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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 Surgery 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.

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.

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 rationale 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 "Bisphosphonates 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, difficulty 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 references 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 spring to all my colleagues and their families. We are happy to accomplish the second issue of 2018.

There are 12 clinical research articles in this issue. These are an anatomical variation, a morphologıcal analysis, 5 sagittal plane analysis, 1 spinal trauma, 5 disc disease articles. 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 spring to Turkish Spinal Surgery family and we present our deepest respects.

Prof. Dr. İ. Teoman BENLİ
JTSS Editor

EDITORIAL

ORIGINAL ARTICLES

ANATOMICAL VARIATIONS

MORPHOMETRIC ANALYSIS

SAGITTAL PLANE

SPINAL TRAUMA

DISC DISEASE

Volume: 29, Issue: 2, April 2018 pp: 67-74 ORIGINAL ARTICLE

ANATOMICAL VARIATIONS OF INTRAOSSEOUS VERTEBRAL ARTERY IN C2 VERTEBRA WITH CT ANGIOGRAPHY PREVALENCE STUDY

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*** Conflict of interest:** The authors declare that they have no conflict of interest.
*** Ethical approval:** Informed consent was obtained from the patient who was presented in this work. The local ethics committee was approved out our work.

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ABSTRACT

Objectives: Vertebral artery (VA) injury as a complication of C1–C2 transarticular or C2 pedicular screw placement is commonly related to the anatomic positional variations of the VA in C2 intraosseous canal. These variations cause the C2 isthmus or pedicle, which constitute the screw path, to be narrower than normal. Narrowing of the C2 isthmus is well known as a high-riding pattern of VA (HRVA), and narrowing of the C2 pedicle is, recently, named as a medial-shifting pattern of VA (MSVA). Herein, we investigated the prevalence of HRVA and MSVA in general population.

Methods: The study population was represented by 216 CT-angiograms consecutively pulled from our radiology database (125 male, 91 female, mean age 62,7 years). VAs were assessed for the anomalous course in the C2 vertebra by measurements of isthmus thickness, internal height, and pedicle width. Particular note was made on VA dominance.

Results: In 53 (24 %) of the 216 patients, there was at least one VA variation. HRVA was identified in 40 (18 %) and MSVA in 45 (20,8 %) patients. Ipsilateral co-occurrence of HRVA and MSVA was highly significant (P<0,01). The relationship between VA dominance and variations was statistically significant (P<0,05).

Conclusions: Because of the high prevalence of various intraosseous courses of VA and also high possibility of ipsilateral co-occurrence of HRVA, MSVA and as well as dominant VA, preoperative imaging should be performed if C2 instrumentation required.

Keywords: CT; CT angiography; Vertebral 24 artery; C2 vertebra; Vascular injuries

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Intraosseous vertebral artery (VA) at the level of the C2 vertebra is reported to show asymmetry between two sides, and vary widely between individuals [9,11,18]. Preoperative evaluation of VA is deemed essential to decrease the possibility of VA injury during C2 vertebra instrumentation. VA injury is not related solely to the proximity of the artery to the path of the screw, but also to the anatomic variations in the position of the VA in the C2 intraosseous canal. These variations cause the C2 isthmus or pedicle, which constitute the screw path, to be narrower than normal. VA frequently shows a lateral bending in the C2 vertebra just under the superior articular facet of the axis [9,18].

The path of the posterior C1-C2 transarticular screw traverses the isthmus of the C2 pars-interarticularis, passes the atlantoaxial joint and reaches the C1 lateral mass (Fig. 1a, b).

The C2 pedicle screw, on the other hand, reaches the C2 vertebral body by passing through the C2 vertebra pedicle (Fig. 1c, d).

The technical objective is to place the screw entirely within the bone for both techniques. In both conditions, the screw remains superior and posteromedial to the bending point of the intraosseous segment of VA [18]. When the artery shows a prominent superior or posterior course in the intraosseous path, it narrows the bony mass of the C2 vertebral isthmus and restricts the safe passage of the screw. This pattern of the VA is well known and has been named as 'high-riding vertebral artery' (HRVA). When the artery shows a prominent medial course in the intraosseous canal of C2, it may cause a

thinning of the pedicle. This condition - a narrow C2 pedicle has also been of concern to surgeons because the area for the passage of the C2 pedicle screw becomes restricted. More recently, this condition or pattern is referred to as 'medial-shifting vertebral artery' (MSVA) [7,11,27-28]. Both anatomic variations are significant in the selection of the technique in C2 instrumentation surgery. Therefore preoperative assessment of the VA at the level of the intraosseous canal of C2 is emphasized [87,12-13,15,19].

Here in, we aimed to determine the prevalence of the HRVA and MSVA and to examine the relationship between these two conditions. We also scrutinized the effect of age, sex, and laterality on both of these conditions. Besides, the rates of coexistence of HRVA and MSVA with dominant VA were analyzed.

MATERIALS AND METHODS

After approval by our institutional review board, we performed a retrospective review of the image data of consecutive 235 patients who underwent computed tomography (CT) angiography examination in a single institution from January-2013 to May-2016. CT-angiography studies were performed with a 16- or 64-multidetector CT scanner (Siemens Somatom Sensation 16, Siemens Medical Solution, Erlangen, Germany or Siemens Somatom Definition 64, Siemens Medical Solution, Forchheim, Germany). A non-ionic contrast agent (Ultravist 370 (iopromide); Schering, Berlin, Germany), with a total volume of 80 ml, was injected intravenously at a rate of 3 mL/sec. CT acquisition was obtained according to the standard protocol of our institution at arterial phase (usually 20 to 40 seconds after the injection). The parameters used were 90 kVp, 150 mAs, 0.75 mm collimation for 16 slices and 80 kVp, 150 mAs, 0.625 mm collimation for 64 slices. Both scanners used a 512 × 512 matrix and a selected field of view ranging from 180 to 240 mm. The CT-angiography files of 235 patients were collected from the servers of the department of radiology. Demographic data were obtained from each patient's electronic chart.

The indications for CT-angiography examination were including medical, vascular, neurological, and/or surgical conditions. Patients with medical conditions distorting the anatomy at the level of the C2 vertebra including a tumor, infection, acquired C1 or C2 deformities, trauma, and postoperative CT-angiography scans, and patients younger than 20 years old were excluded from the study.

Moreover, scans of patients with congenital cervical or craniovertebral junction anomalies were also excluded. In addition, scans with imaging artifacts (i.e., metal or motion artifacts) were excluded. First, DICOM files of CT-angiograms (transverse images with the reconstruction interval of 1.0 mm) were loaded onto the workstation using Siemens Syngo 3-dimensional tools (Leonardo, Siemens Medical System, Erlangen, Germany). Then the sagittal, coronal and axial MPR images that corresponded to the pedicle and isthmus of the C2 vertebra with 1.0 mm slice thickness were obtained using multi-planar reconstruction (MPR), and pedicle and isthmus measurements of the C2 vertebra were evaluated bilaterally.

An HRVA was defined using two parameters. Firstly, the isthmus thickness was measured on the sagittal MPR images by measuring the distance from dorsal to the ventral cortex of the isthmus at the level of the intraosseous canal as shown in Fig. 2a.

Secondly, the internal height was measured on sagittal images by measuring the distance between the roof of the intraosseous canal and superior facet of C2 lateral mass, as also shown in Fig. 2a.

Both of these parameters were measured on a sagittal image passing at the mid-portion of the atlantoaxial joint. An HRVA was considered when the isthmus thickness was less than 5 mm, and/or the internal height was less than 2 mm as previously described [8,14,18-19]. MSVA was defined on axial MPR images by using one parameter: the pedicle width measured at the level where the lateral cortical margin of the pedicle was clearly seen at the uppermost level of the intraosseous canal (Fig. 2b).

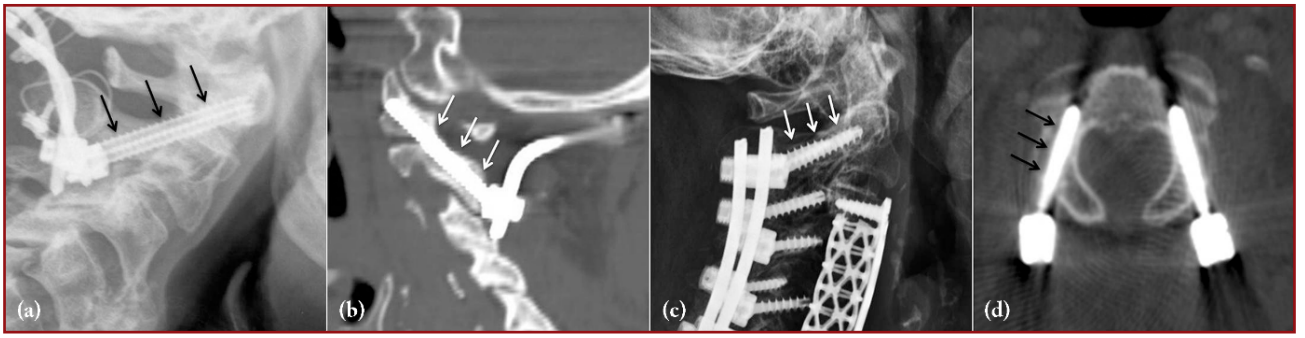

Figure-1. X-ray and CT demonstrations of the paths of the C1-C2 transarticular screw and C2 pedicle screw on two different patients. Postoperative lateral plain radiograph **(a)** and sagittal CT **(b)** images of a patient with unstable dens fracture. C1-C2 transarticular screw traverses the isthmus of the C2 pars-interarticularis, passing the atlantoaxial joint and reaching the lateral mass of C1 (black and white arrows). Postoperative lateral plain radiograph **(c)** and axial CT **(d)** images of a patient with cervical spinal stenosis. C2 pedicle screw passes the C2 isthmus and pedicle and reaches the C2 vertebral body (white and black arrows)

MSVA was considered to be present when the pedicle is narrower than 4 mm. The diameters of commonly used screws are 3.5 or 4.0 mm; therefore, pedicles with a width of less than 4 mm have been considered to be narrow in the literature [28].

Each scan was also evaluated for the presence or absence of side-to-side asymmetry of the VA (left or right-sided VA dominance or co-dominance). Cases of left or right-sided VA dominance were noted when the lumen diameter of the VA on one side was at least 30 % larger than that of the other side.

The presence or absence of an HRVA and 118 MSVA were determined for each side in all patients. The correlation between the high-riding and medial-shifting occurrences were examined accounting for age, sex, laterality, and existence of ipsilateral dominancy of VA.

Statistical Analysis

Isthmus thickness, internal height, and pedicle width measurements were made by a single experienced musculoskeletal radiologist analyzing eligible CT-angiograms of 216 patients for a total of 432 VAs. To ensure the reliability of our data, we re-examined the thickness, height and width scores for 45 randomly chosen (using 'sample' function in R-language) CT-angiograms (20% of total) after 8 weeks. For reliability tests, we used a two-tailed paired t-tests within a boot strapping framework. Difference distributions obtained from 10000 random comparisons (of size 25) between the first and second measurements for the same patients show that the two measurements are statistically equivalent in all three sets (0 belongs to 95 % CI).

Differences between isthmus thickness, internal height and pedicle width across different categorizations (male vs. female, right side vs. left side) were examined using a two-tailed Welch's t-test. We also examined the relationship between age and the pedicle and isthmus bone parameters of the C2 vertebra by using Pearson's product moment correlation. Pearson's chi-square test with Yates' continuity correction (to improve the approximation to discrete probabilities) was implemented to spot significant differences between occurrences of HRVA and MSVA across different categorizations (male vs. female, right side vs. left side) and to identify relationships between arterial pathologies and side to side VA asymmetry. Finally, to detect the relationship between age and HRVA and MSVA occurrences, we used comparisons based on Pearson's moment correlation test and a bivariate logistic regression search algorithm.

RESULTS

We excluded 19 patients based on the exclusion criteria. Finally, a total number of 216 patients, 91 females and 125 males, were enrolled in the study. The mean age of the study population was 62,7 years (range, 20–92 years).

The averaged values and corresponding ranges of the internal height, isthmus thickness, and pedicle width scores are depicted in table 1. Females had significantly lower values compared to males in terms of internal height, isthmus thickness and pedicle width scores (P<0,01) (Table-1).

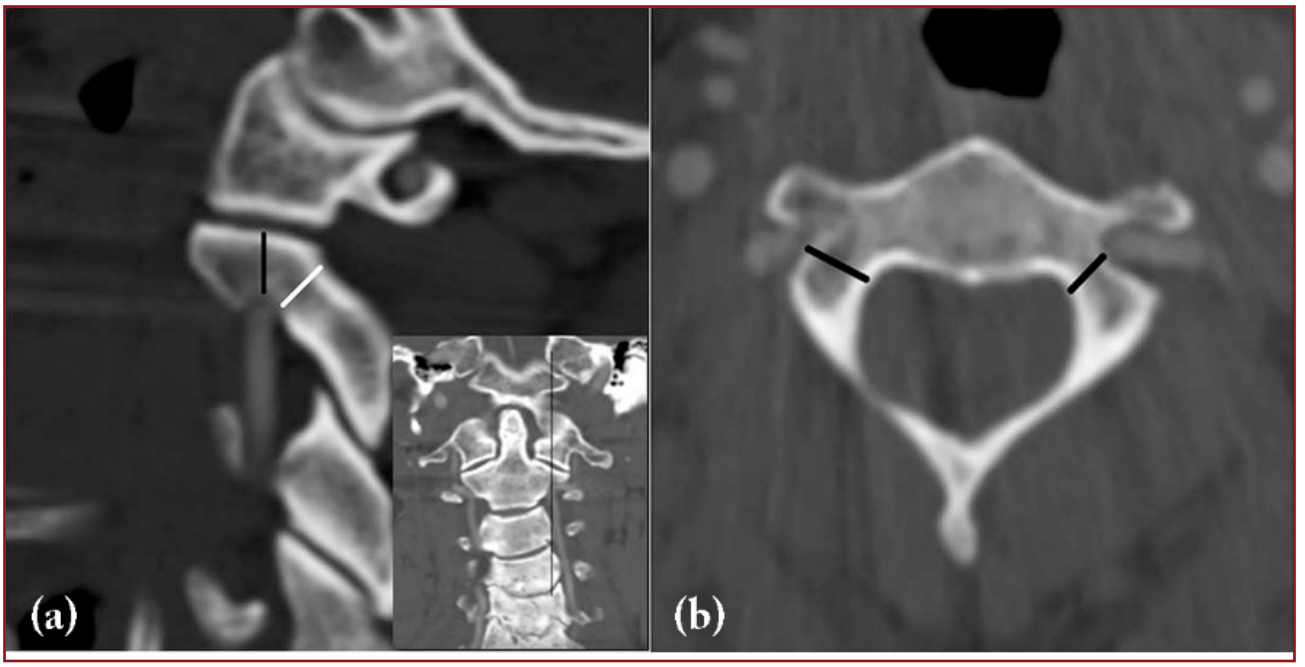

Figure-2. (a) Demonstrations of how to measure internal height (black line) and isthmus thickness (white line) on sagittal MPR image for defining high-riding variant. This sagittal image passes at the midpoint of the atlantoaxial joint as shown by the vertical thin black line on coronal image in smaller corner figure. **(b)** Demonstration of how to measure pedicle widths (black lines) on axial MPR image for defining medial-shifting variant

However, there was no significant difference between right and left sides when the male-female difference was ignored (*P*= 0,247). Correlations between bone parameters and age were close to zero and statistically insignificant.

In 53 (24 %) of the 216 patients, there was at least one abnormality in the intraosseous course of VA at the level of C2. In 40 (18 %) of 216 patients, an HRVA (Fig. 3) was detected either unilaterally or bilaterally. Of these 40 patients, 15 were men and 25 were women. MSVA (Fig. 4) was identified in 45 (20,8%) patients (18 men, 27 women). Distributions of VA variations across gender and laterality are shown in Table-2.

Overall there was a statistically significant difference between males and females for HRVA (propensity to have this condition was higher for women) (*P*<0,05) (Table-2). The difference between males and females concerning MSVA occurrence was also statistically significant (women scoring higher) which once again appeared at *P*<0,05 level (Table-2).

However, in both abnormalities when we ignored male-female distinction and solely focused on the right and left side occurrences we failed to spot any statistical difference (*P*=0,3). When we examined the correlations between increasing age categories (each comprising 10 years) and HRVA and MSVA occurrences, we again failed to detect any significant relationship (Table-3).

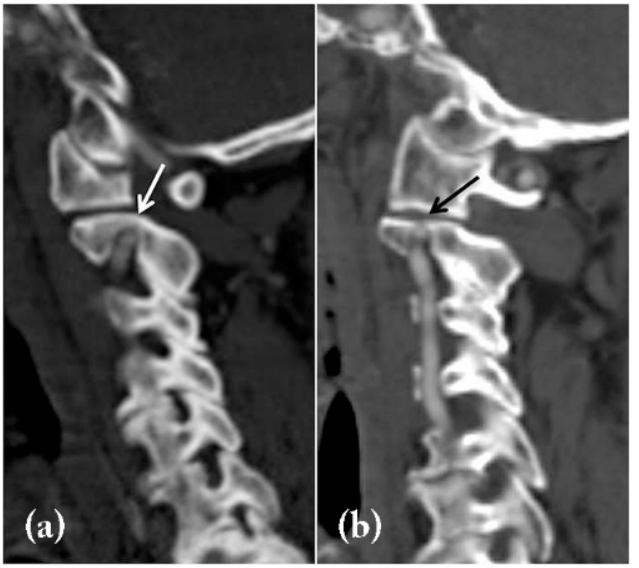

Figure-3. CT-angiography images of two different patients with high-riding VA. **(a)** Sagittal MPR image shows decrease of isthmus thickness (white arrow) and **(b)** sagittal MPR image shows decrease of internal height (black arrow)

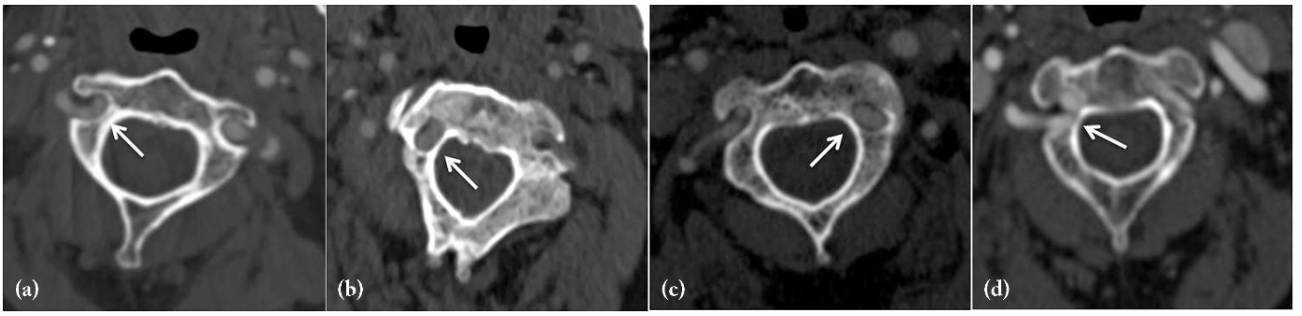

Figure 4. CT-angiography axial MPR images through the C2 intraosseous canal of four different patients demonstrate variable degrees of narrowing of pedicles indicating medial-shifting VA for each four cases (arrows)

Table 1. Descriptive statistics and male-female differences

	Male (n=125)				Female (n=91)				Differences			
	Mean	Sd	Min	Max	Mean	Sd	Min	Max	Mean	Se	P-value	
Internal height												
Right	4.29	1.00	1.5	7.1	3.46	1.03	1	6	0.83	0.14	0.000	**
Left	4.20	0.97	1.4	7.1	3.31	0.96	0.8	5.5	0.90	0.13	0.000	**
Isthmus thickness												
Right	6.53	1.16	3.5	8.9	5.77	1.17	2.7	8.7	0.76	0.16	0.000	**
Left	6.68	1.12	2.2	9.1	5.82	1.13	2.4	8.3	0.86	0.16	0.000	**
Pedicle width												
Right	5.56	1.339	0.1	9	4.93	1.30	1	7.5	0.63	0.18	0.001	**
Left	5.73	1.336	1.3	8.7	5.06	1.49	1.7	9.1	0.67	0.20	0.001	**

Sd: standard deviation
Se: standard error
**: significant at 0.01
P-values are derived from Welch's t-test.

Of all VAs 14,5 % (63/432) had at least one abnormality - either high-riding or medial-shifting variant, or both. There were 49 high-riding (11,3 %) and 54 medial-shifting VAs (12,5 %) among the 432 VAs. Of the MSVA group, 74,4 % (40/54) had a co-occurrent HRVA variation ipsilaterally. On the other hand, 81,6 % (40/49) of the high-riding VAs had concurrent MSVA variation (Table-4).

We detected unilateral VA dominance in 118 of our subjects 166 (55 % of 216). Left and right sided VA dominance were found in 83 (39 %) and 35 (16 %) subjects respectively. Among the arteries with anatomic variations (63/432), 36,5% (23/63) of these were observed on the artery of the dominant side, 12,6% (8/63) on the non-dominant artery and 50,7 % (32/63) in co-dominant cases.

The laterality of the arterial variation and the VA dominance were more likely to occur on the same side than on opposite sides, and this co-occurrence was more frequent for the left side. When we ignored the co-dominant cases, the laterality of VA dominance and variations were correlated. This relationship between laterality of arterial variation and VA dominance was statistically significant (P<0,05) (Table-5).

Table 2. Distribution of variations across gender and laterality

Arterial variations	Male (n=125)	Female (n=91)	P-value	
High-riding	15	25	0.0066	**
Right	7	6	0.7459	
Left	6	12	0.0314	*
Bileteral	2	7	0.0392	*
Medial-shifting	18	27	0.0105	*
Right	9	9	0.5783	
Left	6	12	0.0394	*
Bilateral	3	6	0.1606	

**: significant at 0.01
* : significant at 0.05
P-values are derived from Pearson's Chi- square test with Yates' continuity correction.

Table 3. Relationship between age and VA variations

Age intervals	Observations	Age	High-riding		Medial-shifting		Correlations		
		I	II	III	IV	V			
		Increasing intervals	Counts	%	Counts	%	Correlating variables	r	P-value
20-29	11	1	1	9.1	4	36.4			
30-39	17	2	3	17.6	2	11.8	I-II	0.394	0.3812
40-49	17	3	4	23.5	4	23.5	I-III	-0.139	0.7660
50-59	36	4	9	25	9	25	I-IV	0.333	0.4650
60-69	44	5	11	25	12	27.3	I-V	-0.554	0.1963
70-79	63	6	11	17.5	13	20.6	I-III"	0.566	0.2412
80-89^	27	7	1	3.7	1	3.7	I-V"	-0.205	0.6966

r: Pearson's product-moment correlation coefficient.
P-values are derived from correlation test based on t distribution with n-2 df where n is the number of categories.
If p-value > 0.1 then true population correlation equals to zero.
": seventh age category is ignored in these estimations.
^: There is only a single person in 90-99 age interval. This patient is not included into the analysis.

Table 4. Co-occurrence of high-riding and medial-shifting

		Medial-shifting		
		No	Yes	
High-riding	No	369	14	%
	Yes	9	**40**	81.6
		%	74.4	P-value=0.0000 **

**: significant at 0.01
P-value is derived from Pearson's Chi-square test with Yates' continuity correction.

Table 5. Relationship between arterial dominancy and laterality of VA variations

		Dominancy of VA			
		Codominant	Left	Right	
High-riding or Medial-shifting	None	164	148	57	
	Left	19	12	2	
	Right	13	6	11	p-value= 0.01368 *

* : significant at 0.05
P-value is derived from Pearson's Chi-square test with Yates' continuity correction.

