patients had dislocation (3.3 %) and 2 patiens had infection(3.3 %). When the complication rates were assessed respective to each other, proportion of bilateral numbness was the highest as 35.3 %, and proportions of infection and PLIF dislocation were the lowest as 11.7 % for each. The age distribution between genders was statistically similar (p=0.34). Likewise, the distributions of operation types (p=0.55) and complications (p=0.64) were also similar between female and male patients.

Conclusions: PLIF allows for adequate interbody height restoration and allows for neural decompression. Neurological and paraspinal muscle injury complications due to risk of retraction on thecal sac with nerve roots and paraspinal muscles must be remembered.

Key Words: Posterior lumbar interbody fusion, spinal stenosis, complications of fusion

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Several surgical techniques are available and debate remains whether additional instrumentation and fusion is required [7]. Transpedicular screw fixation and interbody cages are mostly chosen for instrumentation. Spinal stenosis, degenerative disc diseases, trauma, infection and neoplasms are main diagnosis for using lumbar interbody fusion (LIF) [9]. LIF involves placement of an implant material such as cage or structural graft within the intervertebral disc space after discectomy and endplate preparation.

There are 5 main approaches which are posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF or MI-TLIF), anterior lumbar interbody fusion (ALIF), oblique lumbar interbody fusion/anterior to psoas (OLIF/ATP) and lateral lumbar interbody fusion (LLIF) that mostly used for performing LIF. In case of spinal interbody fusion in addition to decompression and pedicle screw fixation, two widely used techniques for spinal fusion are posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF). The PLIF technique for

instrumented spinal fusion was introduced more than a half century ago in 1952 by Cloward [2].

The posterior approach may be suitable for degenerative indications requiring a fusion procedure, segmental instability, recurrent disc herniation, symptomatic spinal stenosis and pseudoarthrosis may also benefit from a PLIF procedure. Contraindications for posterior fusion surgery include extensive epidural scarring, arachnoiditis, and active infection. The aim of study is to investigate the complications of posterior lumbar interbody fusion surgeries with the diagnosis of spinal stenosis.

MATERIALS AND METHOD

Sixty patients who were diagnosed as lumbar stenosis were investigated for the study. The patients that operated with instrumentation and posterior lumbar interbody fusion technique was selected (Figure-1).

All patients were investigated from the files and radiology archieve retrospectively. Vertebrae fractures, spondylolisthesis and neoplastic operations excluded from the study.

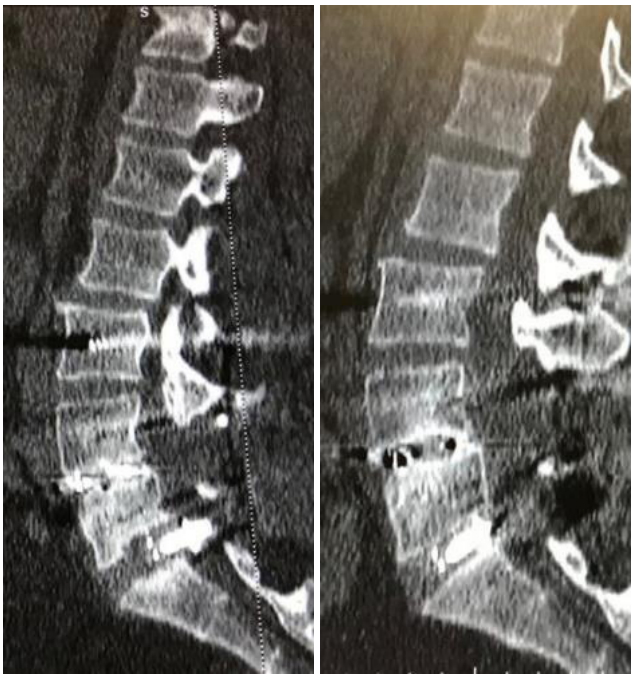

Figure-1. Early postoperative and follow up sagittal computed tomography image of PLIF dislocated patient.

Statistical Analyses

The numerical variables were presented as mean and standard deviation, and categorical data were presented as frequency and percent. The comparisons between independent groups were performed using Mann-Whitney U test for numerical data, and Chi-square test for categorical data. A p value lower than 0.05 was considered as a statistically significant result for that analysis. SPSS 25 (IBM Inc., Armonk, NY, USA) was used for the statistical analyses of the study.

RESULTS

A total of 60 patients were included in this study. Mean age of the patients was 54.3 ± 11.1 years. Forty-four patients (73.3 %) were females and 16 were males (26.7 %) (Table-1).

All patients had spinal stenosis. Most frequent operation applied to patients was L3-4-5 Instrumentation and PLIF in 32 patients (53.3 %), followed by L2-3-4-5 Instrumentation and PLIF in 14 patients (23.3 %) (Table-2).

Forty-three patients had no complication after the procedure (71.7 %), 6 patients had bilateral numbness (10 %), 4 patients had tural tear (6.7 %), 3 patients had bilateral radicular pain (5 %), 2 patients had dislocation (3.3 %) and 2 patients had infection (3.3 %). When the complication rates were assessed respective to each other, proportion of bilateral numbness was the highest as 35.3 %, and proportions of infection and PLIF dislocation were the lowest as 11.7 % for each (Tasble-3).

Demographic and clinical characteristics between females and males were compered. Accordingly, mean ages of the female and male patients were 55.4 ± 11.7 years and 51.3 ± 9.4 years, respectively. The age distribution between genders was statistically similar (p=0.34). Likewise, the distributions of operation types (p=0.55) and complications (p=0.64) were also similar between female and male patients (Table-4).

Table-1. General demographic characteristics of patients

	Mean	**SD**
Age (years)	54.3	11.1
	n	**%**
Gender		
Female	44	73.3
Male	16	26.7

Table-2. General clinical characteristics of patients

	n	**%**
Disease		
Spinal stenosis	60	100
Operation		
L2-3-4-5 Instrumentation and PLIF	14	23.3
L3-4-5 Instrumentation and PLIF	32	53.3
L3-4-5-S1 Instrumentation and PLIF	4	6.7
L4-5 Instrumentation and PLIF	6	10
L4-5-S1 Instrumentation and PLI	4	6.7

Table-3. Complication rates

Complication	n	%
None	43	71.7
Bilateral numbness	6	10
Dural tear	4	6.7
Bilateral radicular pain	3	5
PLIF dislocation	2	3.3
Infection	2	3.3

Table 4. Comparisons of demographic and clinical characteristics between genders

	Female		Male		p
	Mean	SD	Mean	SD	
Age (years)	55.4	11.7	51.3	9.4	0.34
	n	%	n	%	p
Operation					0.55
L2-3-4-5 Instrumentation and PLIF	8	18.2	6	37.5	
L3-4-5 Instrumentation and PLIF	24	54.5	8	50.0	
L3-4-5-S1 Instrumentation and PLIF	2	4.5	2	12.5	
L4-5 Instrumentation and PLIF	6	13.6	-	-	
L4-5-S1 Instrumentation and PLI	4	9.1	-	-	

DISCUSSION

The main advantage associated with PLIF surgery is that this approach is a traditional lumbar approach that all spinal surgeons are well trained and comfortable in performing. A posterior exposure allows excellent visualization of the nerve roots without compromising blood supply to the graft. PLIF allows for adequate interbody height restoration, allows for neural decompression whilst maintaining posterior support structures [8]. There are disadvantages that a surgeon should be wary of when performing PLIF like paraspinal iatrogenic injury associated with prolonged muscle retraction and this could delay recovery and mobilization due to approach-related muscle trauma[3,5]. It may be difficult to correct coronal imbalance and restore lordosis with this approach. Endplate preparation may be difficult compared to anterior fusion approaches and other potential risks include retraction injury of nerve roots causing fibrosis and chronic radiculopathy [6,13,16].

There is no clear definitive evidence for one approach being superior to another in terms of fusion or clinical outcomes [14]. These operations can also be performed using mini-open or minimally invasive approaches [10]. Interbody fusion is preferable to postero-lateral on-lay fusion techniques due to lower rates of postoperative complications and pseudoarthrosis [4].

Kunder et al investigated 990 patients who were operated with using PLIF and TLIF and they found that the complication rate of TLIF was fifty percent lower compared to PLIF [7]. This significant difference was not only the case for surgery related complications as infections, nerve root damage and dural tears, but also for hardware problems and other complications. Severe complications as iatrogenic nerve root dysfunction were more often described for PLIF. They concluded with that the significant difference in complication rate can be explained by the higher a priori chance due to a bilateral instead of unilateral approach, though in case of TLIF the resection of bony structures is more extensive compared to PLIF. Due to less extensive resection of bony structures, there is possibly a larger chance on traction on the nerve root when inserting the cages for PLIF compared to TLIF [11].

Alobaidaan et al evaluated a total of 8609 patients underwent PLIF procedure with or without Human Bone Morphogenic Protein-2 (rhBMP2) for fusion [1]. They found that complication rates for infection, cardiac, pulmonary, lumbosacral neuritis, wound, and urinary tract were significantly lower in the rhBMP2 group. There was no difference in the rates of central nervous system complications or radiculitis between the 2 groups. They concluded with that the data showed that the patients who received rhBMP2 had lower complication rates compared to the nonrhBMP2 group, however use of rhBMP2 was associated with a higher rate of pseudoarthrosis.

Okuda et al evaluated a total of 1000 patients who underwent PLIF for degenerative lumbar disorders for adjacent segment disease (ASD) [12]. The overall ASD rate was 9.0 %, and the average ASD period was 4.7 years after primary surgery. With respect to clinical features of ASD, degenerative spondylolisthesis at the cranial fusion segment was the most frequent. In terms of repeat ASD, second and third ASD incidences were 1.1 % and 0.4 %, respectively. They summarized that as for ASD by fusion length, age, and preoperative pathologies, ASD incidence was increased by fusion length, while the time period to ASD was significantly shorter in elderly patients and those with degenerative lumbar scoliosis.

Teng et al investigated 26 studies which compares complication rates of LIF procedures and reported that there were no statistically significant differences between ALIF, PLIF and TLIF regarding reoperation rates, rates of neurological deficits, rates of infections or rates of venous thromboembolism [15].

We have a complication rate of 29.3 % including bilateral numbness, dural tear, bilateral radicular pain, PLIF dislocation and infection. When the complication rates were assessed respective to each other, proportion of bilateral numbness was the highest as 35.3 %, and proportions of infection and PLIF dislocation were the lowest as 11.7 % for each.

Conclusion

PLIF allows for adequate interbody height restoration and allows for neural decompression. Neurological and paraspinal muscle injury complications due to risk of retraction on thecal sac with nerve roots and paraspinal muscles must be remembered.

REFERENCES

1. Alobaidaan R, Cohen JR, Lord EL, Buser Z, Yoon ST, Youssef JA, Park JB,Brodke DS, Wang JC, Meisel HJ. Complication rates in posterior lumbar interbody fusion (PLIF) surgery with human bone morphogenetic protein 2: medicare population. *Global Spine J* 2017; 7(8): 770-773.
2. Cloward RB. The treatment of ruptured lumbar intervertebral discs by vertebral body fusion. Indications, operative technique, after care. *J Neurosurg* 1953; 10: 154–168.
3. Cole CD, McCall TD, Schmidt MH, Dailey AT. Comparison of low back fusion techniques: transforaminal lumbar interbody fusion (TLIF) or posterior lumbar interbody fusion (PLIF) approaches. *Curr Rev Musculoskelet Med* 2009; 2: 118-126.
4. Eck JC, Hodges S, Humphreys SC. Minimally invasive lumbar spinal fusion. *J Am Acad Orthop Surg* 2007; 15: 321-329.
5. Fan SW, Hu ZJ, Fang XQ, Zhao FD, Huang Y, Yu HJ. Comparison of paraspinal muscle injury in one-level lumbar posterior inter-body fusion: modified minimally invasive and traditional open approaches. *Orthop Surg* 2010; 2: 194-200.
6. Humphreys SC, Hodges SD, Patwardhan AG, et al. Comparison of posterior and transforaminal approaches to lumbar interbody fusion. *Spine* 2001; 26: 567-571.
7. Kunder SL, van Kuijk SMJ, Rijkers K, Caelers IJMH, v Hemert WLW, de Bie RA, van Santbrink H. Transforaminal lumbar interbody fusion (TLIF) versus posterior lumbar interbody fusion (PLIF) in lumbar spondylolisthesis: a systematic review and meta-analysis. *Spine J* 2017; 17(11): 1712-1721.
8. Lestini WF, Fulghum JS, Whitehurst LA. Lumbar spinal fusion: advantages of posterior lumbar interbody fusion. *Surg Technol Int* 1994; 3: 577-590.
9. Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ. Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. *J Spine Surg* 2015; 1(1): 2-18.
10. Mobbs RJ, Sivabalan P, Li J. Minimally invasive surgery compared to open spinal fusion for the treatment of degenerative lumbar spine pathologies. *J Clin Neurosci* 2012; 19: 829-835.
11. Mura PP, Costaglioli M, Piredda M, Caboni S, Casula S. TLIF for symptomatic disc 30 degeneration: A retrospective study of 100 patients. *Eur Spine J* 2011; 20: 57–60.
12. Okuda S, Yamashita T, Matsumoto T, Nagamoto Y, Sugiura T, Takahashi Y, Maeno T, Iwasaki M. Adjacent segment disease after posterior lumbar interbody fusion: a case series of 1000 patients. *Global Spine J* 2018; 8(7): 722-727.
13. Park J, Kim Y, Hong H, Hwang SN. Comparison between posterior and transforaminal approaches for lumbar interbody fusion. *J Korean Neurosurg Soc* 2005; 37: 340-344.
14. Resnick DK, Choudhri TF, Dailey AT, Groff MW, Khoo L, Matz PG, Mummaneni P, Watters WC 3rd, Wang J, Walters BC, Hadley MN; American Association of Neurological Surgeons/Congress of Neurological Surgeons. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 7: intractable low-back pain without stenosis or spondylolisthesis. *J Neurosurg Spine* 2005; 2: 670-672.
15. Teng I, Han J, Phan K, Mobbs R. A meta-analysis comparing ALIF, PLIF, TLIF and LLIF. *J Clin Neurosci* 2017; 44: 11-17.
16. Zhang Q, Yuan Z, Zhou M, Liu H, Xu Y, Ren Y. A comparison of posterior lumbar interbody fusion and transforaminal lumbar interbody fusion: a literature review and metaanalysis. *BMC Musculoskelet Disord* 2014; 15: 367.

