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Corresponding Address:
İ. Teoman BENLİ
Aydıntepe Mahallesi, Beydağı Sokak, Teknik Yapı Evora Evleri B-Parsel, B-12 Blok, Kat:3, Daire: 53,
İçmeler, Tuzla, İstanbul, Turkey.
cutku@ada.net.tr

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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 ra-

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

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

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

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

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

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

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

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

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

es 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 in 2019. We are happy to accomplish the second issue of 2019.

There are 10 clinical research articles in this issue. One of them is from our brother country, Azerbaijan which was about new technique for the surgical treatment of severe scoliosis. Second study is about multiple Ponte's osteotomies in rigid idiopathic scoliosis. In the third study, the importance of diffusion MRI in evaluation of vertebral metastases was reported. In fourth study, follow-up changes of the degenerative process with MRI after anterior cervical disc surgery is presented. In fifth article, surgical principles in posterior transpedicular screw fixation and fusion for treatment of spondylolisthesis are discussed. Sixth study is about the cervical disc herniation treated with PEEK cages. In the seventh study, the demographic and socioeconomic factors affecting recurrence of lumbar disc herniation is evaluated. Eighth study is about the effect of adding dynamic screws to upper fusion segment in patients with degenerative lumbar spine. In the next two article, the epidemiologic and clinical results of the traumatic fractures and complete dislocations (spondylopytosis) of the thoracic, thoracolumbar and lumbar spine are discussing.

In this issue, one case report about the spinal metastasis of colorectal carcinoma is reported.

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.

International Turkish Spine Congress will be held in 3-6 April 2019 in Izmir, Turkey. Foreign authors will also participate in this congress, and we are sure that scientific and social program of the congress will be held at a high level of satisfaction. Due to our regulations, existing President and members of administrative board of Turkish Spine Society who are in charge through 2017 till 2019 will step down and a new president and board members will be elected. We are grateful for the successful works done by the previous board members and we wish luck for the preceding newly elected board members.

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

MANAGEMENT OF IDIOPATHIC SCOLIOSIS

DIAGNOSIS (MR IMAGING)

SPONDYLOLISTHESIS

CERVICAL DISC HERNIATION

LUMBAR DISC HERNIATION

LUMBAR DEGENERATIVE DISEASE

SPINAL TRAUMA

CASE REPORT

Volume: 30, Issue: 2, April 2019 pp: 85-91 ORIGINAL ARTICLE

OPERATIVE TREATMENT OF SEVERE SCOLIOSIS WITH MODIFIED ARC ROTATION MANEUVER

Togrul CALILOV[1]
Cem ALBAY[2]

[1]*Azerbaijan Scientific Research Institute of Traumatology and Orthopedics, Department of Orthopedics, Baku, Azerbaijan.*

[2]*University of Health Sciences, M.S. Baltalimani Bone Diseases Research and Training Hospital, Department of Orthopedics, Spine Unit, Istanbul, Turkey*

ORCID Numbers:
Togrul CALILOV: 0000-0002-5400-0570
Cem ALBAY: 0000-0002-4063-9883

Address: Togrul Calilov,
Azerbaijan Scientific Research Institute of Traumatology and Orthopedics, Department of Orthopedics, Baku, Azerbaijan.
Phone: +99 450 314 78 72
e-mail: ctoqrul@yahoo.com
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ABSTRACT

Objectives: Description of correction of severe scoliosis with modified Cantilever bending technique without anterior discectomy or osteotomy.

Summary of Background Data: Ponte, PSO and VCR type posterior osteotomies are often required for the treatment of rigid deformations above 55°. However, these procedures are monitored with high neurological deficit and bleeding risks, and according to the knowledge of some authors, complications can reach 80 % and can be experienced not only during the operation, but also 6 months after the post-operative period. The classic Cantilever maneuver was described by Kao-Wha Chang in 2003 and is said to have been implemented in 1998. In this study, we will discuss the correction of severe scoliosis with modified Cantilever bending technique without anterior discectomy or osteotomy.

Materials and Methods: The technique was performed in 24 patients. 2 of them were male and 22 were female. The age of the patients was between 12-32, the severity of deformity was 57°-120°. 1 or 1.5 years of outcomes are present.