DISCUSSION

Up to now, four studies have been evaluated the narrow pedicle concept separately from the HRVA concept. Yeom et al. [28] and Wajanavisit et al. [21] assessed non-enhanced CT of 269 and 200 consecutive patients respectively. However, they did not evaluate the relationships of these variations with age, sex, and laterality with the VA dominance.

On the other hand, Lee et al. [11] and Maki et al. [14] separated the arterial variation into two groups as high-riding and medial-shifting, and each study assessed 100 patients with CT-angiography. Nevertheless, the major limitations of those studies were the small number of patients. To the best of our knowledge, we have conducted the first CT-angiographic study, which separately investigates these two intraosseous VA variations on a sufficiently large number of subjects.

The posterior C1-C2 transarticular screw fixation technique developed by Magerl et al. [13] is used successfully in craniovertebral junction stabilization surgery as an effective method for achieving fusion [2,6,12-13,24-25]. However, VA injury is a potential complication, which may lead to morbidity and mortality [2,6,12,24-25]. According to previous studies, the rate of vertebral artery injury of C1-C2 transarticular screw placement ranges from 4.1 % to 8.2 % and the reported rate of neurologic events from VA injury is 0.2 % per patient (1.9 % per VA injury) [2,12,18,25]. The HRVA is known as one of the significant causes of this complication [15,19].

C2 pedicle screw insertion has become a favorite technique for numerous conditions that require C2 vertebra fixation, and during this procedure, a narrow C2 pedicle would also predispose to VA injury [1,4,11,27,29]. Jian et al. [10] reported on a patient in whom one of the C2 pedicle screws was inserted into the C2 intraosseous canal during an occipitocervical posterior fusion operation. The VA injury in this patient resulted in a thrombosis with subsequent brain stem infarction.

Non-enhanced CT is the commonly utilized method for detecting both HRVA and MSVA conditions preoperatively. The assessment is generally carried out by measuring the bone parameters in the C2 intraosseous canal using thin-slice reformatted CT images [2,5,14,22,26].

However, numerous authors have emphasized that the assessment of the VA is as significant as the evaluation of the osseous canal and advocated the assessment of preoperative risk by CT angiography [5,11,16,22,26-27]. Compared to the non-enhanced CT, the additional advantages of CT angiography over non-enhanced CT include ability to determine the presence or absence of dominant VA, the ratio of the VA diameter to the interosseous canal diameter, show relative position of the VA within the C2 canal with respect to the bony edges of the canal, and detect the other vertebral artery anomalies.

Depending on the methods and descriptions, the prevalence of HRVA ranges between 11,7 % and 23 % and the prevalence of narrow pedicle/MSVA reported as between 9,5 % and 32 % [12,14-15,18-19,22-23]. In our study, the prevalence of HRVA and MSVA were 18 % and 20,8 %, respectively, and we observed both VA variations were more common in females as similar to those of previous studies.

We did not observe any significant correlation between age and the HRVA-MSVA. However, Lee et al. [11] showed that both high-riding and medial-shifting pattern of VA positively correlated with age and they claimed this might be associated the age-related degenerative process and arterial tortuosity. They also suggested arterial ectasia and/or tortuosity might increase the risk of arterial injury as the arteries occupy a larger area in the intraosseous canal and become more vulnerable.

For patients who have asymmetry of the VA and high-riding and/or medial-shifting variant at the dominant artery side, screw placement procedures should be undertaken carefully or abandoned [5,25]. If the dominant VA is injured during surgery, the incidence of neurologic events will be increased. Notably, in our study, slightly more than one-third of all cases with VA variation were observed at the side of the dominant VA contrary to previous studies, in which the relationship between the VA variations and VA dominance was not significant [11,27]. We suggested the small sample size in these studies might have led the inconsistencies between the results. We highlight that VA asymmetry should be considered and investigated for patients who had HRVA and/or MSVA detected on non-enhanced CT examination when C2 instrumentation required, particularly for those on the left side.

We had several limitations in our study. First, we used two-dimensional measurements for defining HRVA and MSVA variations. A three-dimensional evaluation would probably

give more precise results for this complex anatomy. In fact, defining easy-to-use three-dimensional measurement parameters for these VA variations would be a fascinating subject for further study.

Second, lacking the assessment of VA anomalies above or below C2 level should be noted as another limitation of our study. It would also be prudent to emphasize that the incidence of anatomical VA variations might be more common in patients with congenital malformations of the cervical spine.

In conclusion, the VAs showed at least one variation in 24 % of our population with high possibility of ipsilateral co-occurrence dominant side; hence, we emphasize VAs should be assessed preoperatively if C2 screw placement required.

Key Points

• VA injury is a potential complication of C2 instrumentation surgery
• 24 % of population have at least one VA variation at the level of C2 intraosseous canal
• In cases with dominant VA, the laterality of VA dominance and variations were correlated
• Preoperative assessment of the varieties courses of VA at the level of C2 is necessary

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Volume: 29, Issue: 2, April 2018 pp: 75-81 ORIGINAL ARTICLE

MORPHOMETRIC ANALYSIS OF POSTERIOR FOSSA AND CRANIAL-VERTEBRAL JUNCTION IN PEDIATRIC CHIARI 1 MALFORMATION

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ABSTRACT

Introduction: Chiari malformations (CMs) are a group of disorders defined by anatomic anomalies of the cerebellum, brainstem, and cranial-vertebral junction (CVJ). We aimed to reveal the differences between pediatric CM-1 and control group according to volume, length and angle of cranium and CVJ.

Material and Methods: We retrospectively evaluated CM-1 patients who were admitted to our hospital between January 2012 and February 2016. Control group was choice from patients who did not have any intracranial pathology. We made necessary volume, length and angle evaluations with the help of special radiological programs.

Results: We evaluated 27 patients; 12 CM-1 cases and 15 control cases. Mean age in patient group was 12,66 ± 4,41 (2-17 years) years. Mean age in control group is 10,40 ± 4,62 (4-17 years) years. We found statistically significant in comparison of CD angle (p: 0,007) and C-SO angle (p: 0,017).

Conclusion: There is no difference between pediatric CM-1 patients and healthy group according to intracranial volumes, length and angle of cranial-vertebral junction. Clive-dental angle is narrower in pediatric CM-1 patients. This sharp passage leads to brain stem compression symptoms.

Keywords: Morphometry, posterior fossa, cranial-vertebral junction, Chiari malformation, type 1

Level of Evidence: Retrospective Clinical Study, Level III

INTRODUCTION

Chiari malformations (CMs) are a heterogeneous group of disorders that are defined by anatomic anomalies of the cerebellum, brainstem, and cranial-vertebral junction (CVJ), with downward displacement of the cerebellum, either alone or together with the lower medulla, into the spinal canal [28]. Chiari malformations were first described by John Cleland in 1883 [5,26]. Hans Chiari later classified them in 1891, into four groups. The pathology is a result of the underdevelopment of the para-axial mesoderm [22,24,30]. Consequently, the components of the posterior fossa outgrow the underdeveloped compartment and cause the herniation of the tonsils into the upper cervical spinal canal [33]. Several studies have attributed this insufficient posterior cranial fossa geometry to embryological defects in the paraxial mesoderm [20,22,34].

A fundamental knowledge of the normal anatomy of the cranial base, especially the foramen magnum and associated structures, is important to the clinician for accurate diagnosis and treatment of various diseases [16]. The cranial base has been noted for its ability to remain intact in cases where the rest of the cranium has been compromised and researchers have made use of that fact by analyzing sexually significant dimorphic trait for this anatomic region [12,14].

In this study, our purposes are 1) to establish whether the posterior fossa volume (PFV) is indeed different in individuals with pediatric CM-1than in healthy individuals, 2) to investigate the correlation within PFV, the area of foramen magnum (FMA) and intracerebral volume (ICV), 3) to understand the pathophysiology of CM-1.

MATERIAL AND METHODS

Patient population

We studied 12 patients and 15 control cases. A retrospective review of patients evaluated or operated for Chiari malformation type 1(CM-1) at the hospital between December 2012 and February 2016 was performed. The study group included patients all CM-1 with or without symptoms. We excluded the patients who do not have data to evaluate cranial volume and morphology. The control cases were included into study from patients admitted to hospital for headache or any reason without any intracranial pathology.

Definition of Chiari malformations

In classical classification [28-29];

- Chiari I malformation (CM-I) is characterized by abnormally shaped cerebellar tonsils that are displaced below the level of the foramen magnum,
- Chiari II malformation (CM-II) is characterized by downward displacement of the cerebellar vermis and tonsils, a brainstem malformation with beaked midbrain on neuroimaging, and a spinal myelomeningocele,
- Chiari III malformation (CM-III) is rare and combines a small posterior fossa with a high cervical or occipital encephalocele, usually with displacement of cerebellar structures into the encephalocele, and often with inferior displacement of the brainstem into the spinal canal,
- Chiari IV malformation (CM-IV) is now considered an obsolete term that describes cerebellar hypoplasia unrelated to the other Chiari malformations.

Radiological evaluation

The protocol for evaluating CMs included a lateral view radiograph of the CVJ. All patients underwent MRI (Sigma 1.5-Tesla; General Electric, Milwaukee, WI, USA). The T2-weighted MRI sequence was used for all measurements. Linear dimensions were derived using Extreme Pacs Workstation 1.5 software (Extreme PACS Healthcare, Ankara, Turkey). MRI of the CVJ at 5 mm intervals parallel to the orbitomental line was performed to determine a plane parallel to the foramen magnum (FM). The measurement of CD was performed on MRI sequences using the same software.

Measurement of volume

Calculation of spheroidal PFV was based on a simple spheroidal formula [13].

PFV=4/3 x ∏ x (X/2 x Y/2 x Z/2)

where: x is the anterior posterior measurement from the posterior clinoid process to the torcula; y is the height of the posterior fossa measured from the basion to the peak of the tentorium cerebelli; and z is the maximum width of the posterior fossa (Figure-1).

The ICV in children was calculated using a Dekaban spheroidal formula, which estimates the cranial volume in individuals up to20 years of age (t = thickness of the skull and scalp thickness) [1,18-19]:

ICV (cm^3) = 0,523 . (length – 2t) x (breadth – 2t) x (height – t) (Figure-2).

Measurement of FM area

The area of Foramen magnum was calculated using formula derived by Radinsky [27].

Radinsky's Formula (FMA) = 1/4 x FML x FMW

Where, (mathematical constant) = 22/7, FML = Foramen magnum length and FMW = Foramen magnum width (Figure-3).

Length of the clivus and sub-occiput

The length of the clivus (LoC) was defined as the distance from the topof the dorsum sellae to the basion, and the length of the suboccipu t (LoSO) was measured between the internal occipital protuberance and the opisthion [24] (Figure-4).

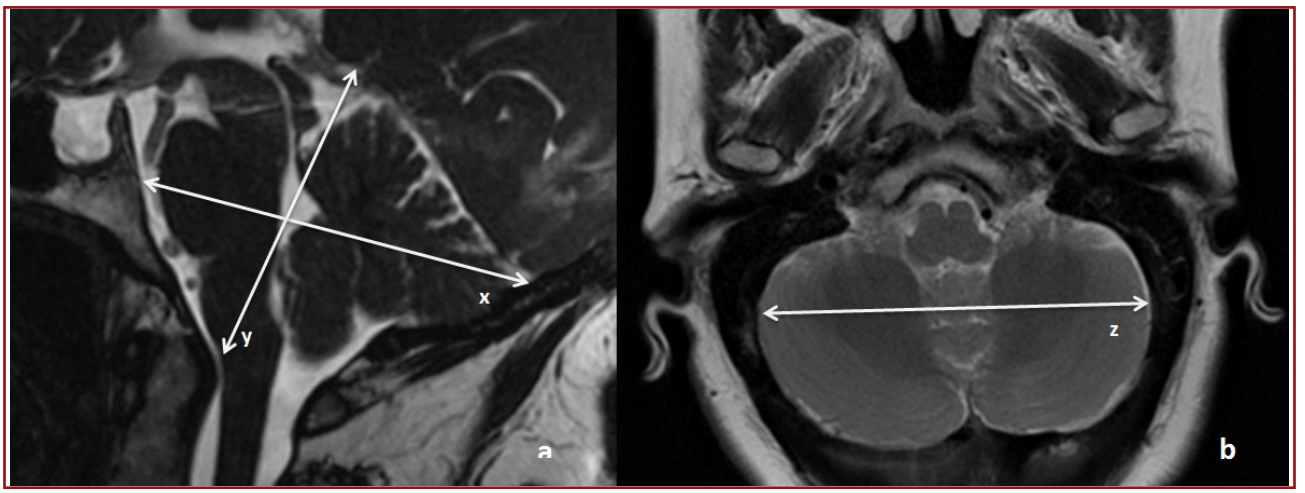

Figure-1. Spheroidal PFV is calculated using simple spheroidal formula.

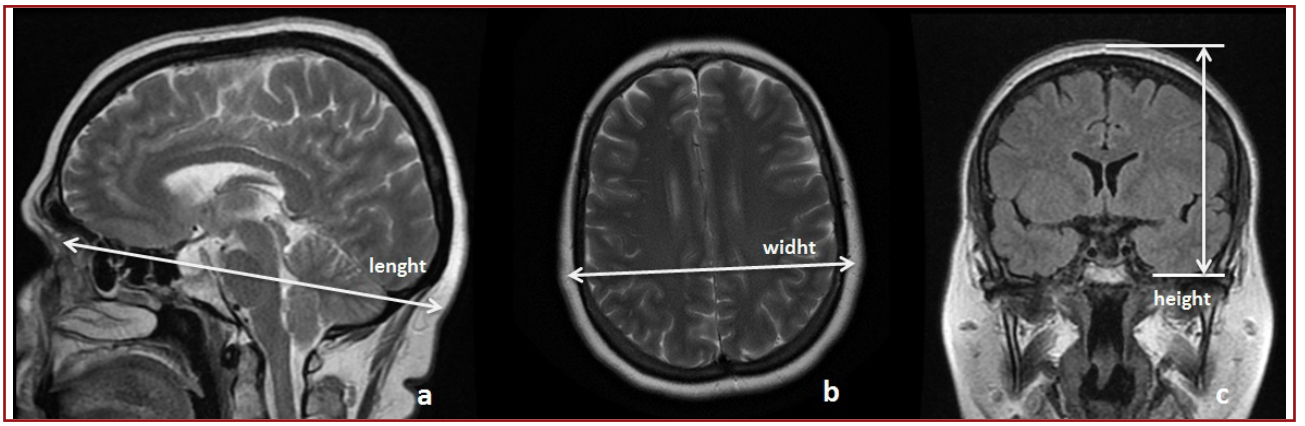

Figure-2. In children (<20 yrs), ISV was calculated using the Dekaban spheroidal formula

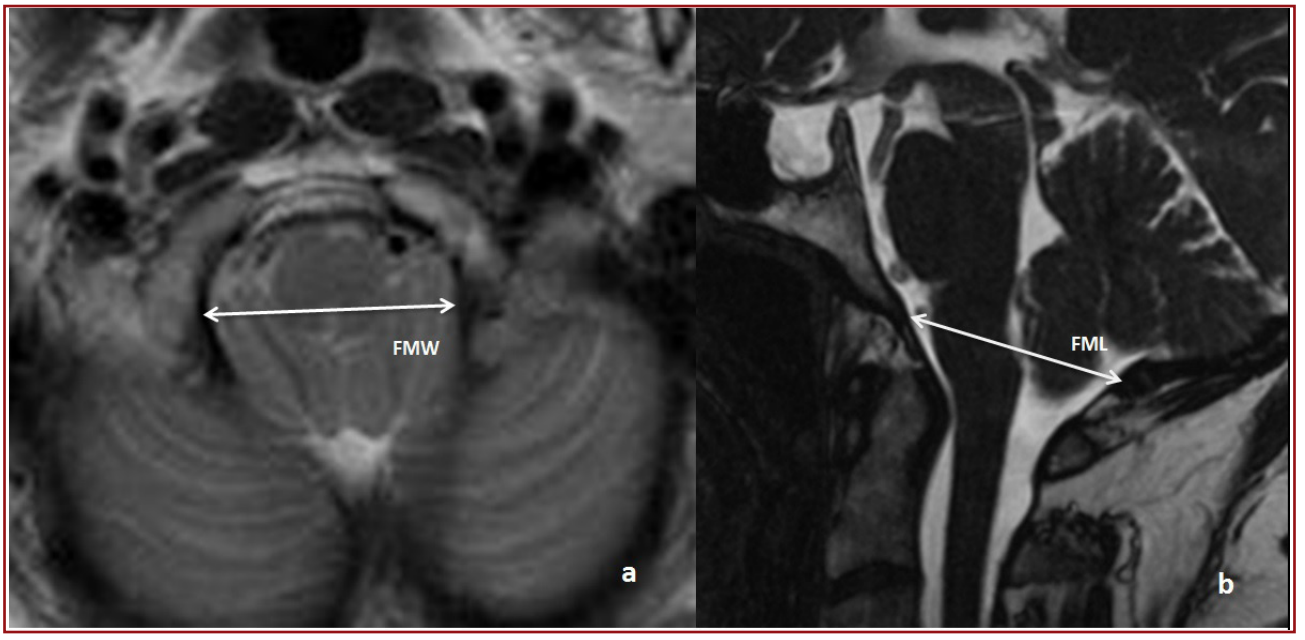

Figure-3. The formula created by Radinsky was used to calculate the Foramen magnum (FM) field.

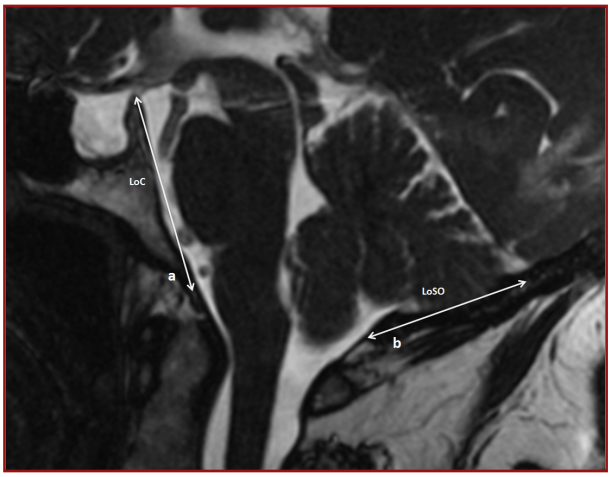

Figure-4. The length of the clivus (LoC), the distance from the top of the dorsum sella to basion; the length of the suboccipital (LoSO), the length between the internal occipital protuberance and the opistion

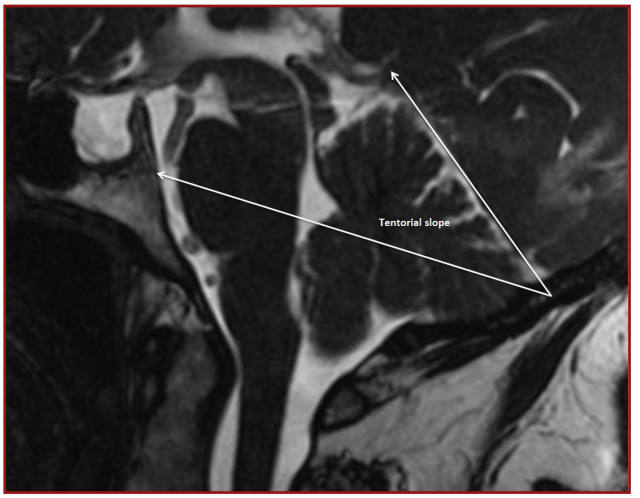

Figure-5. Tentorial slope (TS) was obtained by measuring the angle between the tentorium and the Twining line in the midsagittal cranial MR scan.

Tentorial slope

Tentorial slope (TS) was obtained by measuring the angle between the tentorium and Twining's line on a midsagittal head MR scan (Figure-5).

Clivo-dental angle

Clivo-dental angle (CD angle) is called as Wackenheim clivus base line or cranial-vertebral angle. It is constructed by drawing a line along the clivus and extrapolating inferiorly into upper cervical spinal canal along posterior surface of odontoid bone (Figure-6).

This line should fall tangent to the posterior aspect of the tip of the odontoid process [36].

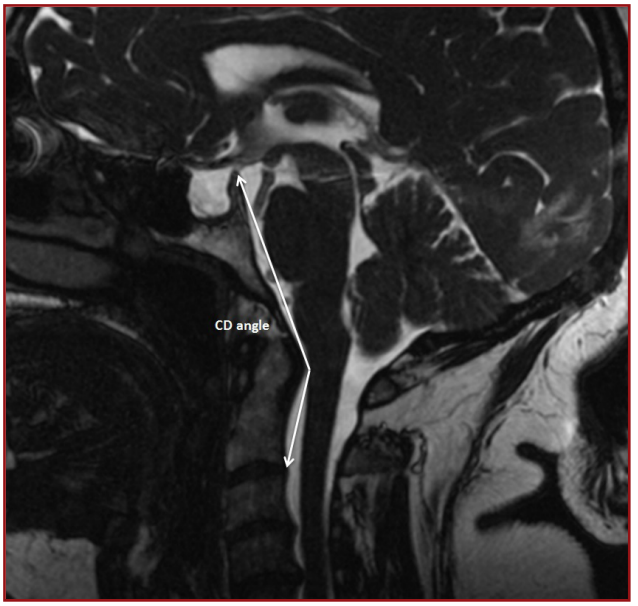

Figure-6. Klivo-Dental Angle (CD Angle) is called Wackenheim Klivus Baseline or Cranial-vertebral Angle. Drawing a line through the clivus and along the posterior surface of the odontoid bone, the upper cervical spinal canal is got at inferiorly. This line should be tangential to the posterior face of the odontoid process tip.

Angle of the clivus and tentorium

The angle between clivus and tentorium (C-T angle) is important for superior compression to structures of posterior fossa. It is constructed by drawing a line along the clivus and another line along the tentorium (Figure-7).

Angle of the clivus and subocciput

The angle between clivus and sub-occiput (C-SO angle) is like a mouth of cone between the clivus and subocciput. It is constructed by drawing a line along the clivus and another line along the subocciput (Figure-8).

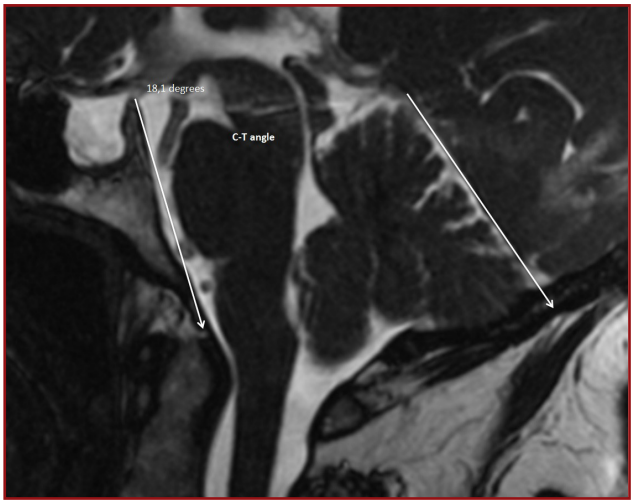

Figure-7. Clivus and Tentorium Angle (C-T angle) is important in the posterior fossa compression superiorly. It was created by drawing a line through clivus and another line through the tentorium.