Volume: 30, Issue: 1, January 2019 pp: 59-64 ORIGINAL ARTICLE

A COMPARISON OF HIGH VISCOSITY AND LOW VISCOSITY BONE CEMENT VERTEBROPLASTY FOR SEVERE OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURES

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ABSTRACT

Introduction: Our aim in this clinical trial was to compare the safety and efficacy of high-viscosity cement (HVC) with low-viscosity cement (LVC) for the treatment of osteoporotic vertebrae fractures in terms of pain, functional capacity and cement leakage in the percutaneous vertebroplasty procedure (PVP).

Methods: From March 2013 to February 2015, 76 patients with vertebrae compression fracture who were admitted into hospital and treated with PVP were reviewed. Pre- and postoperative clinical characteristics of each patient were obtained by using The Visual Analog Scale (VAS) score to evaluate back pain, Oswestry Disability Index (ODI) as a functional assessment. Cement leakage,injected cement volume and the complications assessed due to medical records.

Results: VAS and ODI scores improved ($P<0.05$) significantly in the two groups postoperatively on the other hand there was no significant change between two groups ($P>0.05$).Paravertebral cement leakage was significantly higher in the LVC group ($P<0.05$). Pulmonary cement embolism was also significantly higher in LVC group ($P<0.05$).

Conclusion: HVC had lower complication rates with similar clinical results in the comparison with LVC.

Keywords: Vertebroplasty, cement leakage, bone cement, viscosity, pulmonary embolism, vertebral fracture, osteoporosis

Level of evidence: Retrospective clinical study, Level III

INTRODUCTION

The most common systemic disorder worldwide is osteoporosis and it is characterized by decreased bone mass quality, transformed bone micro architecture and increased fracture risk [3,13]. An estimated 22 million women and 5.5 million men are afflicted with osteoporosis at the European Union. When the treatment cost of fractures related to osteoporosis is added to the cost, it has been reached to 37.0 billion euro and is assumed to increase by 25 % in 2025 [9].

With the aging of the population, osteoporotic vertebral compression fractures (OVCFs) incidence has been increased and it is becoming a serious socio-economic problem. Despite generally believed hypothesis is good prognosis for most of these fractures; OVCF worsens the long term patient's health [18].

During the last decade, with the increased popularity at the minimally invasive surgery and development of new approaches and methods, percutaneous vertebroplasty (PVP) which includes percutaneously cement injection into the fractured vertebral body is an accepted technique for the treatment of the patients with painful OVCFs [6,11]. For this purpose, multiple types of injectable bone cements like PolyMethylMetAcrylate (PMMA), calcium phosphate and composite cements are currently being used in PVP. PMMA is the most widely used cement type due to its good handling properties, strength, long time experience, and low costs.

Severe complications like spinal cord compression, nerve damage, blood vessels thermal damage and pulmonary embolism could be caused by leakage of the cement into vessels or intramedullary channel of

the spine. On the other hand, little amount of cement leakage could be without clinical manifestation [15]. The detection of cement leakage on plain roentgenograms is ranging from 43 % to 45 % on the other hand on the computed tomography (CT) scan rates are changing between 78 % and 91.9 %. Due to these rates, leakage of the cement is a severe problem that spine surgeons have attempted to find a solution [5,19].

The risk for extravasation could be effectively decreased by using high viscosity cement (HVC) and thereby clinical safety could be improved. In an experimental study Baroud et al. demonstrated that cement leakage could be stopped completely with HVC [4]. Also in a prospective comparative clinical study Georgy and Anselmetti confirmed that HVC is safe in application and may decrease cement leakage at PVP procedure compared with low viscosity cements(LVC) [7,14].

HVC directly reaches an optimum injectable viscosity after mixing, without a waiting period of few minutes as in LVC's, and before the cement solidification it conserves the injectable form for 8–10 minutes.

Also in a retrospective study it has been shown that using HVC may have a role in decreasing the risk of cement leakage in PVP procedure and may result in leakage rates comparable with that of balloon kyphoplasty [2].

Our aim in this clinical trial was to compare the safety and efficacy of high-viscosity cement vertebroplasty (HVCV) with low-viscosity cement vertebroplasty (LVCV) for the treatment of OVCFs in terms of pain, functional capacity and cement leakage.

MATERIALS AND METHODS

General data

From March 2013 to February 2015, 76 patients with vertebrae compression fracture who were admitted into hospital and treated with PVP were reviewed. 12 patient excluded from the study due to the exclusion criteria's and 1 patient from the group HVC died because of a cancer 1 patient from the group LVC died in a traffic accident during the follow-up. In 62 patients there were 22 in male and 40 in female.

Patients were included in the study if they [1] were aged above 50 years, [2] had severe OVCFs vertebrae or lumbar fracture without symptom and signs of spinal cord damage or pedicle damage (part of the vertebral body collapsed to less than one-third of their original height), [3] had focal back pain without definite radicular signs and symptoms unresponsive to at least 8 weeks of appropriate conservative treatment, [4] had back pain related to the location of the OVCF on spinal radiographs, [5] Vertebrae compression fracture confirmed by international recognized imaging (X plain film, CT, MRI T2-weightedshort tau inversion recovery sequences) and clinical examination, and [6] Osteoporosis diagnosed by bone mineral density (BMD), BMD was less than 2.5 SD suggested the possibility of osteoporosis.

Patients were excluded if they [1] had ordinary OVCFs (vertebral body collapsed to more than one-third of their original height), [2] had spinal cord compression or stenosis of the vertebral canal > 30 % of the local canal diameter, [3] Injury of neural function including spinal cord damage or cauda equina injury, [4] Unable to undergo related examinations,[5] had systemic or local spine infections, and [6] had severe comorbidity in the heart, liver, kidney, and lung intolerance to surgery. [7] Blood coagulation dysfunction with bleeding [8] Poor compliant patients or loss to follow up during follow-ups.

The study population consisted of 29 patients in the group HVC (mean age, 75.4 ± 9.3 years) and 33 patients in the group LVC (mean age, 75.8 ± 9.1 years). All procedures were per-formed by the same surgeon (MA).

All patients had low back pain and pain when turning over and were unable to stand up. Besides, pain released when patient was in supine position and worsened when bending over. Physical examination showed that there were obvious tenderness and percussion pain at thoracic vertebrae or lumbar fracture site.

Magnetic resonance imaging (MRI), thin slice computerized tomography (CT), dual-energy X-ray absorptiometry (DEXA), and anteroposterior (A/P) and lateral radiographs were evaluated before CT and AP-LAT radiographs after the surgery to determine the appropriateness of the procedure and plan the treated levels.

Cement leakage, defined as the presence of any extravertebral cement, was assessed independent of the treating physician by 2 investigators using a computed tomography (CT) scan made after PVP. Differences were re-examined until consensus was obtained.

All procedures were carried out with sterile equipment. Patients were placed in a prone position on operating table, and sedation was achieved with 1.5 cc intravenous midazolam. The entry point was confirmed by C-arm X-ray machine and marked local anesthesia with 2% prilocaine hydrochloride (8 cc) was administered from the pedicle of fractured vertebra to subcutaneous tissue. An 11-gauge needle was inserted into the pedicle via fluoroscopy. Using anteroposterior and lateral imaging, the pedicle was passed through the body to reach the corpus vertebrae. A biopsy has been taken for identifying if the fracture is due to the osteoporosis or not. Then, cementing

was performed, and a lateral X-ray showed the distribution of the cement inside the corpus. The amount of cement added was determined via lateral imaging. After the procedure, the patients remained motionless in a prone position until the cement polymerized. The patients underwent a neurological examination at every stage of the procedure. All of the patients stayed in the hospital for 1 day, and none of them had to wear a cast after discharge.

Pre- and postoperative clinical characteristics of each patient were obtained by using The Visual Analog Scale (VAS) score to evaluate back pain, Oswestry Disability Index (ODI) as a functional assessment. Routine standing anteroposterior and lateral radiographs of the spine were made 6 weeks and 1 year after PVP and on indication, *e.g.*, sudden new onset of back pain suspect for a new OVCF.

Statistical analysis

IBM SPSS statistic 22.0 was applied in statistical analysis. All data were showed by mean ± SD. Intergroup comparisons were made using the Student's paired t-test or Man Whitney U test. Comparisons between before and after operation were made using the paired simple t-test and Wilcoxon signed Ranks. P-values < 0.05 were considered statistically significant.

RESULTS

Demographic data

There were no significant differences between group HVC and group LVC in the gender ratios, age, and vertebral bodies involved according to the statistical results (Table-1).

The time of follow-ups in group HVC and group LVC were 1.0 - 2.1year (mean 1.6 ± 0.5) and 1.1 - 2.0 year (1.5 ± 0.6) respectively. Sixty-two surgeries were carried on 137 vertebrae.

Surgery time

The average surgery time was 20,97±3,24minutes on average for LVC, and 10,07±1,21minutes for HVC, There was statistical difference between the two groups according to the mean surgery time/vertebrae (P:0.001; P<0.05).

Amount of cement

All surgeries were completed successfully. The injected volume of HVC and LVC were 3,52 ± 1,09 ml and 3,39 ± 1,2 ml respectively. There was no statistical difference about injected volume of bone cement (p: 0,551).

VAS ODI

The two groups reported immediate postoperative pain relief, and none had subjective complaints of worsening pain at any time point of follow-up. Group HVC the mean VAS score before PV of 8.41 ± 1.16 improved significantly, to a mean of 1.31 ± 0.69 at the end point after the procedure (*Mann Whitney U test, Wilcoxon Sign test, p<0.05*). In Group LVC the mean VAS of 8.36 ± 0.99 pre-procedure dropped to 1.36 ± 0.83 post-procedure respectively (*P<0.05*) 12 months follow-up (Table-2).

Table-1. Table showing demographic data of patients included in this study

	GROUP HVC	GROUP LVC	P-value
Number of Participants	29	33	
MEN/WOMEN	10/19	12/21	1.00
Vertebral Bodies (n)	61	66	
Mean Age	72,46±8,03	74,84±5,84	[1]**0,191**
Mean Follow up (years)	1.0-2.1 year (mean 1.6±0.5)	1.1-2.0 year (1.5±0.6)	0.86
Surgery Time	10,07±1,21	20,97±3,24	[1]**0,001***
Cement Volume	3,52±1,09 (3)	3,39±1,2 (3)	[2]**0,551**

Table-2. Comparison of VAS between two groups

VAS	GROUP LVC	GROUP HVC	p[1]
	Mean±SD	Mean±SD	
PREOPERATIVE	8,36±0,99	8,41±1,16	0,878
POSTOPERATIVE	1,36±0,83	1,31±0,69	0,821
Preoerative-Postoperative p[2]	0,001*	0,001*	

[1]*Mann Whitney U test* [2]*Wilcoxon Sign test* **p<0.05*

ODI scores also improved (*P<0.05*) significantly in the two groups, from a mean index of 43.88% ± 3.97 to 6.94% ± 2.63% (Group HVC) and from 42.82% ± 6.2% to 6.71% ± 2% (Group LVC). No differences in clinical outcome were noted between the two groups (p > 0.05) (Table-3).

Table-3. Comparison of ODI between two groups

ODI	GROUP LVC	GROUP HVC	p[1]
	Mean±SD	Mean±SD	
PREOPERATIVE	42,82±6,2	43,88±3,97	0,444
POSTOPERATIVE	6,71±2	6,94±2,63	0,715
Preoerative-Postoperative p[2]	0,001*	0,001*	

[1]*Student t test* [2]*Paired Samples test* **p<0.05*

Complication

No significant clinical complications or post-procedural clinical sequelae were encountered in both groups.

Comparison of data showed a statistically highly significant difference (p: 0.023; p<0.05, Continutity Yates correction) of disc cement leakages between patients treated with group HVC and patients in Group LVC (Figure-1).

In group HVC pulmonary embolism ratio was statistically higher than group LVC (P:0.037; P<0.05) (Table-4) (Figure-2).

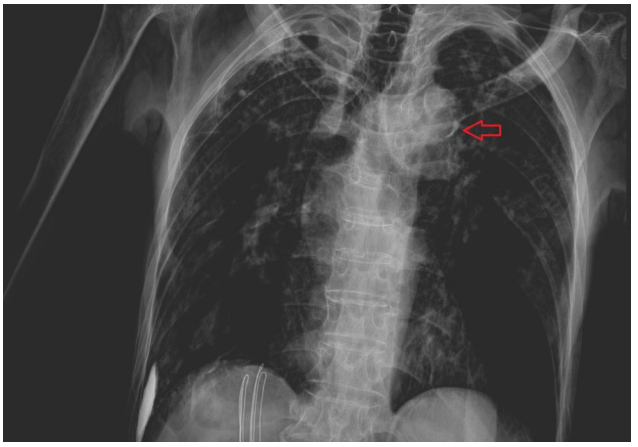

Figure-1. Arrow showing the pulmonary cement embolism in group LVC.