Results: The degree of major curvature was 82.78° ± 19.89° (min. 57°, max. 120°). In order to measure the flexibility of the curves, bending graphs were determined and an average of 21,58° ± 14,46° (% 26.10 ± % 13.69; minimum 2.0°, maximum 40.1°) was detected. This means as the all curves were rigid and severe curves in the patients (t: 2.01; p> 0.05). On the other hand, mean postoperative correction of the major curves was 50,08° ± 13,23° (% 60.49 ± % 14.14; minimum 33.5°, maximum 82.3°) with statistically significance (t:14.85; p<0.01). Postoperative correction percentages were higher than the correction of the curves in the bending graphics with statistically significance (t: -15.42; p< 0.01) Operations were performed without neuromonitarization, none of the patients had neurological complications. One patient had lumbar decompensation, which was corrected by fixing the L4 vertebra. There was no dislocation during the operation, no infection was detected, there were no death issues, and blood loss was 200-250 ml. No clinical signs were observed in follow ups. Thoracoplasty was not performed in any patient and there was no patient complaint requiring thoracoplasty. During the operation, only facetectomies were used, and neither anterior release nor posterior vertebral osteotomies were performed.

Conclusion: We think that the technology does not thoroughly modify the principles of correction and require any special instruments and skills to be applied, so it can widely be used and outcomes observed.

Key words: Rigid scoliosis, surgical management, cantilever, complication.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Nowadays, despite the superior development of technology and medicine, treatment of severe scoliosis is a challenge of surgery. The operative correction of that kind of scoliosis remains a risky procedure. The operative correction of scoliosis at 50°-55° degree can be performed by means of derotation, compression distraction or rod replacement [5].

Surgeons often use special long-headed spondylolisthesis screws on all vertebras, which allows the rod adaptation when the curvature is greater than that. Ponte, PSO and VCR type posterior osteotomies

are often required for the treatment of rigid deformations above 55°. However, these procedures are monitored with high neurological deficit and bleeding risks, and according to the knowledge of some authors, complications can reach 80 % and can be experienced not only during the operation, but also 6 months after the post-operative period [1]. There is a lot of information in literature about the complexity of vertebra osteotomies and the risks of complications. In 2017, Prataly et al reported a high clinical effect of 60 % of the 3 colon resections despite neurological complications risks [13]. Trobisch et al performed PSO in 22 patients without neuromonitarization and an average of 2302 ml blood loss was reported. 2 patients had neurological deficits [17].

Two-stage correction is applied for over 70 degree curves: anterior discectomies followed by 2 to 3 weeks of halo traction and posterior surgery but there is a further complication risk [2,6-7,10,12,18].

The Cantilever maneuver was described by Chang in 2003 and is said to have been implemented in 1998 [4].

In this study, we will discuss the correction of severe scoliosis with modified Cantilever bending technique without anterior discectomy or osteotomy. Correction of advanced scoliosis will be evaluated radiologically and clinically and the effectiveness of the method will be indicated in the article.

MATERIALS AND METHODS

In 2014, when the first author started to apply polisegmental transpedicular systems in AzBÖTOE, severe scoliosis was the majority among the patients. Since neuromonitarization was not present in the clinic, vertebral osteotomy could be a high risk in these patients. For this purpose, the first author tried to create the modified Cantilever bending technique and was able to correct advanced scoliosis without anterior release and posterior vertebral osteotomies. This modification was called Arc Rotation because the correction began with the rotation of the cranial part of the curvature.

The technique was performed in 24 patients. 2 of them were male and 22 were female. The age of the patients was between 12-32, the severity of deformity was 57°-120°. 1 or 1.5 years of outcomes are present.

Standard preoperative and postoperative Scoliosis X-rays were obtained for all patients. Cobb angles and deformity flexibility were obtained. 3D CT and MRI of the spine were performed. Densitometry to determine bone density and heart echocardiography were also performed. In order to mobilize deformities before the operation, corset was used.

Posterior access was performed to all patients. Pedicle screws were driven hands free. Considering the damage of radiation to the personnel and the patient, screws were passed without O-arm. Neither neuromonitorisation nor wake up test was used. In the case of safety screws, mechanical multiple controls of the pedicle, rejection of screwing at this level when there is a suspicion of cortex failure, and the use of a small diameter is needed. Spine translation with passive correction by the assistant is applied and screws are compressed from caudal to the cranial order, as indicated (Figure-1).