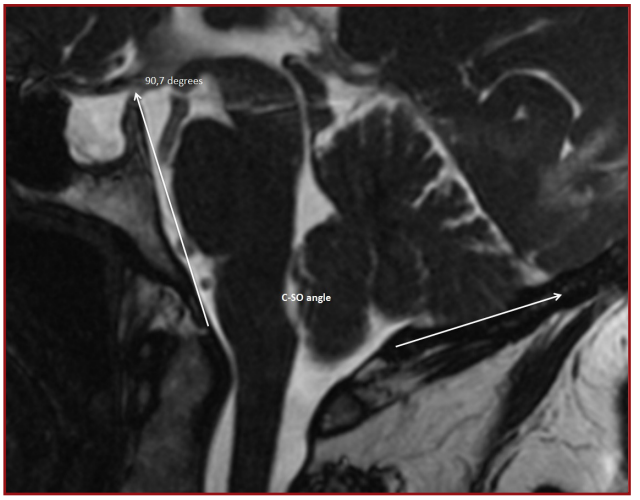

Figure-8. The angle between the clivus and suboxiput (C-SO angle) is similar to the cone mouth. It was created by drawing a line through clivus and another line along the subocciput

Statistical analysis

The data was collected, tabulated and statistically analyzed. Data was analyzed using IBM SPSS program. Descriptive statistics including range, mean and standard deviation was calculated for each parameter. We assessed test of normality with Kolmogorov- Simirnov test. For normal distribution, we assessed mean differences in dimensions of the posterior fossa, volume of posterior fossa and measurements of the occipital bone for study and control groups using independent-sample Student's t-tests. Significance was indicated by a two-tailed with p value < 0.05, and 95% confidence intervals. For abnormal distribution we used the tests of One way ANOVA, Mann Whitney U and Kruskall Wallis

RESULTS

In our study, 27 cases were evaluated. The cases were 12 patients with CM-1 and 15 ones were control group. The age range of the patient group ranged from 2 to 17 years with a mean age of 12.66 ± 4.41. The age range of the control group ranged from 4 to 17 years, with an average age of 10.40 ± 4.62. Gender distribution in the patient group was 5 male, 7 female; In the control group, sex distribution was 6 males, 9 females. Table 1 summarizes the results between the patient and control group and age and gender in our study (Table-1).

In our study, comparative CD Angle (p: 0,007) and C-SO Angle (p: 0,017) were statistically significant (Table-2).

Table 1. Distribution of age and sex in patient and control groups

		Groups			
		Patient		Control	
		n	Mean±SD	n	Mean±SD
Sex	Male	5		6	
	Female	7		9	
Age			12,66±4,41		10,40±4,62

DISCUSSION

The posterior cranial fossa (PCF) is the most posterior aspect of the skull base and it houses the brainstem, cranial nerves and cerebellum. The basilar, condylar and squamous parts of the occipital bone and the mastoid part of the temporal bone form the floor of the PCF. PCF has a roof formed by the tentorium cerebelli, which is a fold of the dura. The cranial-vertebral (or craniocervical) junction (CVJ) is a collective term that refers to the occiput (posterior skull base}, atlas, axis, and supporting ligaments. PCF has rhomboid shape. The floor of rhomboid is composed of clivus and supraocciput, the roof is composed of tentorium cerebelli and mesencephalic aperture.

CM is the downward displacement of the caudal part of the cerebellum and/or medulla oblongata into the spinal canal [8]. The pathogenesis of CM is incompletely understood. CM is considered to be a primary neurological disease involving the posterior cranial fossa and the hindbrain [4]. Many investigators have tried to explain the pathogenesis of CM from the standpoint of primary neural anomaly [4,11,21]. However, clinical and experimental studies indicate that the chronic tonsillar herniation observed in CM could result from overcrowding within a primary small and shallow PCF due to an underdeveloped occipital bone [24]. It is produced by a raised intracranial pressure, which has a varied etiology like hydrocephalus, space occupying lesions and a malformed posterior fossa. When the study of Milhorat TH et al was correlated with etiological factors, the following causal mechanisms were suggested: (1) cranial constriction; (2) cranial settling; (3) spinal cord tethering; (4) intracranial hypertension; and (5) intraspinal hypotension [23].

Sgouros S et al. have shown a study of cranial development in healthy children the rate of increase in intracranial volume is not linear throughout the examined period but displays different phases. There is a rapid linear growth during the first 5 years of life. In subsequent years, growth continues but at a much slower rate, with a mild spurt starting at approximately 10 years and lasting for an additional 5 years. This model of intracranial volume growth slightly differs from models based on skull radiographs in both the rate of growth in the first 5 years and the absolute volume values [31].

Table 2. Comparison of volume, length and angle between patient and control groups

	Patient	Control	*p*
	Mean ± SD	**Mean ± SD**	
ICV (cm3)	1137,646±104,646	1104,190±145,972	**0,511**
PFV (cm3)	279,862±38,755	271,028±38,855	**0,562**
FMA (cm2)	9,076±2,369	8,581±1,409	**0,506**
PFV/ICV	0,247±0,039	0,246±0,027	**0,957**
FMA/PFV	0,032±0,006	0,032±0,004	**0,796**
FMA/ICV	0,008±0,002	0,008±0,001	**0,722**
Tentorial slope (TS) (°)	45,683±6,862	48,533±5,767	**0,252**
Clivus length (LoC) (mm)	35,092±5,302	35,327±3,673	**0,893**
Subocciput length (LoSO) (mm)	36,358±4,502	39,020±4,351	**0,132**
Clivus-tentorium Cobb (C-T) angle (°)	14,058±8,122	15,480±7,551	**0,642**
Clivus-subocciput Cobb (C-SO) angle (°)	92,925±6,773	82,793±10,130	**0,007****
Clivodental (C-D) angle (°)	138,408±10,264	147,273±7,670	**0,017***

Independent sample t- test *p < 0,05, ** p < 0,01

There are many studies examining posterior fossa morphology. However, most of them have been done only on CM-1. The study done in the pediatric patient group is very rare.

Studies on CM-1disease; when compared the patient and the control group are examined; In some studies, PFV was found smaller in the patient group [2,3,9,23-24, 32-33,35]. There was no difference between the groups in ISV [3,9,32-33]. In all of the studies, PFV / ISV was found smaller in the patient group [2- 3,9,32-33]. In some studies, LoC [2, 3, 7, 15, 17, 23-25, 32, 37] and LoSO [2-3,6,11,17,23-24,32,37] were found to be smaller in the patient group. To summarize the studies, there is a shrinkage of the posterior fossa, which is led by shortening of the clivus and subocciput dimensions in the patients.

There are no studies showing morphological changes with age because the studies in the literature are made in a certain subgroup of CMs. Sgouros S and colleagues found that the study of intracranial volume in healthy children naturally shows an increase in ISV with age [31].

In children studies, there was no difference between the LoC [6,9,15,25] and LoSO [9,15,25] groups. There was no significant difference between groups in terms of TS [2,17,33] and C-D angle [2]. In further studies, C-D angle was narrower in the patient group [15,37]. Again, the TS in CM-1 patients in a study conducted in Turkey were found to be larger [17]. Furtado SV and colleagues have shown that the FM field is compatible with a specific ISV in pediatric CM-1 patients and that both the ISV and FM area are not significantly different from the normal pediatric population [10]. Furtado and colleagues did not detect any differences in morphological value with respect to the mean age in pediatric and adult CM-1 cases [9]. Trigylidas and colleagues compared 0 to 9 years of age and 10 to 18 years of age in their study of children under 18 years of age. In the patient group, PFV / ISV ratio with age showed a significant change in the 0-9 age range, whereas in the 10-18 age group, there was no difference with the control group [33]. To summarize the studies performed in pediatric CM cases, there is no difference in volume, length and angle measurements between healthy individuals.

There was no difference in volume studies in our study. Only C-D Angle is found to be narrower in CM patients. This means increased pressure in the anteroinferior of the brain stem. Because of the steep transition between the cranium and the spinal canal, brain stem findings can be seen in patients. In addition, we found a larger angle between clivus and subocciput in patients. İn the sagittal examination with posterior fossa, clivus and subocciput; the tentorium and the tentorial diaphragm form the rhomboid superiorly. Our findings show that the base of this rhomboid region is larger in patients; suggesting that the structures in the posterior fossa have a larger base.

CONCLUSION

This study showed no difference between intracranial volumes and cranial-vertebral junction length measurements in Pediatric Type 1 Chiari Malformation according to the healthy control group. Again, there is a steep transition between the clivus and the dens as in adult CM patients in the cranial-vertebral compartment, which leads to brain stem findings. It should also be noted that the cerebellum is on a wider surface in CM patients.

Conflict of Interest

There is no conflict of interest.

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Volume: 29, Issue: 2, April 2018 pp: 83-87 ORIGINAL ARTICLE

COMPARISON OF SPINAL SAGITTAL PARAMETERS BY TIME OF DAY IN A HEALTHY WORKING POPULATION WITH HIGH BODY-MASS INDEX

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ABSRTACT

Object: To determine the change in spinal sagittal parameters which may occur throughout the day in healthy population with high body-mass index (BMI).

Methods: Twenty-one healthy hospital employees with high BMI were enrolled in the study. Two standing left lateral ortho-roentgenograms were obtained at 8.00 a.m and at 6.00 p.m. Six spinopelvic parameters were measured on the X-rays.

Results: Twenty-one subjects with a mean age of 32.72± 7.84 were evaluated. No significant change was found between morning and evening measurements for any of the parameters. As a result of the correlation of daily changes for study parameters for the high BMI cohort showed significant direct relationship between SS and PI, LL and SS, LL and PI and an inverse relationship between LL and PI minus LL, SS and PI minus LL. ($p < 0.05$).

Conclusion: Routine workload in a hospital environment does not cause significant change in the spinopelvic parameters throughout the day.

Key Words: sagittal balance, change, healthy, collapse, spinopelvic, parameters.

Level of Evidence: Prospective clinical study, Level II

INTRODUCTION

Optimal sagittal balance provides the minimum effort to stand upright [5]. The spinal column and disc complexes will resist physiological compression and maintain upright posture [6]. A degenerated disc or loss of anterior bone support can lead to deformation, which leads to flexion and lateral bending (scoliosis), often associated with torsion (rotation) [7]. For this reason, there is a high likelihood that the spinal alignment will be gradually lost during aging. Research on spinal sagittal parameters, which emphasize the importance of sagittal vertebral balance for better outcomes of spinal deformity surgeons, has become more popular among spinal surgeons [23,25]. The amount of improvement in sagittal parameters was directly related to clinical improvement [12,20]. For this reason, their anatomical and physiological characteristics have become more important than ever to recognize compensatory mechanisms that allow the sagittal balance to be preserved. The previous literature contains a number of focuses on the identification of compensatory mechanisms and the classification of sagittal imbalance [16,22]. We now know that the increase in thoracic kyphosis is compensated by an increase in lumbar lordosis, or that the anterior lobe in the center of gravity is compensated by retroversion of the pelvis [5,19]. Most sagittal parameter studies have focused on the treatment of degenerative spinal cases or other special conditions that cause sagittal imbalance such as idiopathic scoliosis and Scheuermann's disease [4,13]. To our knowledge, physiological sagittal changes may have occurred throughout the day as a possible consequence of working and muscle fatigue. Because of this opening, we tried to determine the change in spinal sagittal parameters that may occur during the day.

MATERIALS AND METHODS

Twenty-three operating room nurses with high BMI (>30) who had no back pain

at the time of the study, with no known spine, hip or pelvic disorders and without any contraindications for radiographic exposure were enrolled in the study. Among them two subjects with previous spinal surgery were excluded. The participants were mainly operating room nurses who work actively throughout the entire day. All participants provided informed consent and the study was approved by the ethical committee of Acibadem University (ATADEK 2016/1).

The radiographic protocol was standardized for all participants. For each subject, two standing left lateral ortho-roentgenograms including the whole spine and pelvis were obtained, with the subject standing 72 inches away from the X-ray tube. The participants were instructed to stand straight and relaxed, with their knees fully extended. The elbows were parked in 90 degrees flexion, with both elbows resting on a horizontal bar at the level of their shoulders. The first X-ray was obtained at 8 o'clock in the morning just before the work shift. The second X-ray was obtained at 6 o'clock in the afternoon at the end of the work shift. Six spinopelvic parameters were measured on the X-rays: thoracic kyphosis (TK), lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI) and sagittal vertebral axis (SVA) [29]. The definition of the aforementioned study variables are provided in figure 1 to provide better apprehension. All radiographs were analyzed by the same surgeon and checked by two other surgeons with the aid of digital graphics software (The Surgimap software New York, NY, USA).

Data were analyzed using SPSS 14.0 software (SPSS Inc., Chicago, IL). Application of the Kolmogorov-Smirnov test showed no normal distribution of data sets, thus Wilcoxon test was utilized and median and range values were calculated and used instead of mean values. The Independent Samples test was utilized to assess comparison of the parameters. Relationships were assessed using Pearson's coefficients. A significance value less than 0.05 was considered to be significant.

RESULTS

Twenty-one subjects; 12 males (57.1 %), 9 females (42.9 %) with a mean age of 32.72 ± 7.84 were evaluated. The mean height and weight of volunteers were 166 ± 9.4 cm and 86.02 ± 21.03 kg and mean BMI was 33.21 ± 2.32.

The values of TK, LL, SS, PI, PT and SVA were not normally distributed in patients. All spinopelvic parameters were measured twice from X-rays obtained in the morning at 8 o'clock and in the evening at 6 o'clock. Descriptive values of all parameters are shown in Table 1 for better comprehension. No significant change was found between morning and evening measurements for any of the parameters. As a result of the correlation of daily changes for study parameters for the high BMI cohort showed significant direct relationship between SS and PI, LL and SS, LL and PI and an inverse relationship between LL and PI minus LL, SS and PI minus LL.

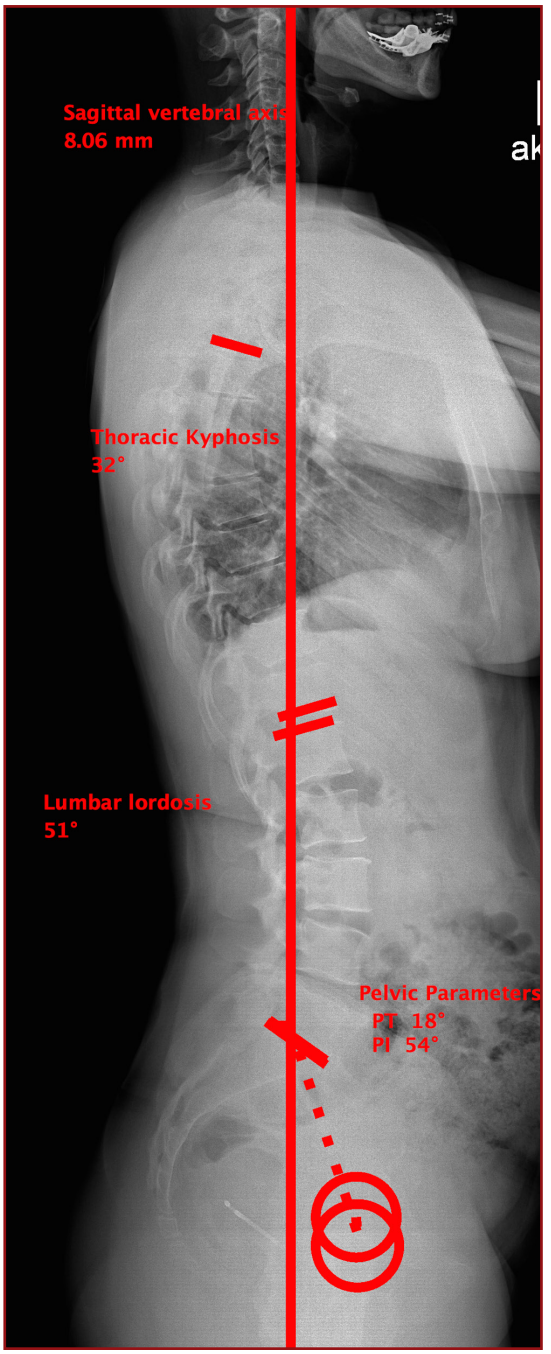

Figure-1. Thoracic kyphosis (TK), the angle between the superior endplate of T4 and the inferior endplate of T12; lumbar lordosis (LL), the angle between the superior endplate of L1 and the superior endplate of S1; sacral slope (SS), the angle between the superior endplate of S1 and the horizontal line; pelvic incidence (PI), the angle between the line perpendicular to the superior endplate of S1 and the line connecting the midpoint of the superior endplate of S1 to the hip axis (HA, the midpoint of the line connecting the centers of two femoral heads); pelvic tilt (PT), the angle between the vertical line and the line connecting the midpoint of the superior endplate of S1 to HA (considered positive if angulated behind the vertical line and otherwise negative); sagittal vertebral axis (SVA), the distance between the C7 plumb line and the posterosuperior corner of S1 in the sagittal plane

Table-1. Descriptive values for all parameters.

N=21	Morning measurement	Evening measurement	P values
Thoracic kyphosis	37.72(46-28)	38.81(48-28)	0.385
Lumbar lordosis	54.18(68-37)	53.45(66-34)	0.878
Sacral slope	36.09(45-24)	34.54(42-24)	0.124
Pelvic tilt	12.36(19-5)	13.37(19-8)	0.322
Pelvic incidence	48.45(61-38)	48.63(61-39)	0.567
PI minus LL	-5.72(11-(-20)	-4.81(12-(-18)	0.759
Sagittal vertebral axis	18.72(83-(-34)	18.62(45-(-19)	0.921

DISCUSSION

In recent years, recognizing the importance of sagittal balance, which affects quality of life significantly, has led to the identification of new targets in deformity surgeons [10,20-21,24-25]. Schwab et. al. defined new values for correction for spinal deformity surgery such as PT <20, SVA <45 mm and PI minus LL <10 [1]. These developments led to an increase in the number of surgeries performed. For this reason, understanding the compensatory mechanism that takes place during a day is an important step in the evaluation of symptomatic patients who visit clinics at different times of the day.

Mac-Thiong et al. [19] when the spinopelvic parameters were evaluated in a study conducted on 709 subjects without any spinal symptoms, the PI range ranged from 32 ° -74 °, PT value 0 ° -27 ° and SS 25 ° -55 °. Lee et al. [17], the LL value was 49.4 °, the SS value was 36.3 ° and the PI was 47.8 °. Finally, LaFage and colleagues [4] reported mean values of 50.7 °, SS 37.9 ° and PI 50.2 ° LL. Parallel to these findings, our study gave a morning mean TK of 37.72 ° and 38.81 ° in the morning, 54.18 ° in the evening LL, 53.45 ° in the evening, 34.09 ° in the morning SS and 34.54 ° in the evening and 12.36 ° in the PT in the morning. and 13.37 ° in the evening, 48.45 ° in the morning and 48.63 ° in the evening. Our study of sagittal vertebrae compliance showed that 18.72 in the morning decreased to 18.62 in the evening and slightly above normal values. Moreover, the literature contains other studies paralleling our definition of SVA that define only the anterior of the posterosuperior corner of the sacrum in a healthy community as two sections [8,11,18].

Thoracic kyphosis is well defined by a series of studies focusing on the correlation of the cervical or lumbar region with hyperlordosis and the relationship of sagittal vertebral parameters to global kyphosis, which can be compensated for by increased pelvic tendency due to pelvic retroversion [16], 10, 17, 23-25. Mac-Thiong and colleagues [19] showed a direct correlation between C7 translation quantity and other spinopelvic parameters such as PT, SS and PI. Ghandhari and colleagues [9] found a direct relationship between TK-LL, LL-PI and LL-SS and an inverse relationship between LL-SVA and PT-PI. In our study, we found a direct relationship between SS and PI, LL and SS, LL and PI, and an inverse relationship between LL and PI minus LL, SS and PI minus LL [15,26].

Our main goal in this study is to investigate the change in sagittal balance between morning measurements and evening measurements and thus to make conclusions about spinopelvic equilibrium of compensating mechanisms. When the main cohort measurements were taken into consideration, there was no significant change in sagittal spinopelvic parameters during the day, the lowest level (18.72 mm to 18.61 mm) between the morning and evening measurements of the SVA value in the high BMI cohort. Boulay and colleagues [2] showed a strong correlation between BMI and LL, SS and PI. Parallel to their findings, we have shown that compensatory mechanisms in high-BMI individuals may be less effective, but we have decided that this difference is insignificant. We believe that surgery can play a role in decision-making since corrective surgery in high-BMI populations can increase complication rates.

This is the first study in the literature to focus on sagittal vertebral alignment changes during the day; for this reason, we think that the results we produce are important for the spinal research community. However, our work has its own limitations. First, the number of participants is limited, but when we consider that morning and evening measurements of our study are parallel to the latest literature findings, we think this is a very worrying source. Second, measurements made with computer software can have their own measurement errors. We tried to address this problem by repeatedly performing measurements with multiple surgeons. Finally, we believe that changing the spinopelvic parameters during the day or in certain occupational study scenarios should be investigated with more subjects with more planned cohorts for age and body mass index.

CONCLUSION

When we collect the all data, we observed no significant change in the spinopelvic parameters throughout the day. This showed that compensatory mechanisms will work to prevent collapse of spinal sagittal balance.

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Volume: 29, Issue: 2, April 2018 pp: 89-92 ORIGINAL ARTICLE

ANTERIOR CERVICAL DISCECTOMY: EVALUATION WITH CERVICAL LORDOSIS AND SAGITTAL VERTICAL AXIS MEASUREMENT

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ABSTRACT

Aim: The purpose of this study is therefore to compare cervical lordosis and sagittal vertical axis values before and after anterior cervical discectomy operations.

Materials-Method: We evaluated 62 patients who were operated for cervical disc herniation between 2016-2018 retrospectively. Cervical X-ray graphics were taken as standing lateral neutral positioned preoperative and postoperative periods. These graphics were searched with the radiology pacs program and CL angle and SVA were measured at preoperative and postoperative periods.

Results: A total of 62 patients included in the analyses. Mean age of the study group was 45.9±8 years, and M/F ratio was 26/36 (41.9 % vs. 58.1 %). Most frequent diagnosis was C4-5 disc hernia (n=28, 45.2 %), and most frequent operation was C4-5 microdiscectomy + interbody fusion. Comparisons between study periods revealed that postoperative CL was significantly increased when compared to preoperative values (p<0.001), but there was no significant difference for SVA (p=0.445).

Conclusion: There are different results for the discussion on cervical sagittal alignment changes after anterior cervical discectomy operations. We found that cervical lordosis is increasing significantly after anterior cervical discectomy operations whereas SVA not. Anterior cervical discectomy operations support to maintain CL in degenerative cervical disc disease. However, further investigations with an increased amount of cervical spine data are needed with long-term results.

Key Words: Anterior cervical discectomy, cervical lordosis, Cobb angles, sagittal vertical axis

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Cervical degenerative disc disease is a common cause of pain and disability. Most symptomatic cases present between the ages of 40-60, although many individuals never develop symptoms [9]. Anterior cervical discectomy surgery has become a standard treatment for cervical degenerative disc disease as it is a proven intervention for patients with myelopathy and radiculopathy as it affords the surgeon the ability to provide direct decompression with discectomy and restoration of disc height [6].

The widest range of motion is on the cervical spine relative to the rest of the spine and this region supports the mass of the head [13]. Sagital balance of the spine is a fundamental element necessary for understanding spinal disease and instituting proper treatment. The procedure of drawing perpendiculars to vertebral body endplate lines to evaluate scoliotic curves on anteroposterior radiographs was reported by Lippman in 1945, which was later popularized in 1948 by Cobb [1,16]. The major parameters used to assess the cervical spine alignment include the Cobb angles, Jackson stress lines, and Harrison posterior tangent lines for the sagittal curvature, and the gravity line or C2 plumb line for the SVA.

The purpose of this study is therefore to compare cervical lordosis and sagittal vertical axis values before and after anterior cervical discectomy operations.