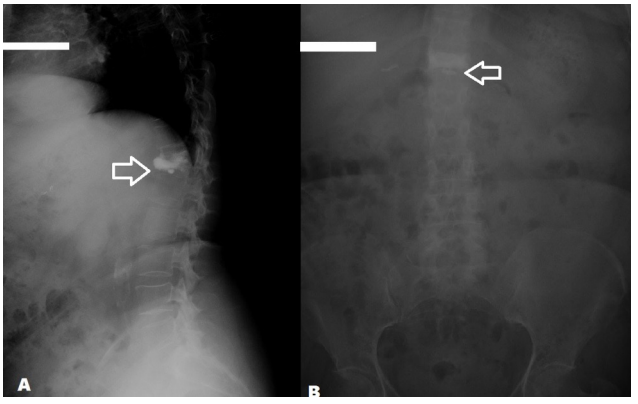

Figure-2. (A) Lateral plane x ray showing cement leakage to the disc and anterior wall of the vertebrae. **(B)** Anterior-Posterior x ray arrow showing the cement leakage to the disc.

One elder patient with severe osteoporotic vertebrae body compression fracture (L-1) in group HVC had distal vertebrae fracture (L-2) postoperatively. Also one case of postoperative adjacent vertebrae fracture was found in group LVC. All new fractures were treated surgically. No statistical difference in new fracture rate was demonstrated between the groups. There was one case with a superficial wound infection that was treated with antibiotics in group LVC.

Table-4. Comparison cement leakages and pulmonary embolism between two groups

	GROUP LVC	GROUP HVC	p
	n (%)	n (%)	
Disc cement leakage			
-	17 (%60,7)	9 (%28,1)	**0,023***
+	11 (%39,3)	23 (%71,9)	
Pulmonary embolism			
-	19 (%67,9)	12 (%37,5)	**0,037***
+	9 (%32,1)	20 (%62,5)	

Continuity (Yates) correction **p<0.05*

DISCUSSION

Osteoporosis had become a kind of common disease with severe damage to elderly health [12]. A female had a risk of osteoporotic fracture at 30 % ~ 40 % worldwide. The rate of osteoporosis was approximately 60 % for the aged over 60 years old, 80 % of who were female.

Traditionally, osteoporosis-related compression fractures of the spine have been treated conservatively, with analgesics and long-term bed rest. However, it is now well accepted that PVP is the treatment of choice for patients with osteoporotic compression fractures. It results in lower morbidity and mortality than open surgery and avoids prolonged immobility. A review of the recent literature on spinal metastases treated with percutaneous transpedicular vertebroplasty revealed that complete or partial pain relief (1–3 days postoperatively) was achieved in 75–89% of patients [1,10,16-17]. The results of our study were at least as successful in treating patients with pathological vertebral body collapse using PVP.

PVP was the one of clinical common operation treatment with severe complication of bone cement leakage. Some studies showed that LVC had a higher rate of cement leakage and para-vertebrae leakage than HVC [4,8]. LVC was easy to leak and diffuse to vein to induce pulmonary embolism with disadvantage of short solidification time and inconvenient operation. Also in our study we found statistically higher cement leakage rates in LVC.

Three major factors may influence the cement flow into and out of the vertebral body: bone- and fracture-related parameters, injection methods, and properties of cement.

Although fracture morphology is impossible to control and the method of injection has been standardized, the properties of cement may be manipulated to ultimately decrease the rate of leakage of cement. In terms of properties of cement, an increased viscosity leads to a uniformly expanding cloud and a decreased spreading distance ideally, ignoring preformed paths by vessels or structural irregularities, thus reducing the risk of leakage [4,7,14].

In group HVC there was a shorter surgery time using HVC in our study can be attributed to earlier beginning of application of the cement immediately after mixing the components of cement in group HVC, on the other hand surgeon have to wait polymerization of LVC to end to prevent leakage of cement in the surrounding musculature at removal of a needle.

It is unclear whether spatial distribution of the cement influenced by its viscosity affects the outcome of PVP. The results of the present study showed a clinically relevant, significant, immediate, and durable reduction in mean back pain and function, which was comparable between both the groups. Thus there is no direct dependence between the quantity of cement applied and clinical outcome.

In fact our study had limitations. First, it was a retrospective study and the patients were not classified according to the fracture type. Secondly the small size of the study group was a limitation of our study. Also, the research assistants involved in the data collection of this study were not blinded to treatment type and may have introduced bias. Finally, length of follow-up in this study is a limitation.

This study showed that HVC had a lower rate of postoperative cement leakage because HVC was improved on basis of LVC, which could improve the liquid phase in the process of bone cement mixing and decrease the leakage rate and other complication rate to enhance the safety of PVP. A controlled prospective, high-powered, randomized multicenter studies also including the medium viscosity cement need to be designed to determine the differences in patient outcomes and to further elucidate optimal treatment strategies for VCF's.

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REFERENCES

1. Alvarez L, Perez-Higueras A, Quinones D, Calvo E, Rossi RE. Vertebroplasty in the treatment of vertebral tumors: postprocedural outcome and quality of life. *Eur Spine J* 2003; 12: 356–360.
2. Anselmetti GC, Zoarski G, Manca A, Masala S, Eminefendic H, Russo F, Regge D. Percutaneous vertebroplasty and bone cement leakage: Clinical experience with a new high-viscosity bone cement and delivery system for vertebral augmentation in benign and malignant compression fractures. *Cardiovasc Intervent Radiol* 2008; 31: 937-947.
3. Appelman-Dijkstra NM, Papapoulos SE. Novel approaches to the treatment of osteoporosis. *Best Pract Res Clin Endocrinol Metab* 2014; 28: 843–857.
4. Baroud G, Crookshank M, Bohner M. High-viscosity cement significantly enhances uniformity of cement filling in vertebroplasty: an experimental model and study on cement leakage. *Spine* 2006; 31: 2562-2568.
5. Chen C, Bian J, Zhang W. Unilateral versus bilateral vertebroplasty forsevere osteoporotic vertebral compression fractures. *J Spinal Disord Tech* 2014, http: // dx.doi.org /10.1097/ BSD.0000000000000118.
6. Evans AJ, Jensen ME, Kip KE, DeNardo AJ, Lawler GJ, Negin GA, Remley KB, Boutin SM, Dunnagan SA. Vertebral compression fractures: Pain reduction and improvement in functional mobility after percutaneous polymethylmethacrylate vertebroplasty retrospective report of 245 cases. Radiology 2003; 226: 366-372.
7. Georgy BA. Clinical experience with high-viscosity cements for percutaneousvertebral body augmentation: occurrence, degree, and location of cement leak-age compared with kyphoplasty. *AJNR Am J Neuroradiol* 2010; 31: 504–508.
8. Habib M, Serhan H, Marchek C and Baroud G. Cement leakage and filling pattern study of low viscous vertebroplastic versus high viscous confidence cement. *SASJ* 2010; 4: 26-33.
9. Hernlund E, Svedbom A, Ivergard M, Compston J, Cooper C, Stenmark J, McCloskey EV, Jönsson B, Kanis JA; *EU* Review Panel of *IOF*. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Arch Osteoporos* 2013; 8: 136.
10. Jang JS, Lee SH. Efficacy of percutaneous vertebroplasty combined with radiotherapy in osteolytic metastatic spinal tumors. *J Neurosurg Spine* 2005; 2: 243–248.
11. Klazen CA, Lohle PN, de Vries J, et al. Vertebroplasty versus conservative treatment in acute osteoporotic vertebral compression fractures (Vertos II): An open-label randomised trial. *Lancet* 2010; 376: 1085-1092.
12. Legroux-Gerot I, Lormeau C, Boutry N, Cotten A, Duquesnoy B, Cortet B. Long-term follow-up of vertebral osteoporotic fractures treated by percutaneous vertebroplasty. *Clin Rheumatol* 2004; 23: 310-317.
13. Litwic A, Cooper C, Dennison E. Osteoporosis therapies in 2014. *Panminerva Med* 2014; 56: 273–283.
14. Nieuwenhuijse MJ, Muijs SP, van Erkel AR, Dijkstra *SP*. A clinical comparative study onlow versus medium viscosity polymethylmetacrylate bone cement in percutaneous vertebroplasty: viscosity associated with cement leakage. *Spine* 2010; 35: E1037–1044.

15. Pan J, Yang HL, Meng B. The research progress of bone cement in percutaneous vertebroplasty and percutaneous kyphoplasty. *Chinese J Spine Spinal Cord* 2012; 22: 81-84.
16. Rand T, Lomoschitz F, Cejna M. Percutaneous radiologically-guided vertebroplasty in the treatment of osteoporotic and tumorous spinal body lesions. *Radiology* 2003; 43: 723–728.
17. Sun G, Cong Y, Xie Z, et al. Percutaneous vertebroplasty using instruments and drugs made in China for vertebral metastases. *Chin Med J* 2003; 116: 1207–1212.
18. Suzuki N, Ogikubo O, Hansson T. The course of the acute vertebral body fragility fracture: its effect on pain, disability and quality of life during 12 months. *Eur Spine J* 2008; 17: 1380-1390.
19. Young C, Munk PL, Heran MK, Lane MD, Le HB, Lee S, Badii M, Clarkson PW, Ouellette HA. Treatment of severe vertebral body compression fractures with percutaneous vertebroplasty. *Skeletal Radiol* 2011; 40: 1531–1536.

Volume: 30, Issue: 1, January 2019 pp: 65-67 ORIGINAL ARTICLE

PATIENT-CENTERED OUTCOMES OF VERTEBROPLASTY VIA QUESTIONNAIRE

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ABSTRACT

Purpose: Our aim was to evaluate patient centred outcomes of patients with compression fractures treated by vertebroplasty.

Methods: Patients with compression fractures treated by vertebroplasty procedure between 2013- 2016 was examined with a 3-question through telephone call.

Results: Fifty-two patients completed the telephone satisfaction survey. Of these, 92.5 % of answerers said the procedure was acceptable, 86.5% had full or partial pain remission and 78.8 % would have the procedure again.

Conclusions: The use of vertebroplasty is supported by randomized trials in osteoporotic and malignant compression fractures. To the results of our study, patients believe vertebroplasty is a tolerable procedure that produces full or partial pain remission and would try the same procedure again if needed.

Keywords: Vertebroplasty; kyphoplasty; vertebral fracture; patient satisfaction

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Compressive vertebral fracture is a situation caused by osteoporosis or due to expansion of malignant tumors into the skeleton. Percutaneous vertebroplasty (PVP) has become a widespread technique in the treatment of osteoporotic compression fractures and vertebral metastatic lesions [(1–3)] since it was described for the first time by Galibert et al. [(4)].

Vertebroplasty is a surgery achieving its effect by applying the cement through a needle into the fractured vertebral body, without correction of kyphosis. The main aim of this procedure is to decrease of the back-pain caused by vertebral fracture [(5)].

Vertebral fractures could affect the patients functionally and could negatively affect mobility outcomes as well as psychosocial outcomes of the patients. Currently, the most important thing for the healthcare reimbursement is higher patient satisfaction [(6-7)].

Our aim in this study was to evaluate patient-centered outcome measures using specific questions directed at procedure tolerability, pain relief, and willingness to undergo the same procedure again to show the utility of vertebroplasty not only objectively, but also subjectively from the patients' perspective.

PATIENTS AND METHODS

All patients who had undergone a vertebroplasty procedure at the year between 2012–2016 were identified. Patients were included in the study if they [(1)] were aged above 50 years, [(2)] had vertebrae or lumbar fracture without symptom and signs of spinal cord damage or pedicle damage, [(3)] had focal back pain without definite radicular signs and symptoms unresponsive to at least 8 weeks of appropriate conservative treatment, [(4)] had back pain related to the location of the OVCF on spinal radiographs, [(5)] Vertebrae compression fracture confirmed by international recognized imaging (X plain film, CT, MRI T2-weightedshort tau inversion recovery sequences) and clinical examination.

Patients were excluded if they [1] deceased patients [2] had spinal cord compression or stenosis of the vertebral canal >30% of the local canal diameter, [3] Injury of neural function including spinal cord damage or cauda equina injury, (4) had systemic or local spine infections.

The indication for vertebroplasty was assessed using the medical records as well as pathological information from bone biopsy. They were separated into osteoporotic/spontaneous fractures, fractures related to biopsy-proven malignancy, or traumatic fractures.

Survey

The included patients were contacted through telephone numbers obtained in the demographic data of their electronic health record. The "Vertebroplasty Telephone Satisfaction Survey", a simple three-question survey, was administered to the patient. In *Table-1* questions asked by the survey are showed. Only the patients are allowed to take the survey. If the patient was close to communication with the telephone they were excluded from the survey and study. If the patient was unavailable for communication by the telephone, two more attempts were made, for a total of three attempts, before the patient was counted as unreachable and excluded.

Table-1. Questionnaire results

Questions results	Number
Q1. Was the procedure to inject cement into your fracture tolerable?	
Yes	47
No	5
Q2. Was the pain in your back relieved by the procedure to inject cement into your fracture?	
Yes	33
Somewhat	12
No	7
Q3. Would you have the same procedure again?	
Yes	40
Not sure	7
No	5

RESULTS

One hundred and seventeen patients were identified from the hospital health system due to inclusion criterias. Eight patients refused to participate in the questionnaire and were excluded. Fifty seven were unreachable or unable to complete the questionnaire. Fifty two patients remained.

The majority of the patients were females. The age range was from 56–91, with an average age of 72.4. The most common level requiring vertebroplasty was T12, followed by L1 and then L2. Overall, 88.4 % of fractures were at the thoracolumbar junction (T10–L2). (Table-2).

The cause for surgery was mainly osteoporotic or spontaneous fractures, which accounted for 75.0 % of all patients.

Overall, 90.3 % of respondents said the procedure was tolerable. When asked regarding pain relief, 86.5 % of respondents had partial or full pain relief from the procedure, with 63.4 % overall stating "yes" to the pain relief question. When asked whether they would have the procedure again, 76.9 % of respondents stated "yes". Full survey results are listed in Table-2.

Table-2. Patient characteristics

Characteristics	Number
Sex	
Male	9
Female	43
Age	
50–69	39
70–89	12
>90	1
Cause of fracture	
Spontaneous/osteoporotic	39
Malignancy	3
Trauma	7
Unknown	3
Number of levels	
T8	1
T9	2
T10	1
T11	8
T12	21
L1	13
L2	3
L3	1
L4	2

DISCUSSION

Our study demonstrated that, the treatment of compression fractures with vertebroplasty procedure results in subjective pain relief from the patient perspective. Most patients'

perspective on vertebroplasty is that given another compression fracture, they would have re-operation in the form of vertebroplasty due to our findings.

This study has several limitations. First there could be recall bias. The patients who had procedures in 2012 were called in 2018, thereby introducing approximately 6 years between time of procedure and questionnaire administration. When breaking down the data to compare years, patients who had the procedure in 2012 had the same overall trend in answer choice. Patients in 2012 responded "somewhat" to pain relief question 2 57.8 %, and "yes" only 36.1 % of the time. This trend was reversed in all following years.

Also the limitation of our study the lack of objective investigation of the pain with ODI and VAS scale, but the main aim of this study was to evaluate patient-centered outcome data.

In conclusion healthcare environment is changing and patient satisfaction is becoming more important. Our patient data has now shown that vertebroplasty is also well-tolerated, effective, and desirable, from the patient perspective.

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REFERENCES

1. Cotten A, Dewatre F, Cortet B, Assaker R, Leblond D, Duquesnoy B, Chastanet P, Clarisse J. Percutaneous vertebroplasty for osteolytic metastases and myeloma: effects of the percentage of lesion filling and the leakage of methyl methacrylate at clinical follow-up. *Radiology* 1996; 200: 525–530.
2. Deramond H, Depriester C, Galibert P, Le Gars D. Percutaneous vertebroplasty with polymethylmethacrylate. Technique, indications, and results. *Radiol Clin North Am* 1998; 36: 533–546.
3. Martin JB, Jean B, Sugiu K, San Millán Ruíz D, Piotin M, Murphy K, Rüfenacht B, Muster M, Rüfenacht DA. Vertebroplasty: clinical experience and follow-up results. *Bone* 1999; 25(2 suppl.): 11S–15S.
4. Galibert P, Deramond H, Rosat P, Le Gars D. Preliminary note on the treatment of vertebral angioma by percutaneous acrylic vertebroplasty. *Neurochirurgie* 1987; 33: 166–168.
5. Cortet B, Cotten A, Boutry N, Flipo RM, Duquesnoy B, Chastanet P, Delcambre B. Percutaneous vertebroplasty in the treatment of osteoporotic vertebral compression fractures: an open prospective study. *J Rheumatol* 1999; 26: 2222–2228.
6. Silverman SL. The clinical consequences of vertebral compression fracture. *Bone* 1992; 13 (Suppl 2): S27–S31.
7. Lyles KW, Gold DT, Shipp KM, Pieper CF, Martinez S, Mulhausen PL. Association of osteoporotic vertebral compression fractures with impaired functional status. *Am J Med* 1993; 94: 595–601.

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A RETROSPECTIVE STUDY ON AUTOLOGOUS CERVICAL INTERBODY FAT GRAFT APPLICATION FOR ANTERIOR CERVICAL DISCECTOMIES

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ABSTRACT

Background: This retrospectively designed study investigates the relation between clinical and radiological results of patients who were performed ACD and autologous interbody fat graft.

Material and Methods: A total of 71 patients who underwent ACD with IFG in Neurosurgery Clinics of Şişli Etfal EAH between 1994 and 2009 were included in this study. Patients age range was between 28 and 56 years with the mean of 41,08±6,67. Patient population was composed of 25 women and 46 men. All the operations were performed by the senior authors (YA). The surgery was applied to 1 or 2 level soft cervical disc herniations. Selected patients have one of the following criteria: 1. Radicular signs as motor weakness, dermatomal numbness etc., 2. Long tract signs, and 3. Refractory or persistent pain to minimum 3 weeks medical treatment. Harrison's posterior tangent method used for ROM measurement on dynamic roentgenograms. Segmental ROM was measured by the same method at the operated vertebral level.

Pain and functional evaluation: Neck Disability Index (NDI) (2) and Short Form 36 (SF-36) (3) were used for functional and pain status of the patients.

Results: Segmental and cervical total lordosis angles are not change statistically after operation. Radiologically detected fusion or developing kyphotic deformity is not seen. ROM levels changed significantly in long-term period. NDI scores decreased significantly early and late period. SF-36 results are increased significantly in long-term follow-up.

Conclusions: Microsurgical technique and autologous interbody fat graft may prevent complication of fusion such as adjacent segment degeneration. Contralateral approach provides better visualization.

Key words: Anterior cervical discectomy, fusion, contralateral approach, interbody fat graft

Level of evidence: Retrospective clinical study, Level III

INTRODUCTION

The anterior cervical approach is widely preferred for surgical treatment of soft cervical disc disease. Prevention of intervertebral space high and appropriate load sharing are the main problems after these operations. Described procedure in this paper has some benefits for prevention sagittal alignment of the cervical spine and decompression neural tissues with protecting normal anatomy. Anterior contralateral microdiscectomy (ACD) with interbody fat graft (IFG) provides some advantages intra and postoperatively, like wide viewing angle, protection of vertebral endplates and adjustment of sagittal profile of the c-spine.

MATERIAL AND METHODS

A total of 71 patients who underwent ACD with IFG in Neurosurgery Clinics of Şişli Etfal EAH between 1994 and 2009 were included in this study. Patients age range was between 28 and 56 years with the mean of 41.08 ± 6.67. Patient population was composed of 25 women and 46 men. All the operations were performed by the senior authors (YA). The surgery was applied to 1 or 2 level soft cervical disc herniations. Selected

patients have one of the following criteria: 1. Radicular signs as motor weakness, dermatomal numbness etc., 2. Long tract signs, and 3. Refractory or persistent pain to minimum 3 weeks medical treatment. All patients' symptoms and signs were accordance with MRI findings. Patients have more than two levels degenerations, spondylosis, previous surgery for c-spine or traumatic lesions were excluded from the study. This study covers only the patients with initial surgery. All patients were informed about technique and other choices and complications of this technique; and an informed consent was obtained from all. All the study patients were performed neurological examination, dynamic c-spine roentgenograms, MRI at preoperatively, and postoperative 1., 3., 6., 12. and 24. months.

Radiological evaluation

Lateral cervical direct and dynamic roentgenograms were evaluated for narrowing disc spaces, new bone formation, abnormal motion, sagittal profile and cervical lordosis. Cervical lordosis was measured as angle between the line passed the posterior borders of C2 and C7 corpus [(14)].

Harrison's posterior tangent method used for ROM measurement on dynamic roentgenograms. Segmental ROM was measured by the same method at the operated vertebral level.

Pain and functional evaluation

Neck Disability Index (NDI) [(23)] and Short Form 36 (SF-36) [(24)] were used for functional and pain status of the patients.

Statistical analysis

All analysis was performed by SPSS Ver 15.0 software. Descriptive statistics were done as mean and standard deviation. Analysis of variance (ANOVA) was used for calculations of standard measurements. Unpaired t-test was used to comparing of groups. Changing by time of groups evaluated and compared by Chi- Square test. A p value less than 0.05 was accepted as significant.

Surgical technique

Surgical technique used for these operations is the similar to anterior cervical discectomy (ACD) with some modifications by approaching from the contralateral side of brachialgia [(3)].

The head is positioned as semi-extended to providing cervical lordosis. All operations were performed under an operating microscope. A 1,5 cm incision is made at the level determined by a fluoroscopy. The platysma is opened longitudinally, the external layer of esophageal muscles is visualized. The carotid bundle is separated from the esophagus by a blunt dissection. The trachea and esophagus are retracted medially; and anterior longitudinal ligament (ALL) is seen. The level is confirmed by a C-arm fluoroscopy. ALL is opened between the left and right longus colli muscles. Intervertebral disc is removed, end plates are left untouched, and posterior longitudinal ligament (PLL) is reached. Lateral parts of the nucleus pulposus is not removed vigorously. PLL is opened, anterior epidural area is controlled. This technique provides better exposure of the compressed neural tissues. While closing, a fat graft which is obtained from subcutaneous tissue is applied to prevent bony fusion between two vertebral endplates. Corset is not used after operation. Patients is mobilized 3 hours after surgery and discharged the same day.

RESULTS

Radiculopathy was detected in 83.1 % of patients while myelopathy was found in 16.9 % of them. Right or left sided brachialgia was found in 45.07 % and 54.93 % of patients respectively. One- or two-level herniations was seen in 90.14 % and 9.86 % of patients respectively. Distribution of patients due to the herniation levels was as follows: C3-4: 5.13%, C4-5: 8.97 %, C5-6: 48.72 %, C6-7: 35.9 %, C7-T1: 1.28 %.

Ruptured disc fragments were removed from 44.87 % of patients; 17.95 % of patients had soft disc protrusion; and 37.18 % of them hard disc herniations. Mean follow-up time was 19.3 months.

Radiologic results

Intervertebral bony fusion or collapse of the interbody space weren't detected in any case. Abnormal motion wasn't found in any dynamic postoperative roentgenograms. Preoperatively normal cervical lordosis was found out in 78.87 % of cases. Loss of lordosis and straight lateral profile was identified in 21.13 % of patients. Straightening of the lateral profile was seen 1.87 % of cases which had normal cervical lordosis preoperatively in early postoperative period. Straight lateral profile continued in 30 % of patients which had also straight profile preoperatively in early postoperative period. In long term follow-up, 91.55 % of patients have normal cervical lordosis. The mean preoperative cervical axe was 15.52° ± 13.08° and postoperative late (24 months) was 26.02° ± 15.02°. The p value was greater than 0.05, so there was no statistical significance of this change. Segmental kyphosis wasn't detected in any cases. The mean segmental angle was 3.34° ± 1.60° preoperatively, and 4.05° ±2.04° postoperatively. The p value of this change was greater than 0.05. The mean ROM was 49.30° ± 6.92° preoperatively and 53.55° ± 11.48° postoperatively. This change also wasn't significant statistically ($p>0.05$). Surgical level ROM change was also insignificant

(p>0.05) in early postoperative period, but long-term results showed significant change (p<0.05). Preoperatively the mean segmental ROM at the surgical level was 7.97° ± 3.43°, early postoperative mean ROM was 7.25° ± 3.08°, late postoperative mean ROM was 11.19° ± 2.97°.

Clinical results

No complication developed intra/postoperatively. Temporary dysphagia was seen only 2.82 % of patients which was resolved in a week. Radiculopathy and neck movement limitation were settled postoperatively in all patients. The mean NDI score was 20.91 ± 2.81 preoperatively, 10.91 ± 2.55 in early postoperative period and 6.91 ± 2.26 in late postoperative period. All of these changes were significant statistically (p<0.05 for both early and late results). The mean SF-36 scores of preoperatively, early and late postoperatively were 44.32 ± 8.58, 77.32 ± 9.19 and 87.66 ± 9.73 respectively. These changes were also significant with p values less than 0.05.

DISCUSSION

ACD is widely used approach for decompression of cervical spinal cord. Anterior techniques change stabilization minimally, and also are less harmful to muscular structure than posterior ones [15-16]. Whether ACD should be followed by bony fusion or not is lasting controversy today. The one of the most important objectives of the spinal interventions is prevention or readjustment of spinal alignment. Normal cervical lordosis is between 10° and 40°.

Dysphagia due to retraction of the esophagus in patients who undergo ACDF is a more frequently seen complication than patients who are performed only simple ACD [10]. Dysphagia is seen up to 25 % after ACDF with anterior plates [1]. During ACD, muscle dissection and retraction of trachea-esophagus are made less than ACDF. Automatic retractors aren't used in the course of operation, so esophageal tissue perfusion can be provided intermittently. An experimental study reveals that, edema, vascular congestion and injury and inflammation, in inner circular and outer longitudinal layers of the muscularis propria are detected in early stage of retraction. They also detected fibrosis in the longitudinal layer of muscularis propria in late stages. They claimed that these lesions were the reason of dysphagia [8].