MATERIALS AND METHOD

We evaluated 62 patients who were operated for cervical disc herniation between 2016-2018 retrospectively. Cervical X-ray graphics were taken as standing lateral neutral positioned preoperative and postoperative period. These graphics were searched with the radiology pacs program and CL angle and SVA measurement of these patient were evaluated with the techniques being explained below (Figure-1):

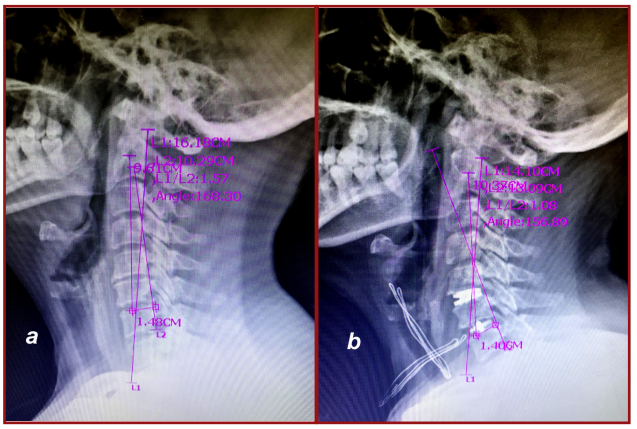

Figure-1. (a) Preoperative and **(b)** postoperative cervical sagittal measurement of the patient A.B.

Cobb Angle: Cobb angles are measured with a line either parallel to the inferior endplate of C_2 to the posterior margin of the spinous process, and another line parallel to the inferior endplate of C_7.

Sagittal vertical axis: A plumb line is drawn from the center of C2, and the distance from this line to the posterior corner of the upper endplate of C7 is obtained.

Statistical Analyses

Descriptive data were presented using mean and standard deviation, and frequencies and percent. Wilcoxon test was used for comparisons between the dependent groups of the study (preoperative and postoperative angle measurements), and statistical significance was evaluated according to a two-sided Type-I error level of 5 %. Statistical Package for the Social Sciences (SPSS) 21 software (IBM Corp. in Armonk, NY) was used for all statistical analyses of this research.

RESULTS

A total of 62 patients included in the analyses. Mean age of the study group was 45.9±8 years, and M/F ratio was 26/36 (41.9 % vs. 58.1 %). Most frequent diagnosis was C4-5 disc hernia (n=28, 45.2 %), and most frequent operation was C4-5 microdiscectomy + interbody fusion. General demographics of the patients was presented in Table-1.

CL and SVA between preoperative and postoperative periods was presented in Table-2. Accordingly, comparisons between study periods revealed that postoperative CL was significantly increased when compared to preoperative values ($p<0.001$), but there was no significant difference for SVA ($p=0.445$).

Table-1. General demographics of the patients

	Mean	**SD**
Age (years)	45,9	8
	n	**%**
Sex		
Male	26	41.9
Female	36	58.1
Diagnosis		
C4-5 disc hernia	28	45.2
C4-5-6 disc hernia	20	32.3
C5-6 disc hernia	10	16.1
C5-6-7 disc hernia	2	3.2
C6-7 disc hernia	2	3.2
Operation		
C4-5 microdiscectomy + interbody fusion	28	45.2
C4-5-5 microdiscectomy + interbody fusion	20	32.3
C5-6 microdiscectomy + interbody fusion	10	16.1
C5-6-7 microdiscectomy + interbody fusion	2	3.2
C6-7 microdiscectomy + interbody fusion	2	3.2

Table-2. Pre- and post-operative angle measurements

	Preoperative		Postoperative		p
	Mean	SD	Mean	SD	
CL: Cervical Lordosis	13	18.1	18.1	13.2	<0.001
SVA: Sagittal Vertical Axis	1.9	1	1.8	0.9	0.445

DISCUSSION

Anterior cervical discectomy has been suggested as an effective and safe treatment for spinal cervical degenerative disc diseases. Clinical importance of sagittal balance is important in the management of spinal degenerative pathologies. Cervical lordosis (CL) may be dependent on the anatomy of the cervico-thoracic junction (CTJ), which typically involves the C_7 and T_1 vertebrae, the C_{1-7} discs, and the associated ligaments [15]. CTJ is the site at which lordosis of the cervical spine changes to kyphosis in the thoracic spine [2].

Although a few studies have reported the normal sagittal balance of the cervical spine and physiological CL has not been clearly defined yet, Hardacker et al. reported a mean CL of 40.0° ± 9.7° that had a significant correlation with thoracal kyphosis [5]. Lee et al. reported that the mean values C_{2-7} angle was 9.9° ± 12.5° [12]. Also Gore et al. reported C_2-C_7 cervical lordosis angles of 16° for men and 15° for women [4]. Özdoğan et al reported mean values of C_{2-7} as 18,37° ± 9,44° in their study [14].

There is not much nominative data for the gravity line or C2 plumb line for the SVA Hardacker et al. reported a C7 SVA mean value of 15.6 mm [5]. Gore et al. reported a mean SVA of 16.8 mm, and also suggested that CL increased with age, but did not address the adjacent spinal alignment measurements or segmental cervical values [4].

Jeon et al reported on 33 patients who were operated for three or more level anterior cervical discectomy and fusion surgery under neutral supine position and they found that surgery did not significantly change the postoperative cervical alignment [7]. Gillis et al found that anterior discectomy with 1 and two levels is able to achieve statistically significant improvement in cervical lordosis by the 1-year follow-up with a mean improvement of 3.46° but not with SVA [3]. Our study's' results are supporting Gillis' report.

Katsuura et al reported with 69 patients that multilevel anterior cervical discectomy and fusion surgery significantly increases and maintains both segmental and global cervical lordosis up to 6 months after surgery and increasing C2-C7 global lordosis is correlated with increasing positive sagittal vertical axis [8]. Kwon et al found that C2-7 SVA after two-level anterior cervical discectomy and fusion surgery was affected more significantly by the sagittal angle and C2-7 angle than by the T1 slope and two-level anterior cervical discectomy and fusion surgery with plate restored more cervical lordosis by obtaining more segmental lordosis at the operated level and was more effective in terms of cervical alignment compared with anterior cervical discectomy and fusion surgery using stand-alone cages [11]. Kim et al reported that anterior cervical discectomy and fusion surgery affects whole spine sagittal alignment, especially in patients with high cervical lordosis and in these patients, alteration of cervical lordosis to a normal angle shortened the SVA and resulted in reciprocal changes in pelvic tilt and sacral slope [10].

Conclusion

There are different results for the discussion on cervical sagittal alignment changes after anterior cervical discectomy operations. We found that cervical lordosis is increasing significantly after anterior cervical discectomy operations whereas SVA not. Anterior cervical discectomy operations support to maintain CL in degenerative cervical disc disease. However, further investigations with an increased amount of cervical spine data are needed with long-term results.

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Volume: 29, Issue: 2, April 2018 pp: 93-95 ORIGINAL ARTICLE

EVALUATION OF SAGITTAL SPINOPELVIC PARAMETERS BEFORE AND AFTER LUMBAR STABILIZATION SURGERIES

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ABSTRACT

Purpose: The aim of the study is to evaluate sagittal spinopelvic parameters before and after lumbar stabilization surgeries.

Materials-Methods: We inspected 60 patients who had been operated for lumbar stabilization between 2015 march and 2018 march retrospectively from the patient files. LL, PI, PT and SS angles were measured before and after surgery with Osirix® software.

Results: A total of 60 patients included in the analyses. Mean age of the study group was 57.2±11.5 years, and M/F ratio was 12/48 (20% vs. 80%). Most frequent diagnosis was L1-L5 stenosis (n=10, 16.7%). Comparisons between study periods revealed that there was no significant difference for LL (p=0.85), PI (p=0.33), SS (p=0.79) and PT (p=0.34).

Conclusion: It is important to always keep the targeted whole spine alignment in mind when performing spinal surgery. Sagittal spinopelvic parameters are not much affected with lumbar stabilization surgeries because the lumbosacral spine compensates so as to maintain the sagittal balance.

Key Words: Sagittal spinopelvic parameters, Lumbar lordosis, Sacral slope, Pelvic index, Pelvic tilt

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Clinical importance of sagittal balance alignment is being recognized increasingly. The sagittal balance of the spine is determined by the pelvic shape, which is set by the pelvic incidence (PI) [6]. Duval-Beaupère et al had first reported the PI in 1992 [1]. Sagittal spinopelvic parameters are being discussed for surgical planning of spinal deformities. Sagittal spinopelvic parameters are PI, Pelvic tilt (PT), sacral slope (SS) and lumbar lordosis (LL). The angle between the perpendicular to the upper sacral end plate at its midpoint and the line connecting this point to the femoral head axis is defined as PI and the angle between the vertical and the line through the midpoint of the sacral plate to the femoral head axis is PT [8]. SS is defined as the angle between the horizontal and the upper sacral endplate [10]. Lumbar lordosis (LL) is defined as the angle between the upper L1 endplate and the upper sacral endplate [8]. PI is strongly correlated with the SS and PT, and represents the algebraic sum of the SS and the PT (PI=SS+PT).

Abnormal spinal sagittal alignment can cause persistent low back pain (LBP) and the association of acute LBP with hyperlordosis, and the relationship of chronic LBP with hypolordosis have been demonstrated before [3]. These parameters must be checked before and after stabilization and deformity surgeries.

The aim of the study is to evaluate sagittal spinopelvic parameters before and after lumbar stabilization surgeries.

MATERIALS AND METHOD

We inspected 60 patients who had been operated for lumbar stabilization between 2015 march and 2018 march retrospectively from the patient files. LL, PI, PT and SS angles were measured before and after surgery with Osirix® software as shown on Figure-1. LL was defined as the angle between the upper endplates of L1 and S1. SS corresponds to the angle

between the upper sacral endplate and the horizontal plane. All measurement values included for statistical analyse.

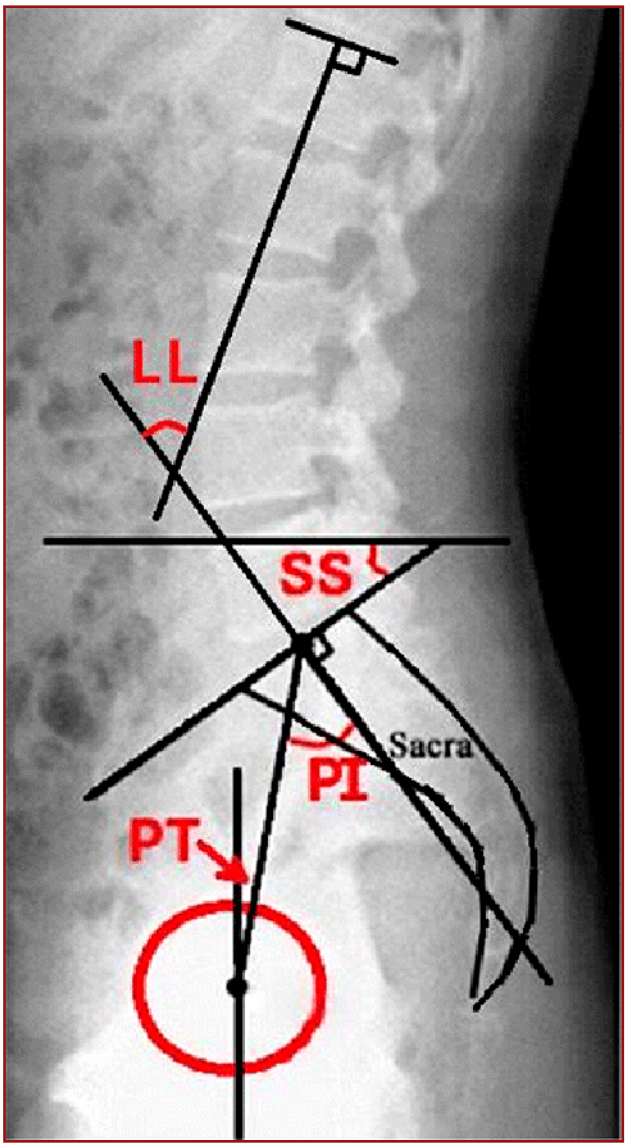

Figure-1. Evaluation of the spinopelvic measurements.

Statistical Analyses

Descriptive data were presented using mean and standard deviation, and frequencies and percent. Wilcoxon test was used for comparisons between the dependent groups of the study (preoperative and postoperative lumbar and pelvic angle measurements), and statistical significance was evaluated according to a two-sided Type-I error level of 5%. Statistical Package for the Social Sciences (SPSS) 21 software (IBM Corp. in Armonk, NY) was used for all statistical analyses of this research.

RESULTS

A total of 60 patients included in the analyses. Mean age of the study group was 57.2±11.5 years, and M/F ratio was 12/48 (20 % vs. 80 %). Most frequent diagnosis was L1-L5 stenosis (n=10, 16.7%). General demographics of the patients was presented in Table-1.

Changes in lomber lordosis angle (LL), pelvic index angle (PI), sacral slope angle (SS), and pelvic tilt angle (PT) between preoperative and postoperative periods was presented in Table 2. Accordingly, comparisons between study periods revealed that there was no significant difference for LL (p=0.85), PI (p=0.33), SS (p=0.79) and PT (p=0.34) (Figure-2).

Figure-2. Spinopelvic parameters of the patient (S.O.) (a) preoperatively,.and (b) postoperatively.

Table-1. General demographics of the patients.

	Mean	SD
Age (years)	57.2	11.5
	n	**%**
Gender		
Male	12	20
Female	48	80
Diagnosis		
L1-L5 stenosis	10	16.7
L1-S1 stenosis	6	10
L2-3-4 stenosis	6	10
L2-5 stenosis	6	10
L2-S1 stenosis	6	10
L3-4 listesis	6	10
L3-4 stenosis	4	6.7
L3-4-5 stenosis	4	6.7
L3-S1 stenosis	2	3.3
L3-S1 stenosis	2	3.3
L4-5 listesis	2	3.3
L4-5 stenosis	2	3.3
L4-S1 stenosis	2	3.3
L5-S1 listesis	2	3.3

Table-2. Pre- and post-operative lumbar and pelvic angle measurements.

	Preoperative		Postoperative		p
	Mean	SD	Mean	SD	
LL: Lomber lordosis angle	50.7	14.1	50.6	7	0.85
PI: Pelvic index Angle	46	7.2	45.5	7.1	0.33
SS: Sacral Slope Angle	32.4	8.6	32.4	7.4	0.79
PT: Pelvic tilt Angle	13.8	5.4	13	5.3	0.34

DISCUSSION

Although the restoration of normal sagittal alignment is a critical goal of reconstructive spine surgery, normal and pathologic alignment remain poorly defined [4]. Abnormal lordotic alignment may lead pathologic changes in the spine from load bearing and accelerate degeneration of the functional motion units [5].

The wedging of the lumbar vertebral bodies and intervertebral discs forms lumbar lordosis. While lumbar lordosis is generally thought to decrease with aging according to Vadentam et al, many elderly subjects in the study of Yokoyama et al were found to have maintained lumbar lordosis [9,11].

Düzkalır et al had reported LL and SS angle values were significantly higher in females when compared to males and LL and SS values showed statistically significant and strong positive correlation with each other through all age groups additionally significantly higher in 61-80 years [2]. Oh et al. reported the spinopelvic parameters of Korean normal population as followings, the PI was 49°; the SS was 38°; the PT was 11°, the LL was 48° [7]. LL and SS value range means in asymptomatic adults is 43-61 and 36-42 degrees [8].

Spinopelvic parameters and global sagittal balance have been studied extensively in the literature. In our study we found that Comparisons between preoperative and postoperative lumbar stabilization surgeries revealed that there was no significant difference for LL (p=0.85), PI (p=0.33), SS (p=0.79) and PT (p=0.34). Many studies needed to make a standart data for either normal or pathologic values of sagittal spinopelvic parameters.

Conclussion

It is important to always keep the targeted whole spine alignment in mind when performing spinal surgery. Sagittal spinopelvic parameters are not much affected with lumbar stabilization surgeries because the lumbosacral spine compensates so as to maintain the sagittal balance.

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COMPARISON BETWEEN THE PRE- AND POSTOPERATIVE RADIOLOGICAL FINDINGS AND CLINICAL OUTCOMES EVALUATION OF THE PATIENTS WHO UNDERWENT SURGERY FOR LUMBAR SPONDYLOLISTHESIS

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ABSTRACT

Aim: We aimed to evaluate the surgical outcomes in the patients who underwent surgery for lumber spondylolisthesis by evaluation pre- and postoperative clinical results, radiological fusion and adjacent segment disease rates.

Material and Methods: Pre- and postoperative clinical evaluations using pre- and postoperative Visual Analog Scale (VAS) were performed in 48 patients who operated on for Grade 1, 2 and 3 spondylolisthesis. Radiological evaluation was retrospectively performed using direct radiographs, three-dimensional lumbar tomography (CT), and lumbar magnetic resonance imaging (MRI). The presence of pars defect, the presence of instability, Meyerding slip rate, slip percentage, slip angle, sacral slope (angle of inclination), sagittal range of motion, sacrohorizontal angle (pelvic tilt), and lumber lordosis angle were measured on direct radiographs. Dynamic radiographs and Lumbar CT were used for fusion detection. Lumber MRI was used to assess adjacent segment degeneration.

Results: 48 (43 female and 5 male) spondylolisthesis patients were operated on, with a mean age of 49.1 years and an average follow-up of 4.5 years. There was a significant decrease in postoperative back VAS ($p = 0.01$), and leg VAS ($p = 0.02$) values of the cases. The mean slippage percentage of the cases was 19.2 % in the preoperative period versus 13.2 % in the postoperative period. The mean slip angle was 10.18^0 in the preoperative period versus 6.64^0 in the postoperative period. The mean lumbar lordosis angle was 34.17^0 in the preoperative period versus 32.51^0 in the postoperative period. The mean sacral slope was 45.82^0 in the preoperative period versus 44.59^0 in the postoperative period.

Conclusion: Good clinical outcomes can be obtained with posterior instrumentation and fusion in the long-term instability patients.

Key Words: Spondylolisthesis, fusion, lumbar lordosis, sacral inclination.

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Spondylolisthesis is the forward slip or displacement of one vertebrate over the other. Andre was the first one who described spondylolisthesis in 1741 as a result of the inward slip of the vertebral column, resulting in a "trough waist" which is difficult to bear a child [15]. Paul Harrington was the first who used the posterior distraction instrument. In 1941, pedicle screws and facet screws were introduced for the first time [1]. Meyerding classified spondylolysis according to the percentage of slip in 1932 (11). This classification was expended and reformed by Wiltse, Newman, and McNab, in 1976, which is still being used today [18].

Conservative treatment such as pain killers, braces, physical treatment and epidural steroid injections may be useful for some of the first-grade spondylolisthesis patients who were presented without neurological deficits. Aim of treatment is usually to relieve short-term symptoms, since symptoms tend to improve following acute exacerbations. In conservative treatment requiring multidisciplinary approach; bed rest, weight loss in overweight patients, smoking cessation, nonsteroidal anti-inflammatory medications and muscle relaxant drug therapy, foraminal and epidural steroid injections, flexion exercises, restriction of pain and slip enhancing movements and bracing are

essential. Stretching and strengthening exercises as well as special education practices also take place in the treatment [6,10,14].

The current study aims to evaluate surgical outcomes in the patients who surgically treated for lumbar spondylolisthesis, by evaluating fusion and adjacent segment disease rates radiologically and by comparing preoperative and postoperative clinical evaluations.

MATERIAL AND METHOD

Patient Population:

48 patients who underwent lumbar laminectomy, transpedicular screw-rod system insertion as posterior instrumentation and posterolateral fusion due to Grade 1, 2 and 3 spondylolisthesis were reviewed retrospectively.

Evaluation of Subjective Complaints of Patients:

Pre- and postoperative VAS (Visual analog scale) was used to evaluate back and leg pain. For VAS measurement, a line which is vertically or horizontally drawn as 10 cm in long, is utilized. There are two extreme descriptive words subjectively at each side of this line. No pain is written on one side of the line and the worst intolerable pain on the other side. The patient is told to place a sign on this line to match the severity of his/her pain, so that this line will break. The distance from the lowest VAS level to the patient's sign is measured with a ruler to obtain the numerical index of the patient's pain severity in cm [2].

Parameters of Radiological Findings:

Preoperative and postoperative direct radiographs were used to measure the presence of pars defect and instability, and Meyerding slip rate, slip percentage, slip angle, sacral inclination, sagittal rotation, sacro-horizontal angle and lumber lordosis angle were measured. In Meyerding slip rate; the distance from the posterior cortex of the superior vertebra to the posterior cortex of the lower vertebra was measured and calculated as the ratio to the anteroposterior distance of the lower vertebra. The angle at which the slip angle intersects the lower end plate of the upper vertebrae and the vertices passing through the upper end plate of the lower vertebrae are calculated. In the lateral radiograph taken to detect sacral inclination, we recorded the straight line drawn along the S1 posterior border and calculating the angle formed by the vertical plan. For sagittal rotation, the line drawn along the S1 posterior face was based on the angle formed by the line drawn along the L5 anterior face. Angle between the line drawn from the sacro-horizontal angle S1 upper end plate and the horizontal axis was recorded. Angle between the lines drawn from the upper end plate of L1 at the angle of the lambs and the line drawn at 90^0 is taken as the angle between the lines drawn at the line 90^0 drawn from the upper end plate of L5.

Fusion and Adjacent Disease Assessment:

Dynamic graphics and three-dimensional lumbar CT were used in the fusion evaluation. However, it is reported that these tests may give pseudo-positive results and the radiological diagnosis of pseudoarthrosis is still difficult and uncertain. Successful fusion criteria were recorded to be the absence of motion on dynamic graphs, the presence of bilateral continuous trabecular bone between fused segments, and the absence of halo around the implant [16]. Three-dimensional tomography has 96 % sensitivity. In three-dimensional CT, cortical ring presence around the graft is the most accurate evidence of anatomic fusion [8,12]. Adjacent segment degeneration was recorded with lumbar MRI.

Statistical Evaluation:

Statistical Package for Social Sciences (SPSS) for Windows 21.0 program was used for the statistical evaluations. Chi-square test was used for comparison of qualitative data between groups, Mann-Whitney U and Kruskal Wallis tests were used for quantitative data. Wilcoxon Signed Ranks test was used to compare quantitative data before and after surgery. When the data were evaluated, descriptive statistical methods, Mean and Standard Deviation, were used. Results were evaluated in a 95 % confidence interval and a significance level of $p < 0.05$.

RESULTS

Demographic Characteristics of Patients:

Of the 48 cases who underwent surgery due to spondylolisthesis, 43 (90.0%) were female and 5 (10.0%) were male. Their ages ranged from 17 to 69 and the average age was 49.1. The majority of cases are at L_5-S_1 level and the number of spondylolisthesis type and cases are shown in Table-1.
Complaint period of the cases ranged from 1 month to 35 years with an average of 5.7 years. Follow-up period of the cases ranged from 1 to 8 years with a mean of 4.5 years.

Findings of Subjective Complaints of Patients:

The preoperative VAS averages were 8.02 for back and 8.79 for leg while the final postoperative VAS averages at last follow-up visits were 1.83 for back and 1.72 for leg (p 0.01 and 0.02, respectively). (Figure-1).

Clinical findings of the cases were found as claudication of 31, flat leg lift test (Laseque) positivity of 32, loss of sensation in 20, motor deficit of 9, reflex abnormality of 11, and sphincter dysfunction of 4 cases. Neurological examination was normal in 10 cases (Figure-2).