Fusion procedures bring new complications to anterior cervical surgery. Pelvic area pain may become more prominent than cervical area pain in the postoperative period in patients whom iliac autograft is used for fusion materials. There are some studies in the literature that reveals pain in the graft harvested area lasts 36 months after operation [2]. Complication rate of graft site is 9 % and the pain lasts 36 % of patients [22]. To avoid these complications, cadaveric bones are started to use. Decontamination process of cadaveric bones made lessen fusion capability of these kind of materials [4]. Authors that advocate fusions claim that any material that prevents height of intervertebral space may provide biomechanical stability, improve kyphotic profile, open neural foramens and as a result of these reduce the cervical pain [5,9]. But, some authors showed that foramen height collapse sometime later after interbody grafting [20]. Besides, fused segments constitute a great moment axis and behave a source of stress. This can cause early degenerations in adjacent segments. Adjacent segment disease develops 2.9 % for every year after a fusion surgery [13]. On the other hand, fusion rate of anterior cervical disc surgery without graft of cage is between 28 % and 100 % [21,25]. A previous study from our clinic showed that fusion rate radiologically detected was 4.90 % in patients who were undergone anterior contralateral discectomy without autologous fat graft [7]. Within the scope of presented study, autologous fat graft was inserted in the interbody space. The aim of using fat graft is prevention of bony fusion, collapse and adjacent disc disease. At the same time, some in-vitro studies in the literature revealed that subcutaneous fat grafts may have a potential of transformation to adipose cell, osteoblast, chondrocyte or myoblast [19]. Recently artificial disc materials are started to use widely because of prevention of segmental motion and thus avoidance of adjacent segment disease. However, heterotopic ossification, periannular calcification, arthrosis of the facet joints, segmental hyperlordosis, subsidence of the material, wide sclerosis around the prosthesis and cystic formation of bone are reported about using prostheses [12,17]. On the contrary of some authors [6], all the posterior and lateral osteophytes that can be cause of compression should be removed microsurgically. Posterior longitudinal ligament (PLL) should be excised [11,18]. Because calcified and thick PLL is one of compressive elements.

Conclusions

The technique described in this manuscript provides direct visualization of the compressed parts and preserves segmental mobility of the c-spine. The fat graft plays a crucial role in achieving prevents undesired bony fusion between two adjacent vertebrae. Using contralateral approach and interbody fat graft may prevent adjacent segment disease, complication of the instrumentation.

REFERENCES

1. Abd-Alrahman N, Dokmak AS, Abou-Madawi A. Anterior cervical discectomy (ACD) versus anterior cervical fusion (ACF), clinical and radiological outcome study. *Acta Neurochir (Wien)* 1999; 141(10): 1089-1092.

2. Aydın Y, Kaya RA, Can SM, Türkmenoğlu O, Çavuşoğlu H, Ziyal İM. Minimally invasive anterior contralateral approach for the treatment of cervical disc herniation. *Surg Neurol* 2005; 63(3): 210-218.

3. Aydın Y, Çavuşoğlu H, Yüce İ, Özdilmaç A, Kahyaoğlu O. A prospective study of interbody fat graft application with the anterior contralateral cervical microdiscectomy to preserve segmental mobility. *Neurosurgery* 2017; 81(4): 627-637.

4. Bridwell KH, DeWald RL (Ed). Textbook of spinal surgery, 2nd ed. Lippincott-Raven, Philadelphia 1997.

5. Cauthen JC, Kinard RE, Vogler JB, Jackson DE, DePaz OB, Hunter OL, Wasserburger LB, Williams RN. Outcome analysis of noninstrumented anterior cervical discectomy and interbody fusion in 348 patients. *Spine* 1998; 23: 188-192.

6. Cloward RB. New method for diagnosis and treatment of cervical disc disease. *Clin Neurosurg* 1962; 8: 93-132.

7. Conolly ES, Esses SI, Kostuik JP. Anterior cervical fusion: outcome analysis of patients fused with and without anterior cervical plates. *J Spinal Disord* 1996; 9: 202-206.

8. Cuatico W. Anterior cervical discectomy without interbody fusion. An analysis of 81 cases. *Acta Neurochir (Wien)* 1981; 57: 269-274.

9. Çavuşoğlu H, Türkmenoğlu O, Kaya RA, Can SM, Aydın Y. Effects of anterior contralateral cervical microdiscectomy on radiological and clinical outcome. *Surg Neurol* 2006; 65(5): 446-452.

10. Çavuşoğlu H, Tuncer C, Tanık C, Mutlu Z, Zengin E, Karabağlı M, Aydın Y. The impact of automatic retractors on the esophagus during during anterioe cervical surgery. An experimental in vivo study in a sheep model. *J Neurosurg Spine* 2009; 11: 547-554.

11. Dowd GC, Wirth PF. Anterior discectomy: Is fusion necessary? *J Neurosurg Spine* 1999; 90: 8-12.

12. Goffin J, Van Calenberg F, Van Loon J, Casey A, Kehr P, Liebig K, Lind B, Logroscino C, Sgrambiglia R, Pointillard V. Intermediate follow-up after treatment of degenerative disc disease with Bryan cervical disc prosthesis: single-level and bi-level. *Spine* 2003; 28(24): 2673-2678.

13. Grob D. Surgery in the degenerative cervical spine. *Spine* 1998; 23: 2674-2683.

14. Harrison DE, Harrison DD, Cailliet R. Cobb method or Harrison posterior tangent method: which to choose for lateral cervical radiographic analysis? *Spine* 2000; 25: 2072-2078.

15. Henderson CM, Henessy RG, Shuey HM, Shuckleford EG. Posterior lateral foraminotomy as an exclusive technique for cervical radiculopathy. A review of 846 consecutive operated cases. *Neurosurgery* 1983; 13: 504-512.

16. Herkowitz HN. The surgical management of cervical radiculopathy and myelopathy. *Clin Orthop Relat Res* 1989; 239: 94-108.

17. Hilibrand AS, Carlson GD, Palumbo MA, Jones PK, Bohlman HH. Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. *J Bone Joint Surg* 1999; 81-A: 519-528.

18. Hoff JT, Wilson CB. Microsurgical approach to the anterior cervical spine and spinal cord. *Clin Neurosurg* 1978; 26: 513-528.

19. Li X, Lee JP, Balian G, Anderson D. Modulation of chondrocytic properties of fat-derived mesenchymal cells in co-cultures with nucleus pulposus. *Connect Tissue Res* 2005; 46(2): 75-82.

20. Murphy MA, Trimble MB, Piedmonte MR, Kalfas IH. Changes in the cervical foraminal area after anterior discectomy with and without a graft. *Neurosurgery* 1994; 33: 93-96.

21. Pointillart V, Cernier A, Vital JM, Senegas J. Anterior discectomy without interbody fusion for cervical disc herniation. *Eur Spine J* 1995; 4(1): 45-51.

22. Rybock JD. Cervical disc and spur. In: Iong DL (Ed) Current therapy in neurologic surgery-2., Decker, Philadelphia 1989.

23. Vernon H, Mior S. The Neck Disability Index: a study of reliability and validity. *J Manipulative Physiol Ther* 1991; 14(7): 409-415.

24. Ware J, Snow KK, Kosinski M, Gandek B. SF-36 Health survey: Manual and interpretation guide. Boston (Mass): The Health Institute, New England Medical Center; 1993.

25. Yamamoto I, Ikeda A, Shibuya N, Tsugane R, Sato O. Clinical long-term results of anterior discectomy without interbody fusion for cervical disc disease. *Spine* 1991; 16: 272-279.

Volume: 30, Issue: 1, January 2019 pp: 73-78 ORIGINAL ARTICLE

SYRINGOMYELIA

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ABSTRACT

Objective: The cavities imbued with glia cells which may develop around the central canal of spinal cord are called syringomyelia. The pathophysiology of syringomyelia is yet to be defined in full. The aim of our study is to investigate the patients with syringomyelia.

Material and Method: The patients who applied to our clinics between 2007-2017 and were diagnosed with syringomyelia in consequence of neurological and radiological examinations were included in the assessment from the automation system of our hospital.

***Results*:** This study was carried out on 208 cases, in total, of which 35.1 % (n=73) were male while 54.9 % (n=135) were female. The ages of the cases included in this study varied between 9 and 81, and the average of ages was 42.52 ± 16.30 years. Chiari malformation were the most frequent etiology among these (28.4 %). The rate of cervical engagement of Chiari Malformation and Disc Pathology were significantly higher compared to the rates of the lumbar engagement of spinal congenital anomaly and the thoracic engagement of trauma.

***Conclusion*:** In consequence of this study, only 43.5 % of the patients with syringomyelia demonstrated etiological causes. On the other hand, a small part of the cases arose due to spinal mass, trauma and discopathy.

Key words: Syringomyelia, spinal cord, syrinx

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Syringomyelia (SM) emerges due to the deteriorations in the cycle of cerebrospinal fluid (CSF), and it is widely believed in the recent literature even though the pathophysiology cannot be explained to the fullest extent that it follows the accumulation of extracellular fluids in spinal cord due to the difference of intracerebral pressure and the pressure of surrounding CSF [17].

While the etiology cannot be elaborated completely, the causes can be classified under three main titles which are congenital causes, acquired diseases and the deterioration of the flow dynamics of cerebrospinal fluid [6,17].

This study aims to contribute to the literature by assessing the epidemiological characteristics of 208 patients who were diagnosed with syringomyelia.

MATERIAL AND METHOD

The patients who applied to our clinics between 2007-2017 and were diagnosed with syringomyelia in consequence of neurological and radiological examinations were included in the assessment from the automation system of our hospital. Retrospectively, the spinal magnetic resonance images (MRIs) of the patients which were taken of cervical, thoracic, lumbar and more than one anatomical regions of spinal columns were analyzed. The patients included in this study were evaluated according to their age, sex, anatomical region, etiological cause and dimension of syringomyelia.

Statistical Analysis

NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used for the statistical analyses. Descriptive statistical methods (average, standard deviation, median, first quartile, third quartile, minimum and maximum) were used while evaluating the data of the study. The compatibility of quantitative data with normal distribution was tested with Shapiro-Wilk Test and graphical analyses. Kruskal-Wallis and Dunn-Bunferroni tests were availed of in the comparison of more than two groups in which quantitative variables did not show normal distribution. On the other hand, Fisher-Freeman-Halton Exact Test was used for the comparison of qualitative data. Statistical significance was accepted to be $p<0.05$.

RESULTS

This study was carried out on 208 cases, in total, of which 35.1 % (n=73) were male while 54.9 % (n=135) were female patients who had applied to Istanbul Training and Research Hospital between 2007 and 2017. The ages of the cases included in this study varied between 9 and 81, and the average of ages was 42.52 ± 16.30 years (Table-1, Figure-1).

Table-1. The Distribution of Demographic Characteristics

Age (years)	*Min-Max (Median)*	9 – 81 (44)
	Ave±Sd	45,52±16,30
Gender n(%)	**Male**	73 (35,1)
	Female	135 (64,9)

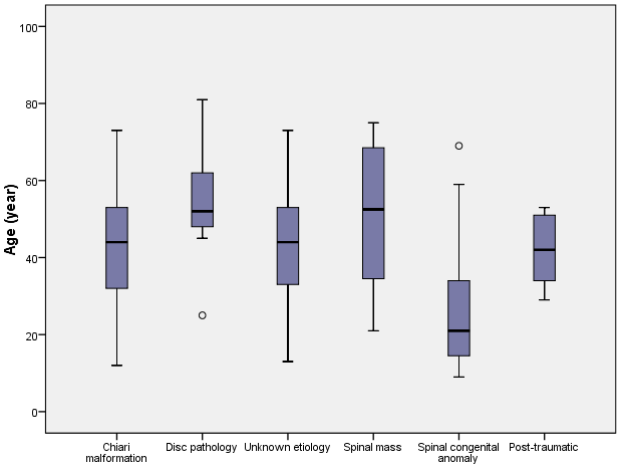

Figure-1. The Distribution of Ages According to Causes

Syringomyelia was found to be in cervical, thoracic, lumbar and more than one region of 61.5 % (n=128), 61.5 % (n=49), 8.2 % (n=17) and 6.7 % (n=14) of the patients, respectively. 51.4 % (n=107) cases showed milimetric syrinx while the other 48.6 % (n=101) demonstrated other dimensions (Table-2).

Table-2. Evaluation of Ages According to Causes

Cause	N	Age (years)			
		Average	SD	Median	Min-Min
Chiari Malformation	59	42.54	14.319	44.00	12-73
Disc Pathology	15	55.00	13.480	52.00	25-81
Unknown Etiology	97	43.69	14.923	44.00	13-73
Spinal Mass	8	50.88	20.420	52.50	21-75
Spinal Congenital Anomaly	23	26.70	17.844	21.00	9-69
Post-traumatic	6	41.83	9.847	42.00	29-53
Total	**208**	**42.52**	**16.302**	**44.00**	**9-81**

Kruskal Wallis test; p=0,001; p<0,01

The causes of syringomyelia were found to be Chiari malformation, disc pathology, unclear etiology, spinal mass, spinal congenital anomaly and post-traumatic in 28.4 % (n=59), 7.2 % (n=15), 46.5 (n=97), 3.8% (n=8), 11.1% (n=23) and 2.9% (n=6) of the patients, respectively (Table-3).

Table-3. Evaluation of Ages According to Regions

Regions	N	Age(year)			
		Average	SD	Median	Min-Min
Cervical	128	44,78	14,158	46,00	9-81
Thoracic	49	38,31	18,260	34,00	9-75
Lumbar	17	36,35	21,374	27,00	9-69
More than one region	14	44,14	17,615	48,50	12-67

Kruskal Wallis test; p=0,039; p<0,05

There was a statistically significant difference in terms of the distribution of ages according to the causes (p<0,01). In consequence of the Dunn-Bonferroni tests carried out in order to distinguish from which group the significance arose, the ages of spinal congenital anomaly cases were found to be significantly lower than those of Chiari Malformation, Disc Pathology, Unclear Etiology and Spinal Mass cases (p=0,006; p=0,001; p=0,001; p=0,020, respectively). No statistical significance was found among the distribution of the ages of other groups (p>0,05).

There was a statistically significant difference in terms of the distribution of ages according to the regions (p<0,01). In consequence of the Dunn-Bonferroni tests carried out in order to distinguish from which group the significance arose, it was inferred that the ages of cervical cases were significantly higher compared to the thoracic cases (p=0,041). No statistical significance was found among the distribution of the ages of other regions (p>0,05)(Figure-2).