Radiological Findings:

39 of the cases (81.3 %) were determined as Grade I, 8 (16.7 %) were Grade II and 1 (2 %) was Grade III. The mean preoperative slip percentage of the cases was 19.2 %, versus 13.2 % postoperatively. The mean preoperative slip angle was 10.18^0 versus 6.64^0 postoperatively. The mean preoperative sacral inclination was measured as 45.82^0 versus 44.59^0

postoperatively. The mean preoperative sagittal rotation was measured as 20.76^0 versus 23.12^0 postoperatively. The mean preoperative sacro-horizontal angle was measured as 49.82^0 versus 47.41^0 postoperatively. The mean lumbar lordosis angle was preoperatively measured as 34.17^0 versus 32.51^0 postoperatively. There was no statistically significant difference between the preoperative and postoperative angular comparisons ($p > 0.05$). Adjacent segment degeneration assessed by Lumber MRI was detected in 14.6 % of our cases. In x-rays, fusion was detected in 27 of the patients, suspicious fusion in 10, no fusion in 9, and pseudarthrosis in 2 patients. In three-dimensional lumbar CT fusion was detected in 36 cases and 12 cases were not fused (Figure-3.a-ı).

Perioperative Findings:

In our cases, the average amount of bleeding during surgery was 910 cc, the average blood transfusion was 1.2 units, and the average operation time was 3.4 hours.

Postoperative Complications:

During the operation, intended dural tear was occurred in two of our patients in which were repaired surgically. In the early postoperative period, two cases underwent revision surgery due to screw malposition. In one case monoparesis was developed in the lower extremity and the motor power recovered completely within one week after steroid treatment. In the late postoperative period, one case was treated using parenteral antibiotics after presentation with surgical site infection. Another case was operated on for incisional hernia which was developed in the iliac graft site. Screw fracture was observed in four patients. Fusion was seen in two of them, in which had no symptoms, therefore no needed to additional surgical treatment. The third patient was re-operated after spondylopytosis was developed. The fourth patient was re-operated for pain in her legs after detected that no fusion. In one patient, one of the connected rods was observed to be loosen in his yearly control visit, but he has no symptom, so there was no additional surgical intervention recommended.

Table-1. Vertebral levels and the spondylolisthesis type of the patients.

	Degenerative		Isthmic		Dysplastic		Iatrogenic		Traumatic	
Level	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
L_5-S_1	**1**	3.3	13	81.25	2	100	1	50	1	100
L_4-L_5	19	63.4	3	18.75			1	50		
L_3-L_4	**7**	23.4								
L_2-L_3	1	3.3								
L_1-L_2	**1**	3.3								
T_{12}-L_1	1	3.3								

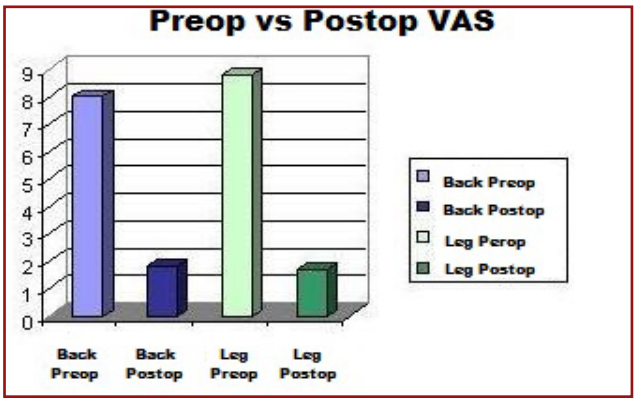

Figure-1. Preoperative and postoperative VAS scores.

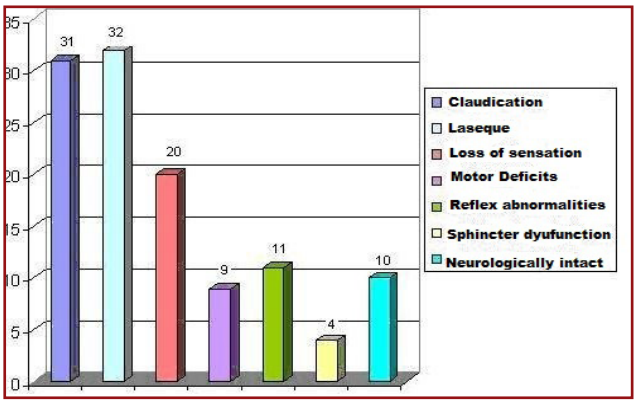

Figure-2. The results of neurologic examination of the patients.

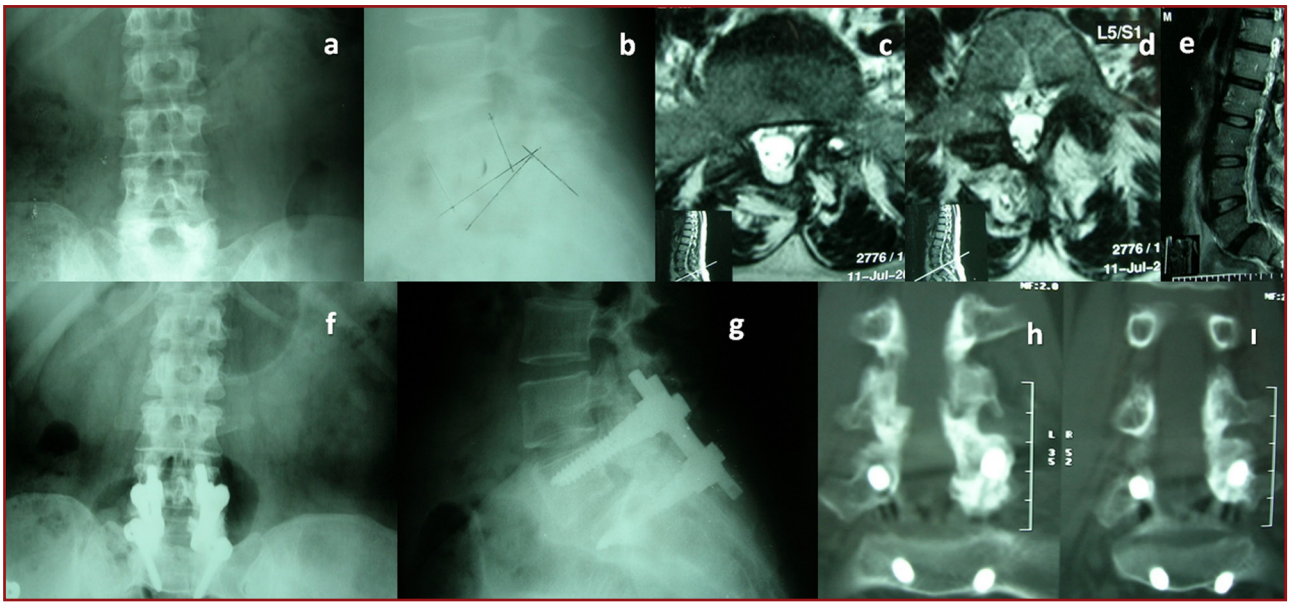

Figure-3. a-ı. A 44-year-old female patient had referred to our outpatient clinic with a 3-year back pain, which was alleviated painkillers and exacerbated with leaning. Except for a claudication at about 20 meters, the patient was neurologically intact. The patient received medication and physical therapy rehabilitation during preoperative period but her pain did not relieve. MRI, CT and x-rays were confirmed diagnosis of L_5-S_1 spondylolisthesis. Total L_5 laminectomy and insertion of bilateral transpedicular screw-rod posterior instrumentation were applied. The screws placement was control with performing x-rays on postoperative first day. The patient was discharged after relieve her symptoms. Postoperative 4th year lumbar CT showed that fusion developed.

DISCUSSION

Surgical intervention for patients were diagnosed with spondylolisthesis success rate is very high when patients are carefully selected and when the criteria of indications are appropriate. One of the most important of the surgical indications is intolerable pain which is resistant to physical therapy and causes activity restriction. In all of our cases, there is complaints of conservative treatment-resistant pain. In our patients, to select the appropriate surgical intervention, we aimed to evaluate the mechanisms of pain formation.

Therefore, we added interbody fusion in some cases in which the patients have scoliosis or/and malformation that lead to sagittal imbalance. But when the patients have spondylolisthesis with intact disc only posterior instrumentation was applied. In the literature, conservative methods have been applied for a long time in the treatment of this deformity and it is seen that the activities of the patients are restricted in this period[14]. Aim of spondylolisthesis surgical treatment is to reduce existing neurological deficits, to prevent deficits, to provide stability, to stop the progress of the slip and to improve the quality of life of the patient by relieving pain.

Various methods are used in the surgical treatment of spondylolisthesis. These include transpedicular fixation, bone or cage anterolateral interbody fusion (ALIF), posterolateral interbody fusion (PLIF), transforaminal lumber interbody fusion (TLIF), extraforaminal lumber interbody fusion (ELIF), facet screw fixation and combined procedures [3,4,7,19].

Success rate increases by adding posterolateral fusion (PLF) and PLIF, ALIF, ELIF, TLIF to the transpedicular screw fixation. The interbody fusion applied with the instrumentation provides a 360° fusion in the moving spine segment. With decompression, the risk of pseudoarthrosis, nonunion will decrease considerably when PLF and interbody fusion are applied. Intervertebral fusion is recommended to be used in situations where the anterior column should be more supported, such as those with high physical activity, obesity, and frontal / sagittal imbalances [3,19].

Currently, most segmental transpedicular screw fixation methods are used. In this method, anatomic changes due to spondylolisthesis are corrected, moving lumbar segments are immobilized, lumber opening is corrected, and fusions are added by reducing shear forces causing anterior sliding. In addition, three columns are stabilized by this method. Biomechanically, pedicle screw systems provide stronger grip than other posterior screw systems and do not require intact posterior elements. It prevents progression of deformity and reduces mechanical pain syndromes to provide early ambulance and increase fusion rate [9,17].

Decompression by laminectomy with transpedicular screw fixation by transpedicular screw-rod method and applying PLF increase the operation time and intraoperative bleeding. In cases when PLIF is added, it is inevitable that this amount of time and bleeding will be higher. In our cases, the average amount of bleeding during surgery was 910 cc, the average blood transfusion was 1.2 units, and the average operation time was 3.4 hours.

Additional PLIF can provide optimal conditions to maintain high disc height and sagittal equilibrium to provide a high fusion rate by providing dense blood flow from adjacent vertebral end plates under compression. However, 3 to 10 % of collapse, slip and graft migrations have been reported in patients underwent PLIF [3,20]. In our cases, we have not seen slip and graft migrations complications.

Spinal fusions provide stability and improves functions by pain relief. Solid fusion failure leads to painful pseudarthrosis. Pseudoarthrosis is the cause of unsuccessful spinal fusion. The most common causes of the pseudoarthrosis are inadequate surgical technique, excessive stress on fusion area, insufficient internal or external stabilization, and metabolic abnormalities. The presence of excessive segmental motion on dynamic flexion-extension graphs is diagnostic criterion for pseudoarthrosis. The other criteria for pseudoarthrosis are absence of trabecular bone in fusion area, loss of autograft height, fracture and/or of any instrumentation (rod, screw, and/or hook) after the expected improvement period. There is excessive movement if slip is more than 2 mm; but if slip be more than 4 mm slip and greater angulation more than 10^0 are diagnostic criteria for pseudoarthrosis. 3D tomography is quite meaningful in evaluating fusion and pseudarthrosis. In three-dimensional CT, cortical ring presence around the graft is the most accurate evidence of anatomic fusion. In our study, we based on dynamic graphs and lumbar CT to detect fusion. According to this, with the use of a roentgenogram, 27 patients were detected to have fusion, 10 had suspicious fusion, 9 had no fusion, and 2 had pseudoarthrosis. We found fusion in 36 cases, 12 cases of fusion, 11 cases of bone scintigraphy out of 34, 22 cases of no fusion and 1 case of pseudarthrosis. In pseudoarthrosis, there is constant movement on the bone surfaces with loading.

Degenerative spondylolisthesis is usually accompanied by spinal stenosis, caudal and radicular symptoms, and neural decompression of these patients with persistent neurogenic symptoms is recommended [6]. We performed decompression to all our cases with degenerative spondylolisthesis. We also performed partial/total laminectomy when all spondylolisthesis had a relative spinal stenosis.

In a study conducted by Wenger and colleagues on 132 cases, 65.3 % of the patients had low back and leg pain, 26.3 % had leg pain, 18 % had neurological dysfunction, 8.4 % had back pain [17]. Kaneda et al. reported that the postoperative lumbalgia has been completely resolved in most of their patients. They reported that lumbalgia was seen in 87 % of their patient preoperatively versus only 7.5 % of their patients were postoperatively suffered from lumbalgia.

Similarly, sciatica was preoperatively seen in 66.7 % of their patients versus only 5.6 % of their patients were suffered from sciatica. In the same study the authors reported that all their patients who preoperatively experienced neurogenic claudication (63 % of their patients) and neurogenic bladder (11 % of their patients) were fully recovered. They also reported that 80 % of the patients who preoperatively suffered from the motor deficits were totally, and 20 % of them partially resolved. The same study reported that 59 % of the patients who preoperatively presented with loss of sensation were completely and 41 % partially resolved [5].

According to our results, 28 out of 32 patients who were presented with preoperative sciatic pain were totally recovered postoperatively. 28 out of 31 patients who were suffered from neurogenic claudication were relieved postoperatively. Eight out of nine patients presented with motor deficit were fully recovered. Eight patients out of eleven who were diagnosed with abnormal reflexes were taken normally in postoperative period. Similarly, three out of four patients who suffered from preoperative sphincter dysfunction were fully recovered (Table-2).

Table-2. Preoperative and postoperative neural problems of the patients.

	Preoperative	Postoperative
Sciatalgia	32	4
Claudication	31	3
Motor deficit	9	1
Loss of sensation	20	4
Reflex changes	11	3
Sphincter dysfunction	4	1

In the study conducted by Wenger et al. for the patients who received surgical intervention with spondylolisthesis reported that the mean postoperative VAS values were 2.13 for low back and 1.59 for leg [17]. In our cases, the preoperative VAS averages were 8.02 for back and 8.79 for leg while the final postoperative VAS averages at last follow-up visits were 1.83 for back and 1.72 for leg.

Complications such as screw malposition, screw fracture, rod fracture, instrumentation failure, dura and root injury, neurological deficit and infection have been reported after insertion of the transpedicular screw-rod systems [5]. Dura injury occurred in two of our cases during the operation. In the early postoperative period, 2 cases underwent revision surgery due to screw malposition. Screw fracture was observed in 4 patients. Wenger et al. reported a 2.3 % surgical site infection in a study of 132 patients [17]. We detected surgical site infection in 1 of our cases (2.1 %). In the same study, adjacent segment degeneration was reported in 9.9 % [17]. In the study of Okuda et al., degeneration of the adjacent segment was reported as 1.4 - 16.8 % [9]. In our study with 48 cases, adjacent segment degeneration was detected in seven of our patients (14.6 %). Adjacent segment degeneration generally develops damage to the superior segment and with the same characteristics as the first operation.

Factors such as adjacent facet joint damage, unnecessary instrumentation, unnecessary fusion length, disruption of the sagittal balance, facet tropism, and horizontalization in the

adjacent lining of the fused segment are predisposed factors for adjacent segment degeneration disease [13,17].

Pseudoarthrosis was reported in 53 % of the cases in the study conducted by Wenger et al. [17]. We detected pseudoarthrosis in 2 (4.2 %) of our cases. One early published study supposed that 43 % of the patients with pseudoarthrosis was found to be asymptomatic [18]. Since spondyloptosis developed in 1 case of 2 pseudoarthrosis-developed cases, reoperation was performed. Our other case was a male patient who had surgical site infection and smoked for a long time. We did not perform surgery since this patient was asymptomatic.

Our work has several limitations; first its retrospectivity nature which may has bias, small number of patients, single center study and follow-up periods of some patients were one year. Our work needs to be supported by prospective, multi-center studies with longer follow-up and more patients.

In conclusion, well-selected patients who describe long-term instability and who do not benefit from conservative treatment, good clinical results may be obtained with posterior instrumentation and fusion.

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Volume: 29, Issue: 2, April 2018 pp: 103-106 ORIGINAL ARTICLE

INTRAOBSERVER AND INTEROBSERVER RELIABILITY OF THE RADIOLOGICAL DIAGNOSIS CRITERIA OF SCHEURMANN'S DISEASE

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ABSTRACT

Objective: Scheuermann's disease is diagnosed radiologically. Radiological measurements play role both in diagnosis of the disease and in the planning of the treatment. In this study, the evaluation of the intra-observer and inter-observer reliability of the radiological measurements used in Scheuermann disease was aimed.

Material and Methods: Ten patients with Scheuermann disease diagnosed by both practitioners were evaluated. The wedging angle on the most wedged vertebra and the kyphosis angle of the patients were measured by two different observers two times for 3 weeks apart.

Results: The correlation coefficients for intra-observer reliability in Scheuermann's disease ranged % 84 - % 92.7 in the measurement of kyphosis angle and it was ranged % 70,8 - % 90,5 in the measurement of the wedging angle. The correlation coefficients for interobserver reliability were detected 87.9 % and 89.7 % for kyphosis angle measurements; and 82% and 68.1% for the measurement of wedging angle.

Conclusion: Radiological measurements used in Scheuermann's disease have high intra-observer and interobserver reliability.

Key Words: Scheuermann's disease, Cobb angle, inter-observer and inter-observer validity

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Scheuermann's disease is the most common cause of rigid kyphosis in adolescents. It was first described by Danish radiologist Holger Werfel Scheuermann in 1921 [17]. It was also called "Osteochondritis juvenile deformans dorsi". In this disease osteochondritis of the secondary ossification centers of the vertebrae is seen.

Scheuermann's disease is diagnosed radiologically. The radiological diagnostic criteria were determined by Sorensen [19]. Sorensen radiological criteria are: at least 3 adjacent vertebrae demonstrating wedging of >5 degrees, spine kyphosis >40 degree in sagittal plan and vertebral end plate irregularity. In addition, radiologically, schmorl nodules, premature disc degeneration, and disc space narrowing are also observed. Patients with Scheuermann's disease also have higher vertebral height [3].

The prevalence of the disease varies between 0.4 % and 8.3 % [10,23]. It is most commonly seen in adolescents aged 12-15 years [22]. About the male/female ratio, ratios like 1:1, 2:1, 7:1 have been reported [13,15,17]. According to recent studies and widespread opinion, prevalence is higher in males than females [16]. Scheuermann's disease is often seen in the thoracic region. The apex of the curvature can be in the mid-thoracic, lower thoracic or thoracolumbar region [8]. This common type is called the classical type. By Edgren and Vanio; atypical, lumbar Scheuermann's disease is described in which similar radiological findings are observed in the lumbar region [5].

The specific etiology of Scheuermann's disease is not fully known. Different theories have been put forward. Developmental defects in collagen aggregation have been suggested to lead to ossification disturbances in vertebral

endplates. About the etiology of the disease, increased secretion of growth hormone, juvenile osteoporosis, recurrent micro trauma, deficiency of vitamin A, poliomyelitis and epiphysitis have been accused [1,15,23]. Some studies have shown that mechanical factors also play a role in the pathogenesis of Scheuermann [10,18]. Children with Scheuermann's disease have been reported to be longer and heavier than healthy individuals. This has been associated with mechanical factors and increased growth hormone. It is also said that the increase in mechanical stress is also effective on kyphotic curvature and symptoms. Genetically, it is assumed to be transferred through autosomal dominant inheritance pattern [2,11].

The disease most often manifests itself with pain and deformity. The treatment is planned according to the kyphosis grade, clinical complaints and the maturity of the patient. In adolescent patients that had not completed the maturity yet, $>50^0$ thoracic kyphosis and $>40^0$ thoracolumbar kyphosis are treated with corset and physical therapy until maturity completion.

Progressive neurological deficit is a definite surgical indication. In addition, surgery may be considered in patients have thoracic kyphosis values of 70^0-80^0, have rapid progressive curvature and unending pain.

As it is seen, the diagnosis of Scheuermann's disease is made radiologically. Radiological measurements play an important role both in the diagnosis of the disease and in the planning of the treatment. In this study, we aimed to test the intra-practitioner and inter-practitioner reliability of the radiological measurements used in Scheuermann's disease.

MATERIAL AND METHODS

Ten patients who were diagnosed with Scheuermann disease by two orthopedic surgeons who were interested in spinal surgery were included in the study. Sorensen criteria were used for the diagnosis of Scheuermann disease. Accordingly, patients were included in the study who determined as having more than 40^0 kyphosis angles and having $>5^0$ wedging on 3 adjacent vertebrae and additionally have vertebral end plate irregularity.

In the patients the wedging angle on the most wedged vertebra and the kyphosis angle were measured. The Cobb method was used to measure the angles. Measurements were made betweenT5 upper endplate and T12 lower endplate for kyphosis angle. For the wedging angle, the most wedged vertebra jointly determined by both surgeons was used and the angle between the upper and lower endplates of this vertebra was measured. Each practitioner measured these two values, unaware of each other's measuring values. Measurements were repeated after 3 weeks. In the second measurements too, the surgeons were unaware of each other's measured values and their initial measuring values.

The intra-observer and inter-observer reliability of the kyphosis angle and wedging angle measurements were statistically calculated.

Statistical Analysis

NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used for statistical analysis. While evaluating the study data, the descriptive statistical methods (mean, standard deviation, median, frequency, minimum, maximum) were used and in comparison of quantitative data, for intra-group comparison of variables with no normal distribution Wilcoxon Signed Ranks test was used. ICC was used to calculate the concordance between the observers. Significance was evaluated at $p<0.05$.

RESULTS

In the measurement of the wedging angle of the most wedged vertebra measured by both two practitioners, the degree of concordance at the 70.8 % level (GOOD) between the first measurement and the second measurement of the first surgeon was statistically significant. (p=0,008; p<0,01). The concordance between the first and second measurements of the second surgeon at the 90.5% (Excellent) level was found to be statistically significant (p=0,001; p<0,01).

It was observed that the first surgeon and the second surgeon had an 82 % (Excellent) concordance between the first septal angle measurements (p=0,001; p<0,01). The first surgeon and the second surgeon were observed to have a concordance of 68.1 % (good) between the measurements of the second wedging angle (p=0,013; p<0,05) (Table-1).

Table-1. Evaluation of the Wedging Angle Measurements of the Surgeons.

First Measurement		The Wedging Angle			*Value*	*ICC*
		Second Measurement	Difference	*p*	*p*	
1. Surgeon	Ort±Ss	14,60±2,32	15,00±1,49	0,40±1,51	Z:-1,006	0,708
	Min-Maks (Medyan)	11-19 (14,5)	13-17 (15)		*[a]0,314*	*0,008***
2. Surgeon	Ort±Ss	14,50±2,76	14,80±2,49	0,30±1,16	Z:-0,791	0,905
	Min-Maks (Medyan)	9-19 (15)	10-18 (15)		*[a]0,429*	*0,001***
	ICC	0,820	0,681			
	p	*0,001***	*0,013**			

[a]Wilcoxon Signed Ranks Test *ICC: Intraclass Correlation Coefficient* **p<0,05* ***p<0,01*

In the T5-T12 kyphosis angle measurements, 84 % (Excellent) concordance between the first and second measurements of the first surgeon was statistically significant (p =0.001; p <0.01). 84 % (Excellent) concordance between the first and second measurements of the second surgeon was statistically significant (p = 0.001; p <0.01).

There was a concordance at the 89.7 % (Excellent) level between the first surgeon and the second surgeon in the first kyphosis angle measurements (p = 0.001, p <0.01). The first surgeon and the second surgeon showed a 87.6% (Good) level of concordance between the measurements of the second kyphosis angle (p = 0,015, p <0,05) (Table-2).