There was a statistically significant difference in terms of the dimensions according to the causes of syringomyelia (p<0,01). The investigation of the group that caused significance showed that the determination rates of spinal congenital anomaly and unclear etiology cases were significantly higher than the others (Table-4).

There was a statistically significant difference in terms of the regions according to the causes of syringomyelia (p<0,01). Similarly, the analysis of the group that led to significance indicated that the rate of cervical engagement of Chiari Malformation and Disc Pathology were significantly higher compared to the rates of the lumbar engagement of spinal congenital anomaly and the thoracic engagement of trauma.

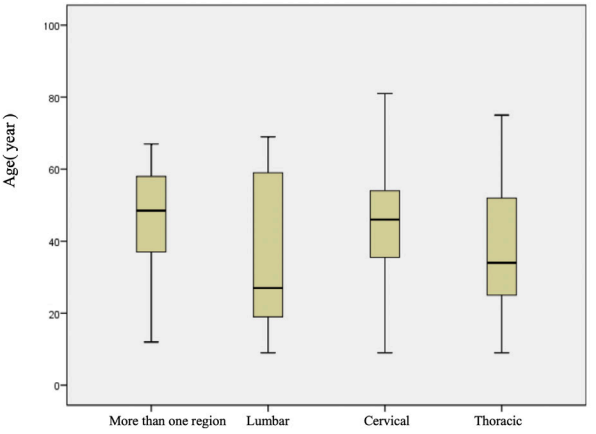

Figure-2. Distribution of ages according to regions

Table-4. Evaluation of dimensions and regions according to syringomyelia causes

	Chiari Malformation	Disc Pathology	Unclear etiology	Spinal Mass	Spinal congenital anomaly	Post-traumatic	p
Dimension							
Other	36(61,0)	10(66,7)	41(42,3)	6(75,0)	5(21,7)	3(50,0)	***0,005***
Millimetric	23(39,0)	5(33,3)	56(57,7)	2(25,0)	18(78,3)	3(50,0)	
Regions							
Cervical	48(81,4)	14(93,3)	59(60,8)	4(50,0)	2(8,7)	1(16,7)	
Thoracic	7(11,9)	1(6,7)	27(27,8)	4(50,0)	6(26,1)	4(66,7)	***0,001***
Lumbar	0(0)	0(0)	4(4,1)	0(0)	13(56,5)	0(0)	
More than one region	4(6,8)	0(0)	7(7,2)	0(0)	2(8,7)	1(16,7)	

Fisher's Freman Halton test **p<0,01

DISCUSSION

Syringomyelia is generally characterized with the loss of pain heat sensation and the conservation of the sense of touch due to the exposure of surrounding spinothalamic tracts after the expansion of central canal. Pyramidal findings, weakness in extremities and muscle atrophies can also be seen. It appears with weakness and muscle atrophy in the lower extremities, neck, upper back and all other extremities. Most of syringomyelia cases are also associated with severe dysesthetic pain in neck, shoulders and back [2].

There was a distinct increase in the incidence of SM upon the emergence of MRI. Because, small sub-clinic lesions can be diagnosed with MRIs which were undiagnosed previously [14,17].

Though there have been numerous studies that have been offered until today, etiologic causes cannot be determined in most syringomyelia patients. The patients with an acquired disease or congenital anomaly are known to have the most frequent etiologic causes [6,13]. In consequence of this study, only 43.5 % of the patients with syringomyelia demonstrated etiological causes. Chiari malformation were the most frequent factor among these (28.4 %). On the other hand, the remaining part of the cases were associated with spinal mass, trauma and discopathy.

However, there has not been a consensus on the surgical treatment or follow-up of syringomyelia patients with unknown etiology. The exact pathogenesis and development of syringomyelia are unknown, and the natural course of it is variable [9,10,16,18]. Furthermore, there is little information on syringomyelia since there are very few studies on syringomyelia with unknown etiology. It does not have any kind of predisposing pathology like chiari malformation or spinal cord tumor. In this study, syringomyelia with unclear etiological cause corresponds to 46.5 % of all the syringomyelia cases. Further examinations that were carried out did not produce etiological factors (Figure-3).

Many studies revealed that there were cases of syringomyelia that developed as secondary to chiari malformation. Chiari malformation was considered to be responsible for almost half of secondary syringomyelia cases [5]. In this study, 28.4 % of the cases showed syringomyelia secondary to chiari malformation. Besides, in most cases, it was observed to have statistically significantly higher possibility to occur in cervical region compared to the other regions (Figure-4).

The exact pathophysiology of post-traumatic syringomyelia is now known clearly. However; mechanical spinal cord compression, spinal cord inflammation, hematoma, secretion of intracellular lysosomal enzymes, ischemia and arterial and venous occlusions are among the factors that are believed to occur prior to the initial formation of the cavity in spinal cord [1]. All of such factors are considered to contribute to the occurrence of syringomyelia [7,12]. In this study, it was observed that post-traumatic syringomyelia made up 2,9% of the cases and that these were most frequently found in thoracic region. Additionally, women were found to have post-traumatic syringomyelia twice as much compared to men. Certain studies indicated that advanced age (with spinal cord damage), the severity of trauma and the cervical localization of such damage have a high potential to develop syringomyelia within five years [11-12]. This study had quite a low number of post-traumatic syringomyelia cases and, particularly, they were generally observed in thoracic region.

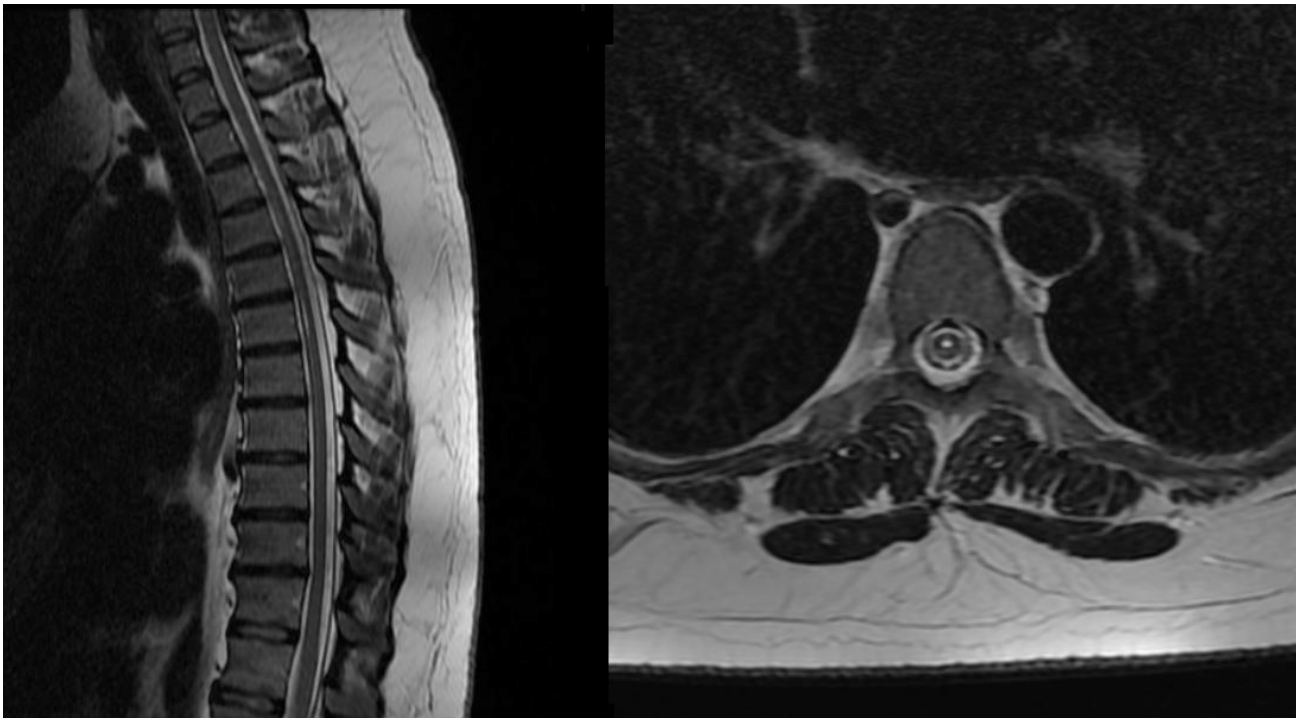

Figure-3. 50 years old female,T3-6 syringomyelia patients with unknown etiology

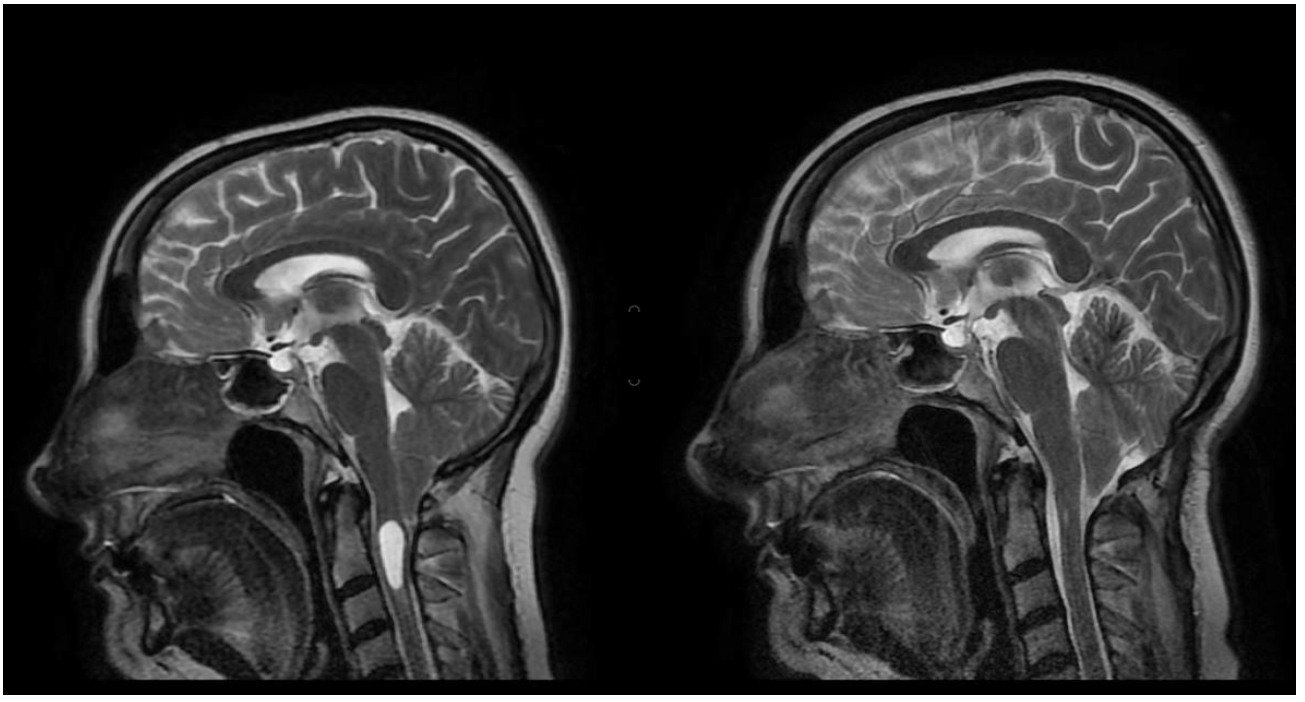

Figure-4. 50 years old female patient preoperative and postoperative chiari malformation

The study carried out by Ramnarayan et al. asserts and provides examples from the literature that childhood syringomyelias can regress without surgical treatment [15]. In this study, the dimensions of shrinks in spinal congenital anomaly and unclear etiology cases were smaller, and no statistically significant difference was found (p<0,01). The fact that milimetric syringomyelia was seen with spinal congenital anomaly in this study and that it was frequently observed in cases with unknown etiology leads to the consideration that this may be the continuation of regressed childhood syringomyelia.

The literature reports syringomyelia due to cervical spondylosis [3-4]. In this study, the rate of syringomyelia due to discopathy was 7.2 %, and 14 of these were in the cervical region while 1 was seen in thoracic region.

Spinal congenital anomalies are observed in lumbar region more compared to other regions. In this study, syringomyelia as secondary to spinal congenital anomaly was also found in lumbar region statistically significantly higher than the other regions (p<0,01).

The treatment of syringomyelia requires, first of all, research on etiology. Because, surgical plan in case of secondary syringomyelia is basically made in consideration of etiology. During follow-up period, shunting surgery may also be planned if there is no resorption [8].

Conclusion

Though there have been numerous studies that have been offered until today, etiologic causes cannot be determined in most syringomyelia patients. The patients with an acquired disease or congenital anomaly are known to have the most frequent etiologic causes [6,13]. In this study, only 43.5 % of the syringomyelia patients produced etiological causes. The most frequent etiological cause was chiari malformation (28.4 %) compared to the others. On the other hand, a small part of the cases arose due to spinal mass, trauma and discopathy.

REFERENCES

1. Agrawal A, Shetty MS, Pandit L, Shetty L, Srikrishna U, Indian J. Posttraumatic syringomyelia. *Orthop.* 2007; 41: 398-400.
2. Anton HA, Schweigel JF. Posttraumatic syringomyelia: the British Columbia experience. *Spine* 1986; 11: 865-868.
3. Badri M, Gader G, Bahri K, Zammel I. Cervicothoracic syringomyelia caused by cervical spinal stenosis: Case Report and Literature Review. *Surg Neurol Int* 2017; 8: 288.
4. Chang HS, Nejo T, Yoshida S, Oya S, Matsui T. Increased flow signal in compressed segments of the spinal cord in patients with cervical spondylotic myelopathy. *Spine* 2014; 39: 2136-2142.
5. Giner J, Pérez López C, Hernández B, Gómez de la Riva Á, Isla A, Roda JM. Update on the pathophysiology and management of syringomyelia Unrelated to chiari malformation. *Neurologia* 2016; 0213-4853(16)30216.