DISCUSSION

The Cobb method is the most important method used to identify coronal and sagittal planar deformities and is described as the gold standard [6-7,12]. The Cobb method was originally described for the evaluation of scoliosis in anterior-posterior radiography. The method used to assess the kyphosis angle on the lateral radiograph is therefore referred to as 'modified Cobb' method. The Cobb method is used to diagnose Scheuermann's disease, follow the progression of the curve, select treatment and evaluate the effectiveness of the treatment. The use of this method at each stage of the disease increases the importance of intra- and inter-observer reliability of the method. Intra- and inter-observer reliability of the Cobb method in coronal plan deformities was investigated in a lot of studies and generally good and excellent reliability levels were found [4,14]. There are also studies investigating the reliability in the sagittal plan of the Cobb method. But there is no specific study tested the reliability of this method in measuring especially kyphosis angle and wedging angle that used to diagnose of Scheuermann's disease.

In our study, the kyphosis angle was measured between T5 and T12, and intra-observer and inter-observer reliability was found high. In similar studies, good and excellent levels of reliability were found in the measurements of kyphosis angle between T5 and T1 However, in one study, the intra-observer reliability (ρ = 0.22-0.65, poor to fair) and interobserver reliability (ρ = 0.33-0.47, low) of the kyphosis measurements between T2 and T5 were found significantly lower than those between T5-T12 [9,24]. It has been said that the superposition of upper ribs, scapula and humeral head region, may cause this in radiography to happen.

Again, in this study the intra-observer and inter-observer reliability of the wedge angle has been found between 0.75 and 0.926, that is, high reliability. In the literature, no similar study for the wedging angle in Scheuermann patients attracts the attention.

Ulmar et al. [21] tested intra and interobserver reliability of vertebral, segmental, and local kyphosis angle measurements in patients with thoracal and lumbar burst fractures. They repeated the measurements on both radiography and computerized tomography.

According to the results of the study, they reported that they found good and excellent interobserver and intra-observer reliability in all categories. In another study, intra and interobserver reliability of vertebral wedging rates and segmental Cobb angle in three groups of patients, including Scheuermann kyphosis, postural kyphosis, and healthy, were tested [20]. In all groups, they found a fairly high reliability. In this study, also, the ratio of vertebral wedging rate over 0.8 and segmental cobb angle over 20 degrees, was found to be highly correlated with Scheuermann disease.

In our study, the kyphosis angle and the wedging angle from the Sorensen criteria used in the diagnosis of Scheuermann's disease were assessed. As a result, in diagnosing Scheuermann's disease both kyphosis angle and wedging angle had high intra-observer and interobserver reliability.

Table-2. Evaluation of the Observers' 'Kyphosis Angle Measurements' on the Wedged Vertebra

First Measurement		Kyphosis Angle			*Value*	*ICC*
		Second Measurement	Difference	*p*	*p*	
1. Surgeon	Ort±Ss	72,40±5,15	71,40±4,97	-1,00±2,83	Z:-1,181	0,840
	Min-Maks (Medyan)	63-80 (73)	62-79 (72,5)		*[a]0,237*	*0,001***
2. Surgeon	Ort±Ss	71,90±7,50	71,40±6,85	-0,50±2,84	Z:-0,669	0,927
	Min-Maks (Medyan)	58-81 (74)	60-82 (73)		*[a]0,503*	*0,001***
	ICC	0,897	0,676			
	p	*0,001***	*0,015**			

[a]Wilcoxon Signed Ranks Test *ICC: Intraclass Correlation Coefficient* **p<0,05* ***p<0,01*

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Volume: 29, Issue: 2, April 2018 pp: 107-113 ORIGINAL ARTICLE

THORACOLUMBAR FRACTURE SURGERIES: ANALYSIS WITH THORACOLUMBAR INJURY CLASSIFICATION AND SEVERITY SCORE (TLICS)

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ABSTRACT

Aim: The purpose of our study is to compare our surgical decisions with TLICS considering our retrospective cases.

Materials and Method: We inspected 38 patients who were operated for thoracal, thoracolumbar and lumbar fractures between February 2016 - February 2018 at Ereğli State Hospital Neurosurgery Clinic and classify according to TLICS.

Results: We analyzed 38 patient with thoracolumbar trauma. Thirteen (34.3 %) female and 25 (65.7 %) male patients were evaluated. Mostly the cause of trauma was fall. The type of the fracture was frequently burst fractures. 16 (42.1 %) patients were operated for thoracal, 19 (50 %) patients were operated for lumbar fractures and three (7.9 %) patient were operated for thoracic-lumbar fractures. According to TLICS scores 20 patients (52.6 %) classified as surgical, 7 patients (18.5%) as surgeon's choice and 11 patients (28.9 %) as non-surgical.

Conclusion: The recommendation by TLICS score for a conservative treatment modality shows to have limitations in certain patients in need to be managed surgically due to their progressing symptoms especially pain.

Key words: Thoracolumbar fractures, TLICS, Spinal trauma

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Thoracolumbar and lumbar burst fractures (TLBF) are commonly the result of major trauma and may be the reason of spinal cord damage resulting in neural deficits, and account approximately 15 % of all spinal injuries [10]. Several different classifications and treatment data have been devised to guide a proper treatment plan for these fractures. The constructed classification modules of vertebral fractures mainly rely on the mechanism of injury and depend on defining stability. Among the most influential were the ideas proposed by Denis [2], Magerl/AO [12] and Vaccaro [20].

TLBF are classified individually by Denis although these fracture patterns have recently been defined as a subtype of fracture occurring as a result of the compression mechanism in the Vaccaro systems [20]. Vaccaro et al. described the Thoracolumbar Injury Classification and Severity Score (TLICS) as an assistance modality for clinical decision-making in consideration of operative versus non-operative care and also surgical treatment approach in unstable injury patterns [20].

TLICS is based on three critical injury characteristics: (1) the morphology of the injury determined by the radiologic patterns, (2) the integrity of the posterior ligamentous complex, and (3) the neurologic status of the patient. The final calculated serves as a guide for a possible conservative (<4 points) or surgical treatment (>4 points) plan. The treatment plan for the outcome score of 4 points can be evaluated according to the surgeon's preference.

TLICS is a theoretical management proposal to aid when facing the decision making process for thoracolumbar traumas. The purpose of our study is to compare our surgical decisions with TLICS considering our retrospective cases.

Figure-1. Preoperative T5 fracture sagittal MRI image

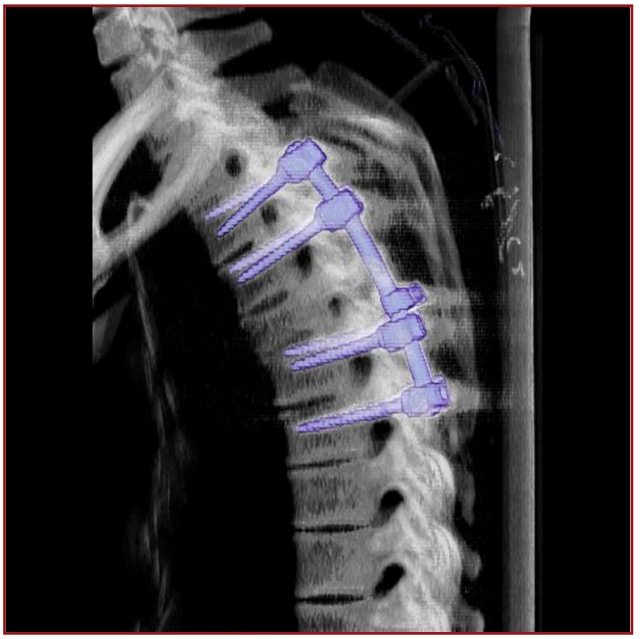

Figure-3. Postoperative T5 fracture stabilization sagittal 3D CT image

Figure-2. Preoperative T5 fracture sagittal CT image

MATERIALS AND METHODS

We inspected 38 patients operated for thoracal, thoracolumbar and lumbar fractures between February 2016 and February. The information's were collected from the patients file archives retrospectively. Radiological data were inspected from the PACS system. We calculated the TLICS scores of the operated patients and evaluated that surgery decision was correct or not according to TLICS (Table-1).

RESULTS

We analyzed 38 patient with thoracolumbar trauma. Thirteen (34.3 %) female and 25 (65.7 %) male patients were evaluated. Mostly the cause of trauma was fall. The type of the fracture was frequently burst fractures. 16 (42.1 %) patients were operated for thoracal, 19 (50 %) patients were operated for lumbar fractures and three (7.9 %) patient were operated for thoraco-lumbar fractures. According to TLICS scores 20 patients (52.6 %) classified as surgical, 7 patients (18.5 %) as surgeon's choice and 11 patients (28.9 %) as non-surgical (Table-2).

Table-1. Thoracolumbar Injury Classification and Severity Score

		TLICS 3 INDEPENDENT PREDICTORS		
1	Morphology Immediate stability	Compression Burst Translation / Rotation Distraction	1 2 3 4	Radiographs CT
2	Integrity of PLC Long term stability	Intact Suspected Injured	0 2 3	MRI
3	Neural Status	Intact Nerve root Complete cord Incomplete cord Cauda equina	0 2 2 3 3	Physical Examination
	Predicts	Need for surgery	0-3 4 ≥5	Non-surgical Surgeon choice Surgical

When we evaluate the table, we saw that we suggested surgery to the patients even that they are scored ≤ four by TLICS. This could be because of pain, which is limiting mobilization. Most of the patients had the diagnoses of burst fracture. Patients and surgeon mostly select surgical treatment for pain management and mobilize immediately. These factors pushes the surgeon to surgery in progression process. If the pain management could be done more affectively, the number of non-surgical treated patients could increase.

DISCUSSION

An ideal spine injury classification system should propose a clear treatment plan and facilitate direct communication between the surgeons, researchers, and trainees. Early manifestations such as the Denis classification and Magerl classification described the thoracolumbar spine and were later extended to describe cervical spine injuries [2,12].

The Spine Trauma Study Group developed an algorithm structured to aid in the clinical decision on following a surgical or conservative treatment plan. TLICS is using a numerical scoring system based on injury morphology, posterior ligamentous complex integrity and neurological status [20]. This manifests the first quantitative scoring system, used to orient the clinical decision-making between conservative and surgical management. Reports have shown this classification to be both valid and reproducible [3,14-15,17].

Whang et al evaluated the validity of the TLICS with 25 consecutive injuries treated conservatively, reassessing the score 3 months following the initial assessment [21]. They found TLICS to be matching with the chosen treatment options in 95.4 % of the cases, reporting substantial effectiveness. The same result was obtained from a study conducted by Patel et al, who also analyzed 25 patients and appraised the TLICS 7 months after the initial assessment [15].

Koch et al applied the TLICS score to 114 patients having been treated conservatively or surgically between 2004 and 2009 [10]. They reported the outcome of 5 or more points to have led to surgical treatment plan in 355 patients among 362 cases with a TLICS, whereas 176 cases out of 195 with a TLICS score lower than 3 were treated conservatively. In total, the authors reported 95 % accord between the performed treatment options and the TLICS proposal. The authors concluded the TLICS to prove an acceptable legitimacy in terms of the treatment recommendations within this historical series.

Joaquim et al assessed a series of 49 patients retrospectively, consecutively treated in two Brazilian centers [6]. A TLICS score of four or more points was calculated for 47 patients (95.9 %), while 2 patients had a TLICS of 2. The authors also reported an association between the AO type fractures, the TLICS score, and the neurologic status. In conclusion, they describe the historical indications for a surgical treatment in their institution to be similar to the indications proposed by the TLICS.

Machino et al reviewed 100 consecutive patients retrospectively with burst fractures, assessing the relation of the Load Sharing Classification and TLICS [11]. Both classifications were used to evaluate the patients; the PLC status was classified as injury with diastasis in the facet joints, facet perch, or subluxation, splaying the spinous process, as well as suggestive changes shown on MRI. Patients presenting with PLC injuries showed higher TLICS scores 1.3 points compared with 1.7 points; ($p<0.001$). However, though showing strong clinical correlation in patients with PLC injury and neurologic deficits, the LSC and the TLICS scores presented low association in cases with intact PLC without neurologic impairment.

Table-2. 38 patients data that operated form thoracolumbar fractures and comparison with TLICS. BF:Burst fracture, F:Fracture, D:Dislocation, PS:Posterior stabilization, M:Male, F:Female.

Gender	Age	Trauma	Diagnosis	TLICS	Operation	TLICS Decision
M	48	Fall	T12-L1 F	9	T10-L2 PS	Surgery
F	30	Fall	L1 BF	2	T12-L2 PS	Non Surgical
M	37	Fall	T12-L3 BF	5	L2-3 PS	Surgery
M	59	Fall	L1 BF	5	T11-L2 PS	Surgery
M	58	Fall	L2 BF	2	T12-L4 PS	Non Surgical
M	76	Fall	T6-7 F	6	T4-7 PS	Surgery
M	56	Fall	L1 BF	2	T11-L3 PS	Non Surgical
F	45	Fall	T7 F	9	T5-9 PS	Surgery
M	45	Fall	L1 BF	2	T11-L3 PS	Non Surgical
M	78	Fall	T12 BF	2	T10-L2 PS	Non Surgical
M	35	Traffic Acc.	T5 F	9	T3-7 PS	Surgery
F	62	Fall	L2-4-5 F	6	T12-S1 PS	Surgery
M	41	Traffic Acc.	T3-8 F	3	T7-9 PS	Non Surgical
M	59	Traffic Acc.	L1 BF	5	T11-L3 PS	Surgery
M	59	Fall	L1 F	2	T11-L3 PS	Non Surgical
F	32	Fall	L1 F	5	T11-L3 PS	Surgery
M	62	Fall	T6-7 D+T7 F	6	T4-10 PS	Surgery
M	55	Fall	T8-L1 F	4	T6-L2 PS	Sugeons' Choice
F	45	Fall	L4 F	4	L3-5 PS	Sugeons' Choice
M	47	Fall	T12 F	3	T11-L1 PS	Non Surgical
M	44	Fall	L1 BF	5	T11-L3 PS	Surgery
M	15	Fall	T12 BF	5	T11-L1 PS	Surgery
F	57	Fall	L2 F	4	T11-L3 PS	Sugeons' Choice
M	29	Fall	L1 BF	4	T11-L3 PS	Sugeons' Choice
F	67	Fall	T7 BF	6	T5-9 PS	Surgery
M	53	Fall	T8 BF	4	T6-10 PS	Sugeons' Choice
F	45	Fall	L3 F	4	L3-5 PS	Sugeons' Choice
F	39	Fall	T11 F	3	T10-L1 PS	Non Surgical
M	47	Fall	L1 BF	6	T11-L3 PS	Surgery
F	21	Fall	T11 BF	6	T10-L1 PS	Surgery
F	59	Fall	L1 F	3	T11-L3 PS	Non Surgical
M	30	Fall	L1 F	4	T11-L3 PS	Sugeons' Choice
M	58	Fall	T7 F	6	T4-10 PS	Surgery
M	55	Fall	T8 F	3	T6-10 PS	Non Surgical
F	45	Fall	L4 F	5	L3-5 PS	Surgery
M	53	Fall	T12 F	6	T11-L1 PS	Surgery
F	49	Fall	L1 BF	5	T11-L3 PS	Surgery
M	19	Fall	T12 BF	5	T11-L1 PS	Surgery

The authors concluded the TLICS used in isolation not to be helpful for patients with low TLICS scores (<4) and severe burst fractures. They proposed the inclusion of LSC to achieve a higher concurrence of the TLICS score and historical cohorts.

Winklhofer et al conducted a retrospective analysis of 100 patients with TLST classified according to the "*Arbeitsgemeinschaft für Osteosynthesefragen*" (AO) and the TLICS based on computed tomography (CT) findings by three radiologists [22]. Six weeks after initial evaluation of the patient data, their CT and MRI scans were reassessed. The two imaging modalities combined increased the number of detected fractures to 196 cases, while previously only 162 were identified when solely the results of CT scans were considered. The TLICS outcome changed in 33 % of patients when the results were compared to only their CT findings. The result of the evaluation of CT and MRI findings together lead to different decisions on conservative treatment plans (TLICS < 5) to surgical treatment (TLICS > 5) in 24 % of the cases. This outcome suggests the safety of the system to be clearly and significantly influenced by the radiologic modalities used for evaluation, adding the importance of MRI in the detection of injuries. Nevertheless, the low specificity of MRI in this setting may also lead to unnecessary surgeries.

From 2007 to 2010, initial conservative treatment with a TLICS score of 4 was performed in 100 % of the 162 patients. However, two patients required late surgery, none with neurologic deterioration, for pain and mild deformity. In the surgical group, 52.4 % matched the TLICS recommendations (4 points). Although suggesting TLICS to improve surgical decision-making, the study was limited by its retrospective application and short follow-up of the majority of patients [5].

A different study with the same patients conducted from 2000 to 2010 with a global analysis of all the 458 patients together, the same authors applied the TLICS retrospectively to the entire cohort [9]. From the 310 (67.6 %) patients treated conservatively, the TLICS matched recommendations in 307 of 310 (99 %), with 3 patients having TLICS of 7 points, requiring late surgery. Additionally, 4 other patients with TLICS < 5 points were managed surgically: 1 patient TLICS of 4 points (severe radiculopathy and burst fractures) and 3 with neurologically intact burst fractures with intractable pain and/or worsening of kyphosis. In the group of surgical patients, however, the TLICS scores matched with only 46.6% of the surgical indications. The main contention in patients was due to neurologically intact burst fractures without neurologic deficits (TLICS of 2 points). The authors suggested a lack of standardized criteria for treatment of burst fractures without neurologic deficits to be a potential cause for the mismatch found between the TLICS scores and surgical treatment. Potential limitations of this study include its retrospective nature, as well as the inconsistencies in defining posterior ligamentous complex injury based on magnetic resonance imaging.

Joaquim et al utilized the TLICS score to instruct treatment plans in a Brazilian population with spinal trauma. A total of 37 patients with TLICS of 3 or less points were first treated conservatively [7]. All patients were neurologically intact, and showed no new deficits with the conservative treatment. Two patients required late surgery with back pain and mild kyphosis, yet without neurologic worsening. The average TLICS score was 1.5 points, ranging from 1 to 2. In the group of 28 patients treated surgically, none showed neurological deterioration and those with incomplete deficits presented improvement during follow-up evaluation. The average TLICS score was 7 points (range 4 to 10 points).

Although the authors demonstrated the use of the TLICS in the decision-making process to be safe with regards to the neurologic status, the study was limited by its short follow-up, potential under reporting of failures, and lack of other outcome measures, such as pain status or functional disability.

In another study, Joaquim et al evaluated the TLICS scores in a series of 458 patients within the United States retrospectively. The patients were divided in two groups according to time of treatment, one being between 2000-2006, the other group representing patients evaluated and treated between 2007-2010 [8]. In the first period, the authors reported no utilization of TLICS in the studied institution, hence it carried no effect on the decision-making process in treatment plans. From 2007 to 2010, TLICS scoring system was used and influenced the planned treatment accordingly. In the report, in 2000-2006, the retrospective application of the TLICS matched the chosen treatment in 97.9 % of the patients managed conservatively and in 39.4 % of the surgically treated patients. The discordance in 60.6 % of patients was caused by the surgical treatment of burst fractures without neurologic deficits (TLICS 2). In 7 patients (4.7%): 3 patients with unrecognized PLC injuries, 1 with severe radiculopathy and a burst fracture (TLICS of 4 points), and 2 with severe back pain without deficits, surgical intervention was required following the previous conservative treatment. None of the patients presented neurologic deterioration.

Shen et al assessed 129 patients with T10-12 thoracolumbar burst fractures with a TLISC score 3 to be treated non-operatively. One hundred and four patients successfully completed the non-operative treatment, while the other 25 patients were later operated on as they presented persistent local back pain or progressive neurological deficits during follow-up appointments. The high score of VAS and the interpedicular distance may be considered as risk factors for the failure of conservative treatment [19].

Juaquim et al evaluated articles about TLICS as a systematic review, and suggested that the TLICS use was safe especially with regards to preservation or improvement of neurologic function [5]. The TLICS system demonstrates good reliability among physicians assessing thoracolumbar fracture treatment in pediatric patients as well [1,18].

Thoracolumbar fracture with score 4 of TLICS is a controversial part of the classification system. While Mohammadi et al suggested that the use of operative method in patients with thoracolumbar fracture with score 4 of TLICS [13], Pneumaticus et al recommends conservative treatment [16].

Hitchon et al reported that because of pain limiting mobilization, a quarter of neurologically intact patients with thoracolumbar burst fractures and a TLICS score of 2 failed nonsurgical management. Patients who has greater kyphosis, stenosis, and fragmentation of the fracture, maybe required surgery [4].

CONCLUSION

The TLICS focuses on three important aspects of thoracolumbar fractures and may offer guidance when choosing between conservative and surgical treatment modalities according to the final score. The recommendation by TLICS score for a conservative treatment modality shows to have limitations in certain patients in need to be managed surgically due to their progressing symptoms especially pain. If the pain management could be done more affectively, the number of non-surgical treated patients could increase.

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Volume: 29, Issue: 2, April 2018 pp: 115-118 ORIGINAL ARTICLE

THE IMPORTANCE OF C-REACTIVE PROTEIN IN DISCOGENIC LOW BACK PAIN: THE ANALYSIS OF 444 PATIENTS*

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ABSTRACT

Background: Low back complaint is the most common health problem. Recent studies point out the role of inflammation on discogenic back pain. In this study, we intended to examine the importance of C-reactive protein (CRP) level in discogenic low back pain.

Material and Methods: 444 patients with discogenic low back pain were assessed in three groups. The first group (n=229) consisted of patients who appealed to outpatient clinic and who were recommended medical therapy. In the second group (n=15), there were patients who appealed to outpatient clinic and who were offered operation but who did not accept surgery. As for the third group (n=200) included patients who were operated because of single level lumbar discopathy. All patients were assessed in terms of CRP positivity at the first admission and whether surgery is recommended or not.

Results: Positivity of CRP was significantly higher in the group to whom surgery is recommended (n=215) than in medical treatment recommended patients (17.8 % vs. 3.1 %, p < 0.0001, OR=6.8, 95 % CI: 2.9-15.6). Furthermore, the positivity of CRP was found significantly higher in the third group compared to the first group (18 % vs. 3.1 %, p < 0.0001, OR= 6.9, 95 % CI: 3.1-16.1). However, it was relatively higher in the second group than in the first group (13.3 % vs. 3.1 %, p=0.0626, OR=4.9, 95% CI: 0.9-25.9).

Conclusion: Discogenic low back pain is caused by both mechanical and inflammatory factors. Preoperative CRP values can be predictive for inflammatory process in lomberdiscopathy. For more accurate results further studies are needed.

Key words: C-reactive protein, low back pain, discectomy

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Low back pain is the second frequent complaint after upper respiratory tract infections in admission to outpatient clinics. It is determined that 80% of all the world's population has complained about low back pain at any time during his/her life [1,23,26]. The most frequent reason of limitation in motion after 45 years is low back pain. For this reason, low back pain can cause a significant loss of labor in industrialized societies. Since ancient historical times, physicians have been interested in lumbalgia, and at 1909 Fedor Krause [6] carried out the first surgical intervention similar to current surgical procedures. Mixter and Barr published surgical series about low back pain at 1934. They emphasized that the most frequent cause of low back pain was lumbar discopathy and the treatment was surgery [6,18]. After this publication, surgeons were also interested in discogenic lumbalgia.

Most important reason of mechanical low back pain is the nucleus pulposus degeneration. It is well described that the main pathophysiology of sciatica is related to disc compression to thecal sac and nerve root. However, severe pain without radiologically significant mechanical compression or severe neural compression without lumbosciatica and decreased satisfaction related to pain at postoperative long-term follow up have led the researchers to re-evaluate the pathophysiology [5]. Clinical and experimental studies in recent years have demonstrated that the inflammation caused by disc content at nerve root may play a significant role in pain mechanism [10,17,18]. Also, it was clearly shown before that the most important mediators of

neural and epidural inflammation are matrix nitric oxide (NO), metalloproteinase, prostaglandin E2, interleukin (IL)-6 and tumor necrosis factor (TNF)-alpha [11,28].

In this study, we aimed to examine the importance of C-reactive protein (CRP) levels at discogenic low back pain proceeding to lomber disc surgery.

MATERIALS AND METHODS

The patients who appealed to our outpatient clinic with low back pain in between January 2012 and July 2012 were inspected retrospectively. Patients who had discogenic low back pain were included to the study. Patients with infectious disease and rheumatologic disease were excluded. All patients were evaluated with magnetic resonance imaging (MRI). Patients having multi-level disc degeneration were excluded from the study. The remaining 244 patients with single level degeneration were evaluated in terms of CRP levels and whether they were recommended surgery or not.

We also retrospectively analyzed another group of the patients who were operated with microdiscectomy for lumbar discopathy during the same time. Two hundred patients aged between 30 and 50 years-old underwent microdiscectomy for single level discopathy. They were the patients who had no additional evidence of infective or rheumatologic disease. Preoperative CRP values of these patients were evaluated for the study.

Statistical Analysis

The MedCalc Software version 10.1.6.0 (Mariakerke, Belgium) was used for analysis. Statistical differences among the groups were identified with *Chi-square* test. In addition, *odds* ratio (OR) and 95% confidence interval (CI) were determined. P values less than 0.05 were considered as significant.

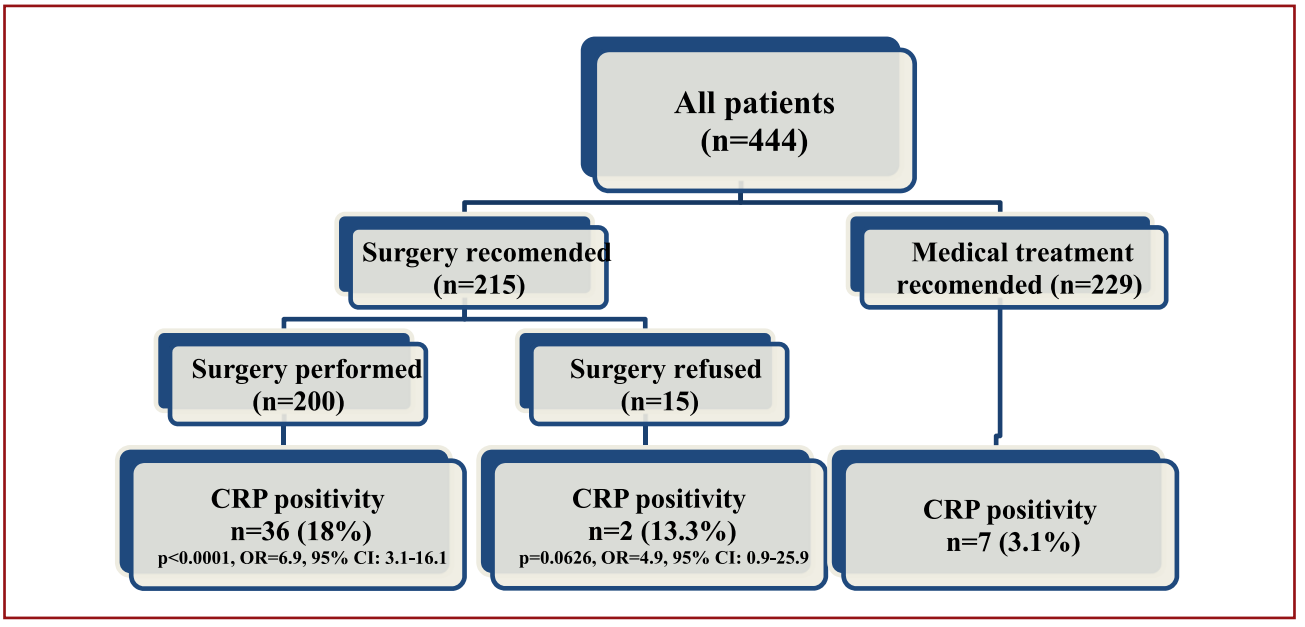
RESULTS

It was seen that surgical intervention was suggested to 15 patients at the evaluation of 244 patients meeting the criteria with discogenic low back pain at our outpatients clinic (Figure-1).

Elevated CRP was detected in 2 of them (13.3 %). Also, it was identified that surgery was not recommended to 7 patients having positive CRP levels (3.1 %). When these results were examined according to percentage analysis, CRP positivity was seen as 3.7 % (n=9) in outpatient clinic's patients. Additionally, CRP positivity was seen at 18% of the operated patients (n=36). The positivity of CRP was significantly higher in the group to whom surgery is recommended (n=215) than in medical treatment recommended patients (17.8 % vs. 3.1 %, p<0.0001, OR=6.8, 95 % CI: 2.9-15.6). Furthermore, the positivity of CRP was found significantly higher in the operated patients compared to the medical treatment recommended patients (18 % vs. 3.1 %, p<0.0001, OR=6.9, 95 % CI: 3.1-16.1). However, it was relatively higher in the patients refused surgery than in the surgery recommended patients (13.3% vs. 3.1 %, p=0.0626, OR=4.9, 95 % CI: 0.9-25.9) (Figure-1).

When the classification function analysis is considered, the sensitivity and specifity of CRP test at recommendation and performance of surgery is about 17 % and 96 % respectively. the positive and negative predictive values are founded 84 %, 55 % (Table-1).

Figure-1. The summary of data



CRP; C-reactive protein, OR; odds ratio, CI; confidence interval

Table-1. The diagnostic performance of C-reactive protein on lomber disc disease

	Surgery (offered and performed patients) (n=215)	Medical treatment (n=229)
CRP positive (n)	38	7
CRP negative (n)	177	222
Sensitivity	17 %	
Specificity	96 %	
PPV	84 %	
NPV	55 %	

CRP; C-reactive protein, PPV; positive predictive value, NPV; negative predictive value

DISCUSSION

Increase in clinical and surgical experience for lumbar discopathy has led the researchers to examine its pathophsiology. After the first identification of lumbar disc herniation in 1930's, the cause of its signs and symptoms was considered as neural compression and this cause was accepted for a long time. However, some debates related to mechanical theory emerged after the development of radiological imaging. Since some clinically apparent herniated lumbar discopathy cases did not show radiologic features despite the presence of severe neural, radicular signs, the probability of another pathophysiologic mechanism besides of mechanical theory is considered [18].

Immune response to disc material was shown and discussed in several articles in 1970's [3,7-9]. However, Guinto et al. were the first to publish a case with spontaneously regressing herniated lumbar disc in clinical interest of this issue[4]. Subsequently, many studies have been published about spontaneous resorption of herniated lumbar disc and have underlined the effect of immunologic response in this process [2,5,11,27].

The study by Olmarker et al. showed that the placement of autologous nucleus pulposus tissue to sacrococcygeal cauda equina on pigs caused reduction of peripheral nerve conduction and increase of degeneration of root without mechanical pressure [21]. Also, it was shown that this application increases production of substance-p and decreases the threshold of nociceptive receptor [11]. Intervertebral disc was found to be immunogenic and the development of granulation after epidural injection were observed in similar studies [18]. Most of the studies on this issue demonstrated that inflammation was also responsible for radiculopathy and in this situation the most effective content was the nucleus pulposus [15,16,22,24,30]. After the contact of nucleus content with epidural space, releasing of some mediators such as phospholipase A2, prostaglandin E2, IL-1 alpha-beta, IL-6, IL-8, TNF-alpha, NO, granulocyte - macrophage colony - stimulating factor, and triggering of inflammatory response were shown in studies [5,10,11,19,24]. Some studies demonstrated that after the beginning of the inflammation, migration of macrophages and lymphocytes to epidural space influence the process [13,14,25,29,30]. TNF-alpha was shown to be more forefront in inflammatory radiculopathy formation by most recent studies [10,18,20].

The release of inflammatory cytokines leads to the increased production of acute phase reactants (APR) by liver in inflammation period. APR are known as indicator of systemic or focal inflammation [3].

In our study, we aimed to investigate whether AFR take place or not in inflammatory process and whether they have positivity in surgical cases. In our results, we found higher CRP levels in the samples of patients to whom surgery is recommended when compared to the other group, and also CRP levels were significantly higher in patients who underwent surgery. To avoid incorrect results, we selected the patients who did not have any additional disease or symptoms. For standardization of release of the mediators, patients with one level lumbar disc disease were included to the study. However, correlation is found between this simple blood test and mechanical compression necessitating surgery. This also reflects the correlation between the CRP levels and inflammation cascade in lumbar discopathy. Our surgical indication for lumbar disc disease is basically to remove the mechanical neural compression. Patients who are recommended surgery have much more mechanical neural compression and when CRP values are taken into account in the same group, it is seen that both mechanical and inflammatory processes are involved in lumbar disc herniation.

When the classification function analysis is considered, the sensitivity of CRP test at recommendation and performance of surgery is about 17 %. This indicates that the efficacy of CRP as a screen test in recommendation of surgery is low. But, specificity analysis demonstrates that CRP positivity is a supporting factor of surgical treatment as it is anticipated (96 %). As for the positive and negative predictive values, positive test highly indicates that surgical treatment will be needed.

The main limitation of our study is that the evaluation of CRP was made as positive/negative rather than quantification. Besides, the authors did not provide any radiological parameter such as size of annular tear, volumetric analysis of the fragment, etc. Surely, the study would be more valuable if CRP values were compared with such technical features.

CONCLUSIONS

Preoperative CRP values can be a predictive value for inflammatory process in lomber discopathy. In discogenic pain, both mechanical compression and inflammation is important. More compression is resulted with more inflammation. For more accurate results, quantitative analysis should be made in the comparison of other cytokines contributing to the inflammatory cascade of lumbar discopathy and CRP, and it should be assessed together with radiological findings.

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Volume: 29, Issue: 2, April 2018 pp: 119-124 ORIGINAL ARTICLE

THE LONG-TERM EFFECT OF TRANS-SACRAL EPIDUROSCOPIC FORAMINOPLASTY IN INTRACTABLE LUMBAR RADICULOPATHY

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ABSTRACT

Introduction: Lumbar radiculopathy is commonly associated with lumbar disc herniation. Epiduroscopy is a method that can be applied in patients who do not benefit from conservative treatment by entering the epidural space with a fiber optic endoscope through the sacral hiatus. We present trans-sacral epiduroscopic foraminoplasty (TSEF) procedure with the Fogarty balloon catheter.

Methods: We collected retrospectively 43 patients who had undergone TSEF between 2013 and 2016. Pain intensity was recorded with visual analogue scale (VAS), and functional outcome was recorded with Oswestry Disability Index (ODI) at preoperative, postoperative 1st, 6th and 12th month follow-ups. Surgery satisfaction was evaluated with Macnab criteria at 1st, 6th and 12th month follow-ups.

Results: There were 27 female (62.8%) and 16 male (37.2%) patients. The mean age of the patients were 70.04 ± 7.78 years. The mean follow-up period was 15.25 ± 1.97 months. Preoperative VAS score averages were 6.44 ± 0.88, decreased to 1.72 ± 1.34, 3.21 ± 0.91 and 3.41 ± 1.17 in postoperative 1st, 6th and 12th month respectively ($p<0.0001$). The preoperative ODI scores decreased from 71.52 ± 6.72 to 19.31 ± 5.49, 27.61 ± 5.37, 31.31 ± 7.91 postoperative 1st, 6th and 12th month respectively ($p <0.0001$). The surgical satisfaction in terms of Macnab criteria were found at 12th month follow up as 60% excellent, 35% good and 5% fair results.

Conclusion: The TSEF procedure is a minimally invasive surgical technique that is easily performed to the patients who are resistant to lumbar radiculopathy, especially those who do not respond to epidural steroid injections, with good long-term results.

Keywords: Lumbar radiculopathy, lumbar disc herniation, trans-sacral epiduroscopic foraminoplasty

Level of Evidence: Retrospective Clinical Study, Level III

INTRODUCTION

Lumbar radiculopathy is commonly associated with lumbar disc herniation, spinal stenosis, and degenerative spondylolisthesis. Disc herniation typically presents with pain in the affected dermatomal area, which is reflected from the back down the leg. In addition, epidural corticosteroid injections (interlaminar, transforaminal or caudal) are highly effective in nerve root compression, which is accompanied by a severe inflammatory response due to herniated nucleus pulposus. In the literature epidural injections also reported pain relief in the mid-term of 55-84% [10,13].

Minimally invasive surgical options for disc decompression are available in pain resistant to epidural steroids or other injection methods. As opposed to open surgery, by protecting the spinal architecture, these methods include less tissue destruction and procedural complications at lower rates.

Epiduroscopy is an epidural spinal endoscopy system developed for this purpose. A method can be applied in patients who do not benefit from conservative treatment and is used in the treatment of symptomatic disc herniation by entering the epidural space with a fiber optic endoscope through the sacral hiatus. The endoscope was first invented by Adolf Kussmaul in 1868, and in 1958 Hirschowitz introduced a flexible fiberglass endoscope, a milestone for the period of minimally invasive surgery [19]. In

principle, Burrman[18] introduced the concept of epiduroscopy in 1931, and Leu et al. reported trans sacral peridural intraductal endoscopy. Rueten et al.[15] reported the clinical application of epiduroscopic assisted laser therapy for post-nucletomy syndrome. In 2003, Ruetten and his colleagues performed epiduroscopy in 93 patients[16] and Graziotti in 300 patients with lower back and leg pain[17].

This technique can be used in lumbar pain and lumbar radiculopathies that do not respond to conservative treatments, and can be widely used to perform adhesion-lysis in intractable failed back surgery syndrome[8]. Epiduroscopy is a method of direct visualization of the lumbar epidural lesions and surrounding structures by entering the body through a natural opening called the sacral hiatus. In contrast to the lumbar disc surgery, minimal defects occur in musculoskeletal structures. This flexible epiduroscopy system can be used to diagnose, as well as to reduce disk pressure with laser applications [9].

In our study, patients suffering from lumbar radiculopathy and treated with epiduroscopy and foraminoplasty with inflated fogarty balloon at the inferior medial of the exiting root at the foraminal level, and disc pressure reduced with this method called trans-sacral epiduroscopic foraminoplasty (TSEF), were presented.

MATERIAL AND METHODS

Study design and patient population

In our hospital, records of 43 patients who had undergone TSEF between 2013 and 2016 were retrospectively collected. Our study protocol was approved by our hospital ethics committee. Informed consent was obtained from all patients. All patients underwent lumbar spinal MRI and x-rays (radiologic examination) before the procedure and problematic disc levels were recorded. As inclusion criteria, single or double level, back and radicular pain, and patients with lumbar degenerative disc disease, annulus rupture sign -high intensity zone (HIZ)- on MRI imaging and foraminal bulging or protruding lumbar disc herniation. In pre-treatment examinations of the patients, they were found to be straight leg raising test + without neurological deficit. TSEF procedure was carried out on patients who had no pain relief following a 4 week follow up after pharmacotherapy (NSAID) and physical therapy due to back and leg pain, given transforaminal epidural steroid injections or those with recurrent pain. Patients with extruded or sequestered disc herniation, neurological motor deficits, Tarlov cysts, lumbar spinal stenosis or spondylolisthesis, hemorrhagic diathesis, infections or tumor pain have been excluded from the study.

Pain intensity was recorded with visual analogue scale (VAS) and patient's functional outcome with Oswestry disability index (ODI), at preoperative, postoperative 1st, 6th and 12th month follow-ups. Postoperative surgical satisfaction was evaluated according to Macnab criteria, and recorded at 1st, 6th and 12th postoperative months.

Percutaneous trans-sacral endoscopic foraminotomy (TSEF) procedure

All patients were subject to hemodynamic monitoring and intravenous access was established in the prone position in the operating room. Sedation was provided with intravenous midazolam and fentanyl as required. After sterile skin preparation and draping, the appropriate opening of sacral hiatus was identified, and the overlying skin and the underlying ligaments were infiltrated with 1% lidocaine. A vertical 5-10 mm skin incision was made in sacral hiatus and 17 gauge Touhy needle was inserted into the sacrum, guidewires and dilators were placed respectively. A steerable 3.0 mm video-guided catheter (VGC) incorporating epiduroscopes was placed. The position of the VGC in the ventral epidural space was checked under the C-arm scope. The VGC end tip was push forward to the corresponding exiting nerve root foramen. Ventral epidurogram was performed with 1-2 ml of contrast (Figure-1).

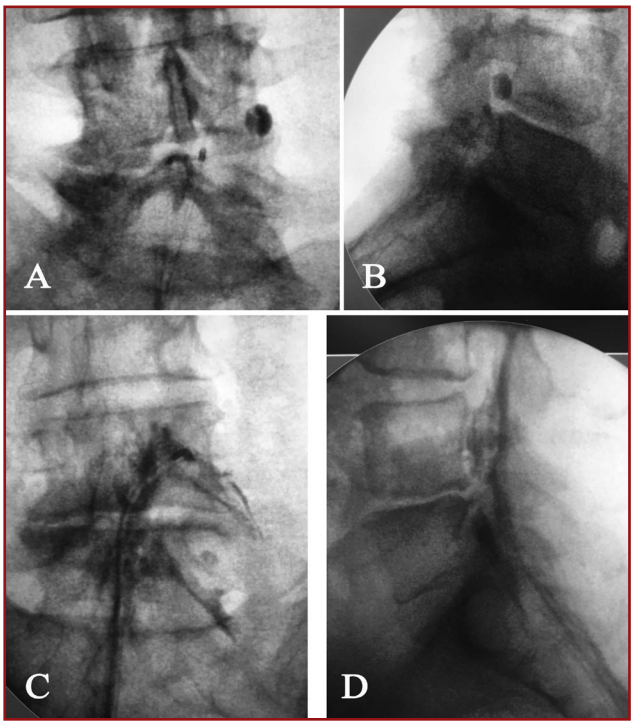

Figure-1. Antero-posterior **(A)** and lateral **(B)** fluoroscopic view, fogarty balloon catheter are seenin the left L4 foramen. Catheter are placed ventral epidural space, antero-posterior **(C)** and lateral **(D)** epidurogram.

Subsequently, the 2-F fogarty was placed adjacent to the infero-lateral of exiting nerve and foraminal disc, was inflated, carrying out a foramen foraminoplasty by widening the foramen. The root was washed by serum saline irrigation and 1 ml of 40 mg methyl prednisolone acetate was administered. After the procedure was finished, the VGC was removed, the sacral hiatus primer was sutured and the patient was transferred to the recovery room.

We observed dural puncture in 2 patients during surgery, transient mild motor neurologic deficit in postoperative period in 2 patients and mild sensorial neurologic deficit in 4 patients. No complications were observed in the other 35 patients.

Statistical Analysis

Statistical analysis of data was performed using SPSS v.21 for Windows (IBM corp., Armonk, NY, USA). The normally distributed continuous variables are reported as means± standard deviations (P>0.05 in Kolmogorov-Smirnov test or Shapiro-Wilk). The paired T test was used for the comparison of normally distributed data among groups, and the Kruskal-Wallis test was used for non-normally distributed data. The Pearson's correlation coefficient was used to investigate a relationship between the factors. A p value of <0.05 was considered statistically significant.

RESULTS

There were 27 female (62.8%) and 16 male (37.2%) patients in the 43 patients we included between the years of 2013 and 2016, with the mean age of the patients being 70.04 ± 7.78 years. The mean symptom duration of the patients was 9.58 ± 1.05 weeks, and the mean follow-up period of the patients was 15.25 ± 1.97 months. The demographic characteristics of patients are given in Table-1.

Preoperative VAS score averages were 6.44 ± 0.88, 1.72 ± 1.34 in the first postoperative month, 3.21 ± 0.91 in the 6th month and 3.41 ± 1.17 in the 12th postoperative month, while the decrease in pain intensities was significant at the postoperative 1st, 6th and 12th months (p<0.0001, Figure-2).

When we considered the functional effect of TFSE according to ODI scores, preoperative scores decreased from 71.52 ± 6.72 to postoperative 1st month 19.31 ± 5.49, 6th month 27.61 ± 5.37, 12th month 31.31 ± 7.91, and there were significant improvement at the postoperative 1st, 6th and 12th months ODI scores (p <0.0001, Figure-3).

The patients treated with TSEF were considered for surgical satisfaction in terms of Macnab criteria at 12th month follow-up, we found 60% excellent, 35% good and 5% fair results (Figure-4).

Table-1. Demographic factors of the patients (SD: standart deviation)

Age (years, mean± SD)	70.04±7.78
Gender (n, %)	
Male	16 (37.2 %)
Female	27 (62.8 %)
Symtom Duration (weeks, mean± SD)	9.58±1.05
Follow-up (months, mean±SD)	15.25±1.97
Levels (n):	
L4-5	37
L5-S1	30

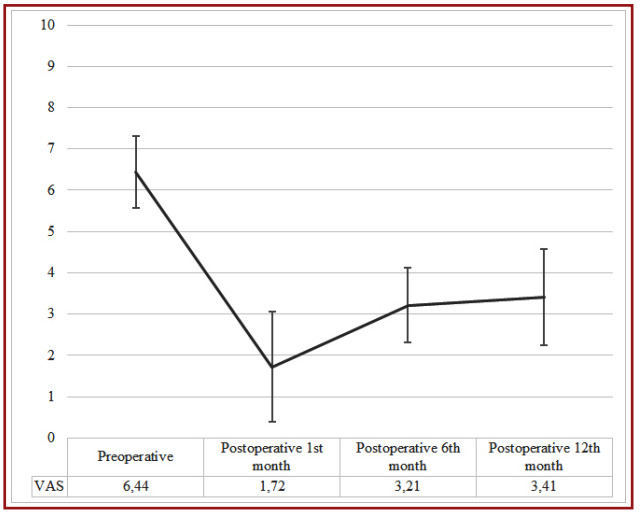

Figure-2. The comparison of preoperative and postoperative Visual Analogue Scale (VAS) scores

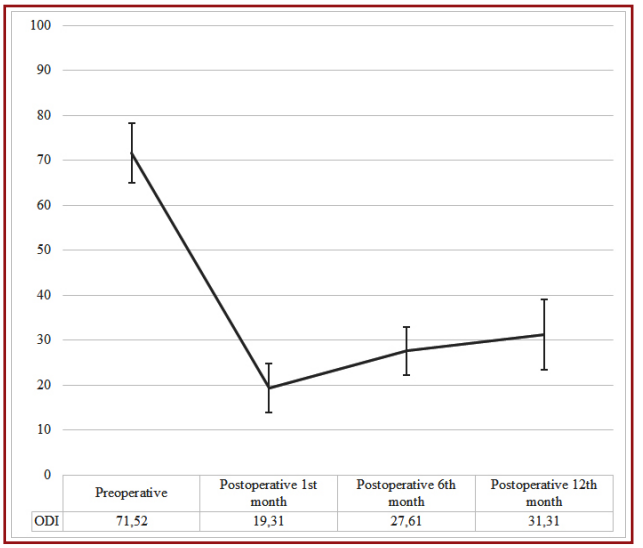

Figure-3. The comparison of preoperative and postoperative Oswestry Disability Index (ODI) scores

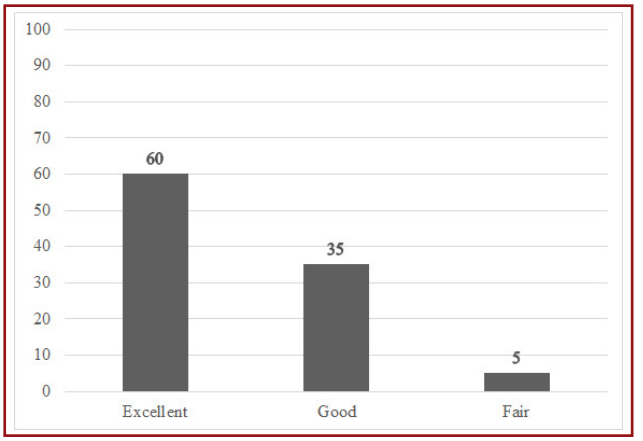

Figure-4. Postopertive 12th month Macnab score results (percentage of the patients)

DISCUSSION

Low back pain and radiculopathy are a painful condition that disrupts the quality of life. The prevalence of life-long prevalence in individuals is between 54-80%, with an annual prevalence of 15-45%[2,20]. Although most of these patients can be treated conservatively, using the epiduroscopy technique in patients who do not respond to conservative treatment, in particular epidural injection techniques, to better visualize the spinal canal and to use some modalities to reduce disc pressure is an alternative method.