6. Greitz D. Unraveling the riddle of syringomyelia. *Neurosurg Rev* 2006; 29: 251–254.
7. Honan WP, Williams B. Sensory loss in syringomyelia: not necessarily dissociated. *J R Soc Med* 1993; 86: 519-520.
8. Justin W, Alotaibi NM, Samuel N, Ibrahim GM, Fallah A, Cusimano MD. Acquired chiari malformation and syringomyelia secondary to space-occupying lesions: A systematic review . *World Neurosurg* 2017; 98: 800-808.
9. Kastrup A, Nagele T, Topka H. Spontaneous resolution of idiopathic syringomyelia. *Neurology* 2001; 57: 1519-1520.
10. Kyoshima K, Kuroyanagi T, Oya F, Kamijo Y, El-Noamany H, Kobayashi S. Surgical experience of syringomyelia with reference to the findings of magnetic resonance imaging. *J Clin Neurosci* 2004; 11: 273–279.
11. Krebs J, Koch HG, Hartmann K, Frotzler A. The characteristics of posttraumatic syringomyelia. *Spinal Cord* 2016; 54: 463-466.
12. Lodhi MU, Kuzel AR, Syed IA, Rahim M. An atypical clinical presentation of posttraumatic syringomyelia: a case report and brief review of the literature. *Cureus* 2017; 9(11): e1852.
13. La Marca F, Herman M, Grant JA, McLone DG. Presentation and management of hydromyelia in children with Chiari type-II malformation. *Pediatr Neurosurg* 1997; 26 (2): 57-67.
14. Raftopoulos C. Surgical treatment of syringomyelia based on magnetic resonance imaging criteria. *Neurosurgery* 1993; 33: 535–536.
15. Ramnarayan R, Ganesh CVS, Kumar R. Spontaneous resolution of chiari 1-associated syringomyelia: a report of two cases. *Pediatr Neurosurg* 2018; 53(4): 238-242.
16. Sung WS, Chen YY, Dubey A, Hunn A. Spontaneous regression of syringomyelia– review of the current aetiological theories and implications for surgery. *J Clin Neurosci* 2008; 15: 1185-1188.
17. Vandertop WP. Syringomyelia. *Neuropediatrics* 2014; 45(1): 3-9.
18. Yanni DS, Mammis A, Ebersole K, Roonprapunt C, Sen C, Perin NI. Revision of chiari decompression for patients with recurrent syrinx. *J Clin Neurosci* 2010; 17: 1076–1079.

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ADULT LUMBAR SCOLIOSIS

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ABSTRACT

Scoliosis in the adult is a disorder that involves a convergence of deformity and degenerative disease in the spine. It can be defined as a coronal deformity with Cobb angle of more than 10 degrees in mature patients. The treatment of adult lumbar scoliosis deformity requires a multidisciplinary approach and preoperative planning, and to be extended to the development of new treatment methods in the future along with the expected life expectancy. It often manifests with low back pain. Etiology of the disease is related with primary degeneration or continuation of a deformity from adolescence. The main objective of surgical management is to decide which patient is to be treated with surgical treatment, to evaluate the general condition and to analyze the comorbidities of the patient and to draw a treatment scheme considering the patient's expectations.

Key words: Adult scoliosis, De novo scoliosis, Degenerative scoliosis, Adult idiopathic scoliosis, surgical management

Level of Evidence: Review article, Level V

INTRODUCTION

Adult lumbar scoliosis is defined as coronal spinal curvature with Cobb angle >10° in skeletally mature patients [(1)]. It is a three-dimensional deformity, often accompanied by the sagittal and rotational component [(18)]. Compensatory thoracic curve may also be accompanied [(3)]. Adult scoliosis is mainly seen as two types; degenerative and idiopathic. Adult degenerative scoliosis is also known as de novo scoliosis. The majority of patients are older than 60 years and more common in women [(15)]. Asymmetric disc degeneration and facet hypertrophy, ligament laxity, osteoporosis, compression fractures play role in the etiology of the disease [(22)]. The degree of curvature is less than 20 degrees in most patients. Adult idiopathic scoliosis is an advanced presentation of adolescent scoliosis [(4)]. It occurs at younger ages and the degree of curvature is generally higher [(2)].

CLINICAL ASSESSMENT

The most important clinical manifestation of adult degenerative scoliosis is low back pain [(16)]. It is usually seen as a combination of axial back pain and radicular leg pain. Pain may be due to spinal instability, facet joint arthropathy, disc degeneration or foraminal stenosis [(2)]. In adult idiopathic scoliosis, degenerative changes are less due to young age. The main complaint of these patients is their cosmetic appearance rather than low back pain. With the aging process, the pain complaint due to degenerative changes gradually increases. During the patient's examination, detailed sensory and motor neurological examination should be performed and the gait of the patient should be examined. In patients with neurological deficits, bilateral lower extremity electromyography (EMG) should be used to determine the degree of radicular involvement.

RADIOLOGIC ASSESSMENT

The treatment plan of adult scoliosis is possible by radiological analysis of the curvature. As in all deformity cases, radiological evaluation starts with X ray. At this stage, not only the lumbar region

but the entire vertebral column should be evaluated. For this purpose, standing scoliosis anteroposterior (AP) and lateral radiographs is the standard method. Global spinal balance should be evaluated and the size of both structural and compensatory curves should be determined. Then, bending X-rays are taken to evaluate the flexibility of the curvature [5]. In order to detect instability in degenerative scoliosis, lateral lumbar dynamic radiographs should be taken. Computed tomography (CT) provides detailed evaluation of bone structure. Detection of spinal canal or foraminal stenosis, facet joint degeneration, presence and location of osteophytes are evaluated with CT during the surgical plan. The status of neural structures is examined by Magnetic Resonance (MR). Especially in cases with neurological deficits, soft tissue pathologies, condition of cord and nerve roots, presence of disc degeneration and ligament hypertrophy should be evaluated by MRI and the strategy of neural decompression should be determined during surgery. Finally, bone density measurements should be made with Dual-energy x-ray absorptiometry (DEXA) in osteoporotic patients, and necessary precautions should be taken to increase the implant strength during the operation [12].

NONOPERATIVE TREATMENT

There is no consensus-based treatment method for conservative treatment of adult scoliosis. Anti-inflammatory and analgesic drugs, bracing, physical therapy and steroid injections are the most commonly used methods. Currently, conservative treatment is more common in patients who have mild symptoms or need to be not operated because of comorbid risk factors.

SURGICAL TREATMENT

Operative goals for adult spinal deformity include restoration of sagittal and coronal plane alignment, stabilization via instrumentation, and decompression of neural elements. Although surgical treatment of adult scoliosis is very useful, some studies reported complications up to 80 % [6]. Risk factors for complications include advanced age, comorbidities, long segment instrumentation, osteotomy and revision. Major complications occurring in the perioperative period include, for example, vascular injury, excessive blood loss, deep vein thrombosis, nerve root injury, and deep wound infection as well as life-threatening complications such as sepsis, myocardial infarction, pulmonary embolism, and catastrophic neurologic injury.

To avoid these complications, blood loss control, hypotensive anesthesia, autologous blood donation, use of antifibrinolytic agents, intraoperative neurophysiologic monitoring is required. In addition, it should be noted that surgical procedure is the work of team especially in this age group. If possible, the complication risk decreases even more with two experienced surgeons working in harmony with each other [11].

Determining the levels necessary for central and foraminal decompression is decided by a combination of clinical and radiographic findings. For example, if the patient demonstrates signs of neurogenic claudication and has corresponding significant lumbar central stenosis, then laminectomies and decompression should be incorporated into the surgical plan in addition to correction of the deformity. Similarly, if the patient has signs of a particular radiculopathy and corresponding foraminal stenosis on imaging, then the surgeon should be conscientious about decompressing those nerve roots in the surgical plan either through direct or indirect decompression methods. The surgeon must also be careful during the reduction of the deformity across osteotomy levels as nerve compression may result from iatrogenic narrowing of the neural foramen or of the spinal canal [14]. For elderly patients with osteoporosis and for patients requiring advanced correction maneuvers, cement augmentation should be considered to advance the attachment and strength in bone-screw interface (Figure-1).

Decompression of the neural elements may be achieved by direct laminectomy and/or facetectomy or indirectly via interbody grafts or other devices that increase foraminal height and/or canal diameter [16].

The methods of interbody device placement include anterior (anterior lumbar interbody fusion [ALIF]), anterolateral (oblique lumbar interbody fusion [OLIF] and lateral lumbar interbody fusion [LLIF]), and posterolateral (transforaminal lumbar interbody fusion [TLIF] and posterolateral lumbar interbody fusion [PLIF]) techniques (Figure-2).

In recent years, minimally invasive surgery (MIS) techniques have been used in the surgical treatment of adult scoliosis. The most common method is minimally invasive surgery for transforaminal lumbar interbody fusion (MIS-TLIF) technique. MIS-TLIF showed less blood loss and shorter hospital stay than the open surgery. There was no significant difference in fusion rates. Increased radiation exposure and prolonged operation time due to long learning curve are disadvantages [10].

Correction of the deformity is one of the main goals in the surgical treatment of adult scoliosis. The lumbar curvature in the coronal plane does not have to be corrected fully. An excellent cosmetic appearance is usually a secondary goal in this population. Recently, the sagittal plane has gained a lot of emphasis. The sagittal plane deformities appear to be more painful and poorer outcomes on health-related quality of life

questionnaires [7]. When the lumbar scoliosis is corrected, one has to pay special attention to obtain adequate lumbar lordosis. There is nothing worse than a lumbar scoliosis that is diffuse without adequate lumbar lordosis leading to a very flat rigid lumbar spine resulting in a flat back posture. These patients usually end up requiring a pedicle subtraction osteotomy so they can stand up straight [8].

Correction of deformity in adult scoliosis is more difficult than adolescent idiopathic scoliosis. Because the curvature of these patients is rigid. The disc spaces are narrow and stiff due to the advanced degenerative disc disease. There are osteophytes present at the degenerated levels that are frequently bridging across the disc space over time. At times, the facet joints are hypertrophied and almost ankylosed. Often, in order to correct the spinal deformity, one has to release the disc space by cutting the entire annulus, removing the disc, and distracting the disc space manually.

The intradiscal release provides the ability to change coronal and sagittal alignment. Resecting the facet joints posteriorly also provides the ability to mobilize the spine to gain segmental correction. All these release and resections increase the flexibility of the rigid curvature and facilitate the correction. However, in patients with solid fusion, the correction can only be achieved by osteotomy. The most commonly used osteotomies are Smith Peterson and pedicle subtraction osteotomies.

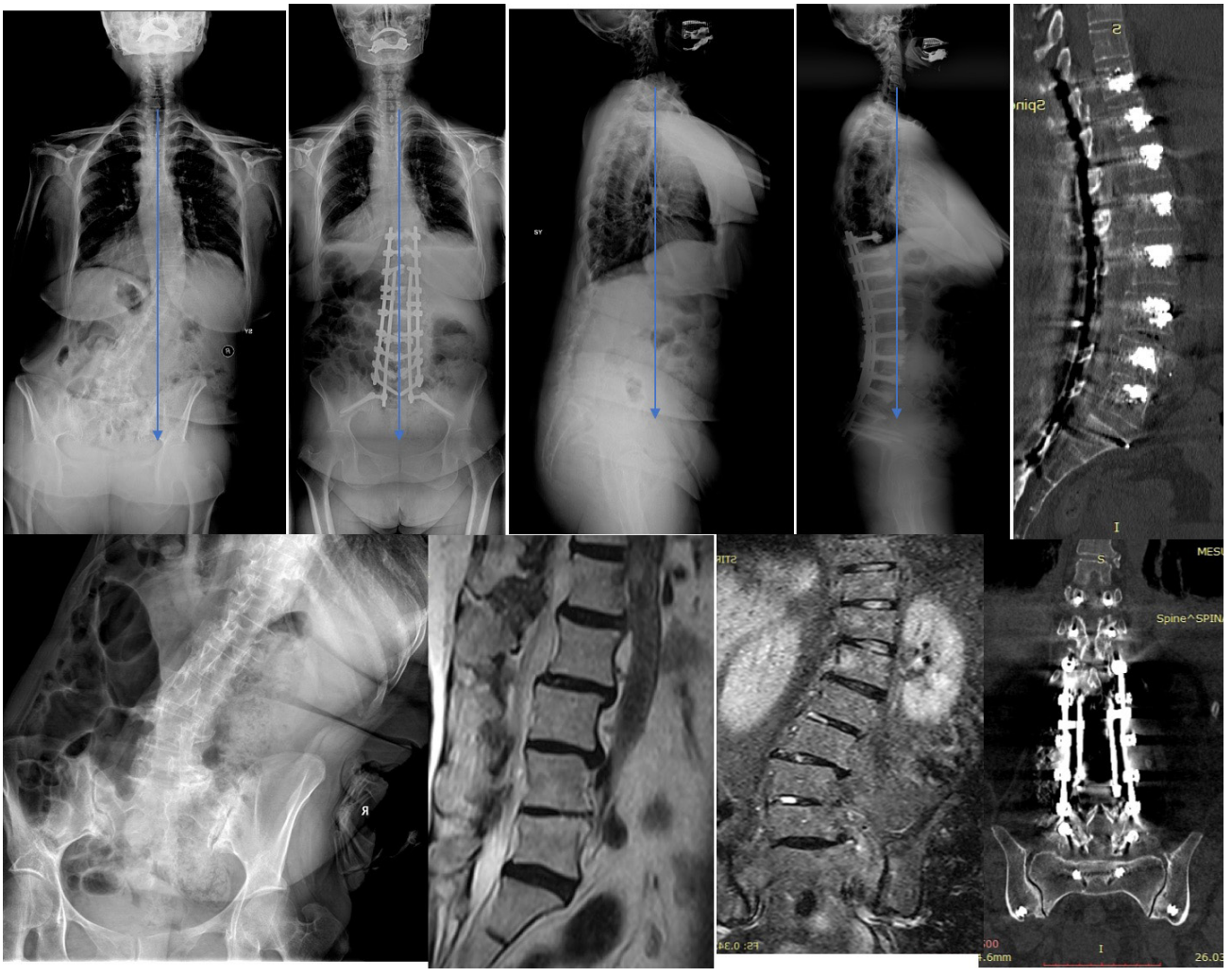

Figure-1. 65 years old female patient. Adult degenerative scoliosis with coronal and sagittal imbalance is obvious in preoperative radiological assessment. The global spinal balance restored by T10-S1 posterior instrumentation with fenestrated pedicle screws, cement augmentation and distal iliac fixation.