Pain formation is a condition that is affected by inflammatory, vascular, biomechanical, and compressive events in addition to the mechanic pressure created by the disc and nucleus pulposus. The nucleus pulposus is a biologically active tissue that triggers a chain of inflammatory type chemical reactions in the degenerative disc disease. Nucleus pulposus is an avascular structure, as well as a tissue that is considered an antigen due to causing a strong inflammatory reaction when making contact with nerve structures. When inflammatory and mechanical reactions develop between the intervertebral disc and posterior longitudinal ligament and nerves, it is thought that back pain and radicular pain is provoked. Along with this, when the nerve is inflamed, it becomes more susceptible to mechanical irritation. The effect of epidural steroid injections on radiculopathies is to clean the mediators released around the nerve, and / or to inhibit secretions, and to block the nociceptive C-fiber connection [4,5,7,11].

Transverse sacral epiduroscopic laser applications are widely used in lumbar foraminal disc herniation. It has been used since 1984, when Ascher and Heppner[1] used CO2 and Nd lasers for treatment of lumbar disc hernias for intradiscal pressure reduction. The laser is used for cutting, evaporation, ablation and welding. However, while the Ho: YAG laser is frequently used in trans-sacral endoscopic laser decompression, it damages the annulus.[3] Unlike laser treatment methods, the TSEF procedure is thought to reduce radicular symptoms by providing widening in the foramen without destroying the natural shape of the structures in that area. In addition to observing that the mechanical pressure of the catheter balloon shrinks the foraminal discs, we think that pain reduction is a result of serum irrigation around the root creating a washout affect. There is no published literature about the TSEF procedure.

One of the minimally invasive surgical techniques in our study, the epiduroscopy procedure, is a popular treatment modality among spinal surgeons because of its ease of operation, short hospital stay, use of local anesthesia and high efficacy and patient satisfaction[6]. However, the presence of complications in trans sacral endoscopy procedures has not been comparatively investigated and is estimated to be below 10.9%[14] . Complications that may develop; Epidural infections can be seen as abscess in very rare cases. Increased intracranial pressure (ICP) can occur with related findings such as headache, nausea, vomiting. It may arise due to the hydrostatic pressure from the irrigation fluid supplied from the catheter during the TSEF. In addition, increased ICP may cause minor visual changes and may cause more severe visual changes in glaucoma patients. Bolus application of irrigation fluid may cause sudden visual loss as it affects the optic nerve microcirculation. The surgeon should consider these symptoms; reduce the irrigation rate in conditions such as acute onset headache, neck pain. Pneumocephaly is a complication that occurs because of air entrapment in the epidural space. As with irrigation, it arises from the difference between the barometric pressure outside and the epidural space. A sudden onset headache during the procedure may be a symptom, and it is reabsorbed within 1 week. Dural puncture (DP) can usually be seen in the ventral epidural space around the S2 area during epiduroscopy. The thecal SAC endpoint may vary because the DP vary from patient to patient. The end of thecal SAC should be determined from the preoperative MRs before the procedure is started, and great care must be taken in this point as the catheter advances towards the ventral epidural space during the procedure. In addition, as we have seen in 6 patients with TSEF procedure in our series, transient neurological deficits can be seen after balloon foraminoplasty [12].

There are also limitations of our study. The number of patients is low, and is retrospective in terms of nature, this being the weaknesses of our study. In addition to this, the operation being performed by a single senior surgeon is a strong point of our study. Reliable information related to this technique will be available in randomized, controlled, prospective studies.

CONCLUSION

The TSEF procedure is a minimally invasive surgical technique that is easily performed to the patients who are resistant to lumbar radiculopathy, especially those who do not respond to epidural steroid injections, with good long-term results.

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Volume: 29, Issue: 2, April 2018 pp: 125-128 ORIGINAL ARTICLE

ANALYSIS OF LUMBAR DISCECTOMY OPERATIONS

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ABSTRACT

Objective: The aim of the study is to analyse the lumbar discectomy operations in one year.

Materials and Method: We inspected 240 patients who were operated for lumbar disc herniation between January-2017 and January-2018 at Özel Aile Hospital Neurosurgery Clinic. The parameters that evaluated are the level of discopathy, side of the disc herniation, recurrent or first operation and type of surgery.

Results: A total of 240 patients were included in the analyses. Mean age of the patients was 48±12,8 years, and M/F was 134/106 (55.8 % vs. 44.2 %). Most frequent levels of operation were L4-5 (n=128, 53.3 %), L5-S1 (n=64; 26.7 %), and L3-4 (n=18, 7.5 %). About 53.3 % of cases had operation on the left side, 44.2 % had on the right side, and 2.5% had bilateral operation. First-time operation was present in 90.4 %, and 6.3 % had operation for recurrent disease. Majority of the patients (n=209, 87.1 %) had microdiscectomy operation.

Conclusions: Lumbar microdiscectomy is the gold standart and most preferred surgical treatment modality on herniated lumbar degenerative disc diseases.

Key Words: Lumbar microdiscectomy, Lumbar disc herniation, Analyse of lumbar disc herniations

Level of Evidence: Retrospective Clinical Study, Level III

INTRODUCTION

The most common cause of low back pain is lumbar degenerative disc disease is. Herniation of nucleus pulposus is the commonest indication for lumbar spine surgery [(11)]. Lumbar discectomy indications include neurological deficit causing weakness of functionally important muscles, cauda equina syndrome and progressive neurological deficit in spite of conservative treatment [(9)]. Relative indications for discectomy include persistent pain refractory to conservative care and pain that adversely affects the quality of life [(11)]. In 1977, Caspar and Williams described a surgical microdiscectomy technique [(3,14)].

The prevalence of symptomatic herniated lumbar disc is about 1–3 %, with the highest prevalence among people aged 30–50 years [(5)]. Annually, it is estimated that 2.75 out of 1000 people with episodes of low back pain will suffer an episode of hospitalization [(4)]. Along with this, the number of lumbar spine surgeries has been increasing during the last 20 years, which also leads to an increase in hospital costs and complications related to surgery [(1)]. Surgery is indicated when conservative treatment fails [(13)]. Traditionally, the accepted surgical treatment has been discectomy [(12)].

The aim of the study is to analyze the lumbar discectomy operations in one year with the parameters of level of discopathy, side of the disc herniation, recurrent or first operation and type of surgery.

MATERIALS AND METHODS

We inspected 240 patients who were operated for lumbar disc herniation between Jan-2017 and Jan-2018. The information's were collected from the patients file achieves retrospectively. Radiological data were inspected from the

PACS system. The parameters that evaluated are the level of discopathy, side of the disc herniation, recurrent or first operation and type of surgery.

Statistical Analyses

Descriptive data were presented using mean and standard deviation, and frequencies and percent. Chi-square and Mann-Whitney U tests were used for comparisons between the independent groups of the study, and statistical significance was evaluated according to a two-sided Type-I error level of 5%. Statistical Package for the Social Sciences (SPSS) 21 software (IBM Corp. in Armonk, NY) was used for all statistical analyses of this research.

RESULTS

A total of 240 patients were included in the analyses. General demographic information of the patients are shown in Table-1. Mean age of the patients was 48±12,8 years, and M/F was 134/106 (55.8 % vs. 44.2 %). Most frequent levels of operation were L4-5 (n=128, 53.3 %), L5-S1 (n=64; 26.7 %), and L3-4 (n=18, 7.5 %). About 53.3 % of cases had operation on the left side, 44.2 % had on the right side, and 2.5% had bilateral operation. First-time operation was present in 90.4 %, and 6.3 % had operation for recurrent disease. Majority of the patients (n=209, 87.1 %) had

Comparisons between genders revealed that the mean age of males was 46.8±12.6 years, and mean age of females was 49.5±13 years. Age distribution was similar between genders (p=0.10). Most frequent levels of operation were L4-5 (n=73, 54.5 %) and L5-S1 (n=36; 26.9 %) in males, and L4-5 (n=55, 51.9 %) and L5-S1 (n=28; 26.4 %) in females. Distribution of levels of operation was similar between genders (p=0.69). For males, 53 % of cases had operation on the left side, 45.5 % had on the right side, and 1.5 % had bilateral operation. For females, 53.8 % of cases had operation on the left side, 42.5 % had on the right side, and 3.8 % had bilateral operation. Distribution of sides of the operation was similar between genders (p=0.51). First-time operation was present in 89.6 % and 91.5 %, and operation for recurrence was present in 8.2 % and 3.8 % of the males and females, respectively. Distribution of cause of operation was similar between genders (p=0.34). Majority of the patients (88.8 % of males and 84.9 % of females) had microdiscectomy operation, and the distribution was similar (p=0.39)(Table-2).

Table-1. General demographics of the patients

	Mean	**SD**
Age (years)	48	12.8
	n	**%**
Sex		
Male	134	55.8
Female	106	44.2
Lumbar disc level		
L4-5	128	53.3
L5-S1	64	26.7
L3-4	18	7.5
L3-4, L4-5	13	5.4
L4-5, L5-S1	11	4.6
Other	6	2.5
Side		
Left	128	53.3
Right	106	44.2
Bilateral	6	2.5
First or recurrent disease		
First	217	90.4
Recurrence	15	6.3
Operation type		
Microdiscectomy	209	87.1
Other/combined	31	1.3

Table-2. General clinical features according to gender of the patients.

	Males		Females		p
	Mean	SD	Mean	SD	
Age (years)	46.8	12.6	49.5	13	0.10
	n	%	n	%	
Lumbar disc level					0.69
L4-5	73	54.50	55	51.9	
L5-S1	36	26.90	28	26.4	
L3-4	10	7.50	8	7.5	
L3-4, L4-5	5	3.70	8	7.5	
L4-5, L5-S1	5	3.70	6	5.7	
Other	5	3.70	1	1.0	
Side					0.51
Left	71	53.0	57	53.8	
Right	61	45.5	45	42.5	
Bilateral	2	1.5	4	3.8	
First or recurrent disease					0.34
First	120	89.6	97	91.5	
Recurrence	11	8.2	4	3.8	
Operation type					0.39
Microdiscectomy	119	88.8	90	84.9	
Other/combined	15	11.2	16	15.1	

DISCUSSION

The degenerative process is identified as multifactorial, irreversible and associated with a mechanical dysfunction [6]. Progressive disc degeneration will result in a loss of the intervertebral disc space height which depends on the degree of disc degeneration, and it has been shown to have a significant influence on the biomechanics and kinematics of a lumbar motion segment [7]. Magnetic resonance imaging is the gold standard for radiological diagnosis.

Microdiscectomy is the most commonly performed spinal surgery for lumbar disc herniation. Lumbar level discopathies have the highest ratio of diagnosed spine regions more than thoracic and cervical levels [8]. Incomplete resolution of lumbar disc herniation symptoms or inadequate response to conservative measures may result in surgery in 10 % of patients [2]. Sometimes spontaneous regression of lumbar disc herniations could be seen [10].

The surgical techniques have been used in our study were simple microdiscectomy, lumbar disc replacement and instrumentation. Our major choice is simple microdiscectomy as seen at the statistical analysis. Most frequent levels of operation were L4-5 (n=128, 53.3%), L5-S1 (n=64; 26.7%), and L3-4 (n=18, 7.5%). About 53.3% of cases had operation on the left side, 44.2% had on the right side, and 2.5% had bilateral operation. First-time operation was present in 90.4%, and 6.3% had operation for recurrent disease. Majority of the patients (n=209, 87.1%) had microdiscectomy operation. We found no statistical significance between genders on any parameter.

Many technical improvements have decreased operative trauma by reducing incision size, thereby reducing postoperative pain and hospital stay and time off work, while improving clinical outcome. Magnification and illumination systems by microscope and endoscope have been introduced to enable minimally invasive techniques. Several comparative studies have analyzed the clinical results of these various surgical techniques to improve the outcomes [2].

Lumbar disc herniation removal techniques have greatly evolved in terms of instrumentation over the last 30 years. Lumbar microdiscectomy is the gold standard and most preferred surgical treatment modality on herniated lumbar degenerative disc diseases.

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Volume: 29, Issue: 2, April 2018 pp: 129-132 ORIGINAL ARTICLE

AN EVALUATION OF EFFECTIVENESS OF ACUPUNCTURE THERAPY APPLIED TO DISTANT POINTS IN LUMBAR DISC HERNIA

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ABSTRACT

Objective: We hypothesized that determining the acupuncture therapy protocol based on the level and lateralization of lumbar disc herniation would be a more correct approach. We therefore planned to enroll patients with bilateral leg pain in addition to lumbar pain. The purpose of this study was to evaluate the effectiveness of acupuncture therapy applied to distant points in patients with lumbar disc hernia.

Methods: This was an observational clinical study. Twenty patients with leg pain in addition to lumbar pain were included. The Existing Pain Severity Scale was administered to patients when they first attended and at the end of treatment. Acupuncture treatment was performed in two sessions per week. The GB 32 (Zhongdu), GB 34 (Yanglingguan), GB 40 (Qiuxu), ST 36 (Zusanli), and BL 60 (Kunlun) acupuncture points, distant points in the treatment of lumbar pain, were selected.

Results: Patients' mean pain score on first arrival was 4.30 ± 0.66, decreasing to 1.40 ± 0.82 at the end of the fourth session of acupuncture therapy. A statistically significant decrease was thus determined in pain severity before and after acupuncture therapy (p=0.001).

Conclusion: Our study shows that acupuncture therapy directed toward the cause and involving distant point application only is effective in patients with lumbar pain. We conclude that treatment protocols applied to fewer acupuncture points will increase patients' compliance with treatment and make a positive contribution to the healing process.

Key Words: Acupuncture, Lumbar Disc Hernia, Pain Management.

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

The multiple nature of the causes underlying lumbar pain result in problems concerning treatment [1,11]. Failures in both pharmacological and surgical treatments have led to interest in and research into complementary therapeutic modalities. One such complementary medical procedure is acupuncture, which has recently become increasingly widely used [3].

The analgesic effect of acupuncture has been attributed to gate-control and/or neurohormonal mechanisms [4]. The application of a needle to the acupuncture point results in the release of endogenous opioids through receptor stimulation, and thus in pain control [2,13]. While acupuncture therapy produces an analgesic effect through these mechanisms, it also helps eliminate muscle spasms and rigidity gradually developing secondary to trauma in the skeletal muscles, and particularly the paravertebral muscles.

Conflicting results have been reported in studies of the effects of acupuncture in patients with lumbar pain [5,8]. Discrepancies concerning lumbar pain show that the scientific studies in this area to date are insufficient [10]. Therapeutic approaches involving more specific methods directed toward the causes of lumbar pain would make it easier to collect reliable evidence.

One of the most common causes of lower back pain is lumbar disc herniation. The acupuncture therapy applied to patients with lumbar disc herniation consists of complex treatment protocols involving both close and distant points [9].

In our previous experience, we observed that acupuncture treatment with distal point was effective in patients with lower back pain accompanied by leg pain. We considered that determining the acupuncture therapy protocol on the basis of the level and lateralization of lumbar disc herniation would be a more correct approach. We therefore planned to enroll patients with lateral leg pain in addition to lower back pain. The purpose of this study was to evaluate the effectiveness of acupuncture therapy applied to distant points in patients with lumbar disc hernia.

MATERIALS AND METHODS

This study is an observational clinical research. The participants were selected from patients diagnosed with lumbar disc herniation, with symptoms persisting despite medical treatment and presenting to the acupuncture clinic. Atatürk University ethical committee approval was also obtained. All the patients that were chosen for the study, volunteered for acupuncture treatment. An Existing Pain Severity Scale involving values from 1 to 5 was applied to patients before and at the end of treatment.

Twenty patients with back pain were included in the study. All patients were present in lateral leg pain. Acupuncture treatment was performed in two sessions per week. The GB 32 (Zhongdu), GB 34 (Yanglingguan), GB 40 (Qiuxu), ST 36 (Zusanli), and BL 60 (Kunlun) points, distant points in the treatment of lower back pain, were selected [7] (Figure-1).

Since all patients had lateral leg pain accompanying lower back pain, point selection was based on cardinal points on the meridians localized to the area in question. Sessions lasted 30 min, and steel needles were used. During treatment, the acupuncture needles were inserted to a depth of 1.5-2 cm at the GB 32, GB 34, ST 36 and BL 60 points, and of 1 cm at the GB 40 point, at an oblique or vertical angle (Figure-2,3).

Figure-1. The GB 32 (Zhongdu), GB 34 (Yanglingguan), GB 40 (Qiuxu), ST 36 (Zusanli), and BL 60 (Kunlun) points, distant points in the treatment of lower back pain, were selected.

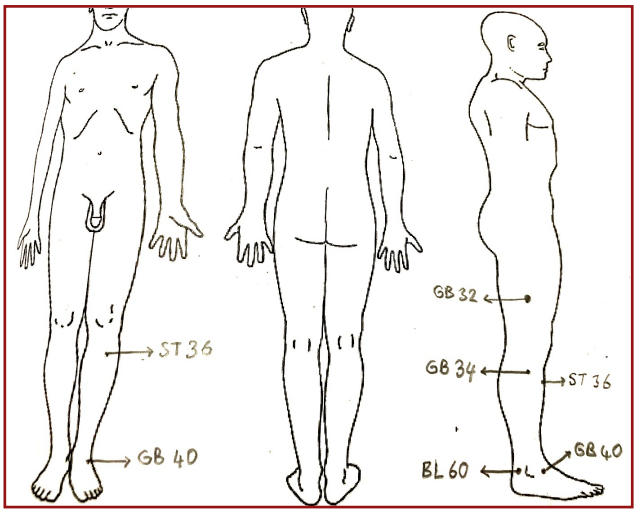

Figure-2. Acupuncture treatment was performed in two sessions per week

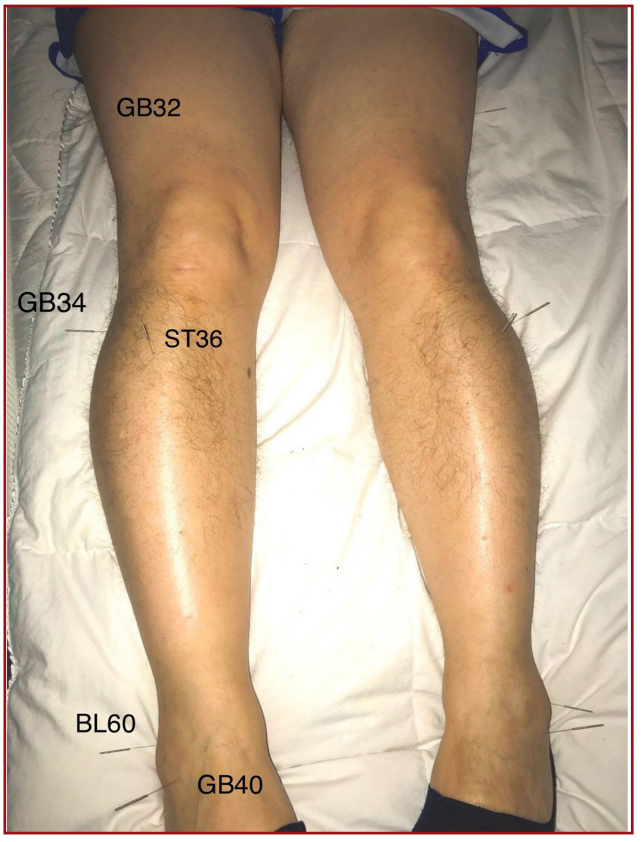

Figure-3. During treatment, the acupuncture needles were inserted to a depth of 1.5-2 cm at the GB 32, GB 34, ST 36 and BL 60 points, and of 1 cm at the GB 40 point, at an oblique or vertical angle

Moxa and modulation methods were not applied Data analysis was performed on SPSS (Statistical Software Package) (PASW Statistics for Windows, Version 16.0. Chicago, SPSS Inc.) software. Demographic data were evaluated with frequency analysis. Existing Pain Severity Scale data were analyzed using ANOVA at repeated measurements in dependent groups. Since the assumption of sphericity was not met according to Mauchly's test ($p< 0.05$), Greenhouse – Geisser corrections were used for F values. Multiple comparisons between repeated measurements were performed using the Bonferroni method.

RESULTS

Twenty patients, 4 men and 16 women, aged between 34 and 76 years were included in the study. Patients' mean age was 52.20 ± 12.47 years, and mean body mass index was 29.33 ± 4.45. A decrease in pain was determined in 19 patients, while no change was observed in one.

Patients' mean pain severity score on arrival was 4.30 ± 0.66, while the mean severity score at the end of the fourth treatment session was 1.40 ± 0.82. The decrease in pain severity after application of acupuncture compared to pretreatment was statistically significant (p=0.001) (Table-1).

Bonferroni -analysis indicated that this decrease was more marked after the first two sessions.

DISCUSSION

A significant decrease in pain occurred following acupuncture therapy applied to the GB 32, GB 80 34, GB 40, ST 36 and BL 60 distant points in patients with lumbar disc herniation presenting with pain diffused to the lateral part of the leg. Studies in the literature have shown a decrease in lower back pain following acupuncture applied to distant points of the ankle and the wrist in addition to application to the ankle alone [12,14].

Our findings also supported the results of the few studies in the literature. These studies show that even acupuncture in which only distant points are selected in patients with lower back pain is promising in terms of providing effective treatment.

According to Bonferroni analysis, the first session of acupuncture therapy produced a significant decrease in pain severity. There is evidence in the literature that even a single session of acupuncture is more effective in reducing the severity of lumbar pain than 'sham' acupuncture [6,12]. The significant decrease in pain severity after the first session in our study is in agreement with studies reporting that acupuncture is effective in lower back pain.

There are studies showing that acupuncture is effective in patients with both acute and chronic lumbar pain. These have mainly been planned on the basis of application to distant points in addition to local points [5,8]. Significant improvement was observed in our study in patients with lumbar disc herniation not responding to medical treatment. These results support previous studies suggesting that acupuncture can be used as an effective treatment in lumbar pain [3,5,7-9,12,14].

In conclusion, our study shows that acupuncture therapy aimed at the cause and involving distant point application alone is effective in patients with lumbar pain. We conclude that treatment protocols applied to fewer acupuncture points will increase patients' compliance with treatment and make a positive contribution to the healing process. We also think that further studies are now needed on this subject.

Acknowledgments

The limitation of this study is the absence of control groups such as a sham acupuncture group, an electro-acupuncture group or an acupuncture group with a combination of 103 local and distant points.

Disclosure statement

The authors declare that they have no conflicts of interest and no financial interests related to the material of this manuscript.

Table-1. Comparison of Existing Pain Severity Scale scores at repeated measurements

	n	Mean ±SD*	95% Confidence Interval		F	P
			Lower Bound	Upper Bound		
On arrival	20	4.30 ± 0.66	3.99	4.60		
First application	20	2.45 ± 0.99	1.98	2.91	87.96	0.001
Second application	20	1.75 ± 0.96	1.29	2.20		
Third application	20	1.50 ± 0.82	1.11	1.88		
Fourth application	20	1.40 ± 0.82	1.01	1.78		

*SD: Standard Deviation

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