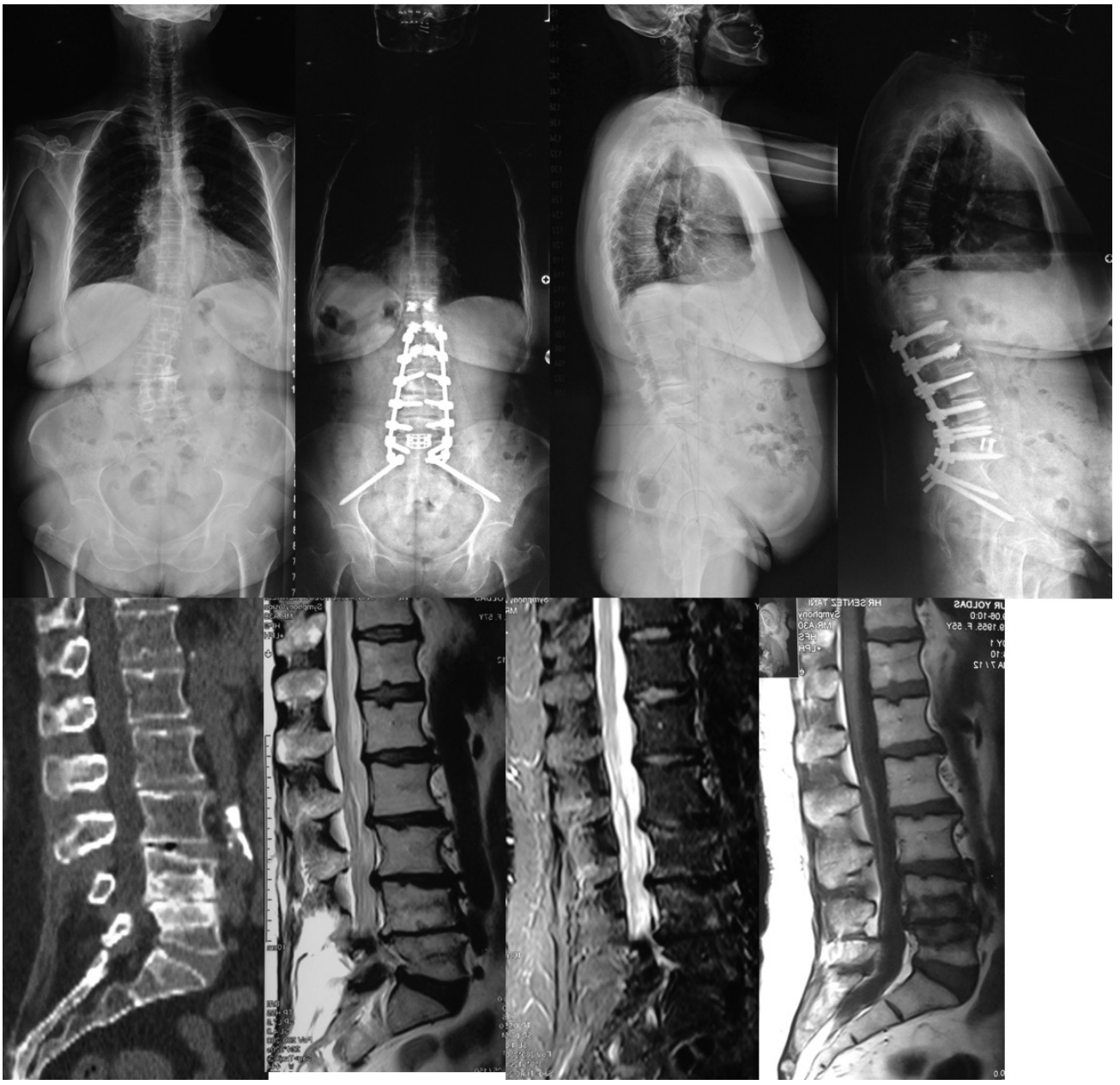

Figure-2. 74 years old female patient. Lumbar spinal stenosis and degenerative de novo scoliosis. Posterior L1-Iliac instrumentation and TLIF at L5-S1 level were performed.

These osteotomies are mainly used to correct sagittal alignment. However, with the biplane pedicle subtraction osteotomy, coronal and sagittal plane correction is possible.

Pelvic fixation should be considered and utilized when there are greater biomechanical stresses expected than S1 screws can withstand. An inability to achieve adequate fixation strength through sacral screws only can lead to an unacceptably high risk of implant loosening, pseudarthrosis, and failure. In this regard, the primary goal of pelvic fixation is to ensure a stable foundation for the construct and allow for maintenance of the deformity correction and solid arthrodesis [13]. Indications of pelvic fixation are high grade spondylolisthesis (Meyerding Grade 3-4), long fusions to sacrum (extends L2 vertebra or more proximal), the use of corrective osteotomies and osteoporosis that effects the pullout strength of the S1 pedicle screws.

COMPLICATIONS FOLLOWING SURGERY

Numerous studies have reported the incidence of complications of adult scoliosis surgery. Early surgical complications are

iatrogenic neurologic injury (27.8 %) [19], dural tear (2.2 %) [21], surgical site infections (4.1 %) [17] bleeding and hematoma (8.9 %) [16]. Most of the late complications are related with implant related complications include breakage, malposition, migration/dislodgement, and pain/prominence (32 %) [20]. There is also medical complications consist of death, myocardial infarction, ileus, deep vein thrombosis (DVT) and urinary tract infections. Despite the relatively high rates of associated complications and adverse events, multiple studies have demonstrated the potential of surgical treatment of adult spinal deformities including scoliosis to provide significant improvement in health-related quality of life measures.

CONCLUSION

Adult scoliosis is a complex, heterogeneous disease that encompasses a vast array of pathology and symptoms. Non-operative management runs the gamut from benign neglect to more invasive interventions such as epidural steroid injections.

Similarly, operative management can range from minimally invasive surgery and smaller open procedures to much larger operations addressing multiple levels of the spine. Traditional open surgery and minimally invasive surgery appear to benefit the patient, so long as the appropriate procedure is chosen. Emphasis on alignment goals and achieving a balanced spine are critical for patient improvement. Surgeons must understand the spinal deformity and the needs and goals of the patient in order to achieve a good outcome [9].

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REFERENCES

1. Aebi M. The adult scoliosis. Eur Spine J 2015; 14(10): 925–948.
2. Agabegi SS, Kazemi N, Sturm PF, Mehlman CT. Natural history of adolescent idiopathic scoliosis in skeletally mature patients: a critical review. *J Am Acad Orthop Surg* 2015; 23(12): 714–723.
3. Ailon T, Smith JS, Shaffrey CI, Lenke LG, Brodke D, Harrop JS, Fehlings M, Ames CP. Degenerative spinal deformity. *Neurosurgery* 2015; 77(4): S75–91.
4. Cheng JC, Castelein RM, Chu CC, Danielsson AJ, Dobbs MB, Grivas TB, Gurnett CA, Luk KD, Moreau A, Newton PO, Stokes IA, Weinstein SL, Burwell RG. Adolescent idiopathic scoliosis. *Nat Rev Dis Primers* 2015; 1: 15030.
5. Cheung WY, Lenke LG, Luk KD. Prediction of scoliosis correction with thoracic segmental pedicle screw constructs using fulcrum bending radiographs. *Spine* 2010; 35(5): 557–561.
6. Drazin D, Shirzadi A, Rosner J, Eboli P, Safee M, Baron EM, Liu JC, Acosta FL Jr. Complications and outcomes after spinal deformity surgery in the elderly: review of the existing literature and future directions. *Neurosurg Focus* 2011; 31(4): E3.
7. Glassman SD, Berven S, Bridwell K, Horton W, Dimar JR. Correlation of radiographic parameters and clinical symptoms in adult scoliosis. *Spine* 2005; 30(6): 682–688.
8. Gupta MC, Gupta S. Releases and osteotomies used for the correction of adult lumbar scoliosis. In: Klineberg E. (Ed.) *Adult Lumbar Scoliosis*. Springer, Cham 2017.
9. Hershman SH, Gornet ME, Kelly MP. Patient-Reported Outcomes Following the Treatment of Adult Lumbar Scoliosis. In: Klineberg E. (ed.). *Adult Lumbar Scoliosis*. Springer, Cham 2017.
10. Khan NR, Clark AJ, Lee SL, Venable GT, Rossi NB, Foley KT. Surgical outcomes for minimally invasive vs open transforaminal lumbar interbody fusion: an updated systematic review and meta-analysis. *Neurosurgery* 2015; 77(6): 847–874.
11. Lingard L, Espin S, Whyte S, Regehr G, Baker GR, Reznick R, Bohnen J, Orser B, Doran D, Grober E. Communication failures in the operating room: an observational classification of recurrent types and effects. *Qual Saf Health Care* 2004; 13(5): 330–334.
12. Marshall D, Johnell O, Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. *BMJ* 1996; 312: 1254–1259.
13. Raman T, Kebaish K. Distal fixation for adult lumbar scoliosis: indications and techniques. In: Klineberg E. (Ed.) *Adult Lumbar Scoliosis*. Springer, Cham 2017.
14. Schwab F, Dubey A, Gamez L, El Fegoun AB, Hwang K, Pagala M, Farcy JP. Adult scoliosis: prevalence, SF-36, and nutritional parameters in an elderly volunteer population. *Spine* 2005;30(9):1082–1085.
15. Scheer JK, Smith JS, Clark AJ, Lafage V, Kim HJ, Rolston JD, Eastlack R, Hart RA. Comprehensive study of back and leg pain improvements after adult spinal deformity surgery: analysis of 421 patients with 2-year follow-up and of the impact of the surgery on treatment satisfaction. *J Neurosurg Spine* 2015; 22(5): 540-543.
16. Smith JS, Shaffrey CI, Berven S, Glassman S, Hamill C, Horton W, Ondra S, Schwab F, Shainline M, Fu KM, Bridwell K; Spinal Deformity Study Group. Operative versus nonoperative treatment of leg pain in adults with scoliosis: a retrospective review of a prospective multicenter database with two-year follow-up. *Spine* 2009; 34(16): 1693–1698.
17. Smith JS, Shaffrey CI, Sansur CA, Berven SH, Fu KM, Broadstone PA, Choma TJ, Goytan MJ, Noordeen HH, Knapp DR Jr, Hart RA, Donaldson WF 3rd, Polly DW Jr, Perra JH, Boachie-Adjei O; Scoliosis Research Society Morbidity and Mortality Committee. Rates of infection after spine surgery based on 108,419 procedures: a report from the Scoliosis Research Society Morbidity and Mortality Committee. *Spine* 2011; 36: 556–563.

18. Smith JS, Shaffrey CI, Fu KM, Scheer JK, Bess S, Lafage V, Schwab F, Ames CP. Clinical and radiographic evaluation of the adult spinal deformity patient. *Neurosurg Clin N Am* 2013; 24(2): 143–156.

19. Smith JS, Klineberg E, Lafage V Shaffrey CI, Schwab F, Lafage R, Hostin R, Mundis GM Jr, Errico TJ, Kim HJ, Protopsaltis TS, Hamilton DK, Scheer JK, Soroceanu A, Kelly MP, Line B, Gupta M, Deviren V, Hart R, Burton DC, Bess S, Ames CP; International Spine Study Group. Prospective multicenter assessment of perioperative and minimum two-year postoperative complication rates associated with adult spinal deformity surgery. *J Neurosurg Spine* 2016; 25: 1–14.

20. Soroceanu A, Diebo BG, Burton D, Smith JS, Deviren V, Shaffrey C, Kim H. Radiographical and implant-related complications in adult spinal deformity surgery: incidence, patient risk factors, and impact on health-related quality of life. *Spine* 2015; 40: 1414-1421.

21. Williams BJ, Sansur CA, Smith JS, Berven SH, Broadstone PA, Choma TJ, Goytan MJ, Noordeen HH, Knapp DR Jr, Hart RA, Zeller RD, Donaldson WF 3rd, Polly DW Jr, Perra JH, Boachie-Adjei O, Shaffrey CI. Incidence of unintended durotomy in spine surgery based on 108,478 cases. *Neurosurgery* 2011; 68: 117–123.

22. Youssef JA, Orndorff DO, Patty CA, Scott MA, Price HL, Hamlin LF, Williams TL, Uribe JS, Deviren V. Current status of adult spinal deformity. *Global Spine J* 2013; 3(1): 51–62.