Surgical technique

Neuroleptoanalgesia is performed. Posterior surgical exposure is performed. The patient is extended to the prone position on special parallel cylindrical devices which are based on the shoulders and pelvic corners on the surgical table, and the hip is extended in 30 degrees of flexion. Starting from the neck with antiseptic solutions, the surgical area and lower extremities are washed and covered with sterile drapes. The skin is cut linearly at the posterior projection of the C7- S1 vertebrae.

Dissection is performed from central to the lateral transverse projections. Three polisegmental polyaxial pedicle screws are driven to start from the cranial neutral vertebrae at the concave side of the deformity. On the concave and convex side spondylolisthesis screws are placed to all possible levels. For concave side; a rod with half the curvature of the scoliotic deformity is prepared. The rod is fixed inside the 3 screws located on the cranial site of the concave side. Assistant corrects the deformity by applying force against each other in the opposite direction; one hand from the rib convexity, one hand by the patient's crista iliaca.

The surgeon places the rod into the caudal screws by fixing the cranial screws by gently holding the caudal part of the rod and applying force, and fixing it with clamps. Rod is derotated as much as possible. Then, we place the rod on the convex side in the same way and place it into the screws. Derotation is done as much as possible carefully. If the derotation is overperformed, failure of the screws may be possible. It is natural that the rod on the concave side does not pass through the vertex screws. To do this, rod is removed from the concave side and curvature of the rod is reduced. By first fixing the rod to the cranial 3 screws, we can fix the screws by applying the modified cantilever bending maneuver. The clamps of spondylolisthesis screws in the vertical vertebrae are not tightened. Derotation maneuver is performed. In order to make the derotation on the concave side, the convex side screw clamps must be loosened. On the convex side, the rod is removed and the normal sagittal contours of the curvature is given. In the concave side, the spondylolisthesis screws of the vertex vertebrae are tightened in order and the risk of dislocation should be considered. The clamps are compressed

in half. The rod is placed on the convex side and the derotation is performed. If necessary, the curvature of the rod may be reduced on the concave side, when not required; the spondylolisthesis screws in the vertex are tightly compressed from the caudal to the cranial. The assistant must still correct by pressing hands to avoid dislocation during compression. One or 2 crosslinking and bone grafts are placed. The incision is sutured. No drain is needed.

The results of this study consist of minimum 2 years results of 24 patients (2 males and 22 females). The mean age of the patients was 19,043 (maximum 32.0, minimum 12.0). The etiology was idiopathic scoliosis in all patients.

The results were evaluated by SPSS statistical analysis. Probability value was taken as 0.05.

RESULTS

The degree of major curvature was 82.78° ± 19.89° (min. 57°, max. 120°). In order to measure the flexibility of the curves, bending graphs were determined and an average of 21,58° ± 14,46° (% 26.10 ± % 13.69; minimum 2.0°, maximum 40.1°) was detected. This means as the all curves were rigid and severe curves in the patients (t: 2.01; p> 0.05). On the other hand, mean postoperative correction of the major curves was 50,08° ± 13,23° (% 60.49 ± % 14.14; minimum 33.5°, maximum 82.3°) with statistically significance (t:14.85; p<0.01). Postoperative correction percentages were higher than the correction of the curves in the bending graphics with statistically significance (t: -15.42; p< 0.01) (Table-1). Operations were performed without neuromonitarization, none of the patients had neurological complications. One patient had lumbar decompensation, which was corrected by fixing the L4 vertebra. There was no dislocation during the operation, no infection was detected, there were no death issues, and blood loss was 200-250 ml. No clinical signs were observed in follow ups. Thoracoplasty was not performed in any patient and there was no patient complaint requiring thoracoplasty. During the operation, only facetectomies were used, and neither anterior release nor posterior vertebral osteotomies were performed.

Table-1. Indicative statistics

	Mean ± SD*	Range
Age	19,04 ± 5,62	12 - 32
Cobb Angle	82,78° ± 19,89°	57° - 120°
Flexibility (Degree)	21,58° ± 14,46°	2° - 40,1°
t	2,01	-
p	> 0,05	-
Correction (Degree)	50,08° ± 13,23°	33° - 82°
t	14,85	-
p	< 0,01	-
% FLEX, **	% 26,10 ± % 13,69	-
% COR,***	% 60,49 ± % 14,14	-
t	-15,42	-
p	< 0,01	-

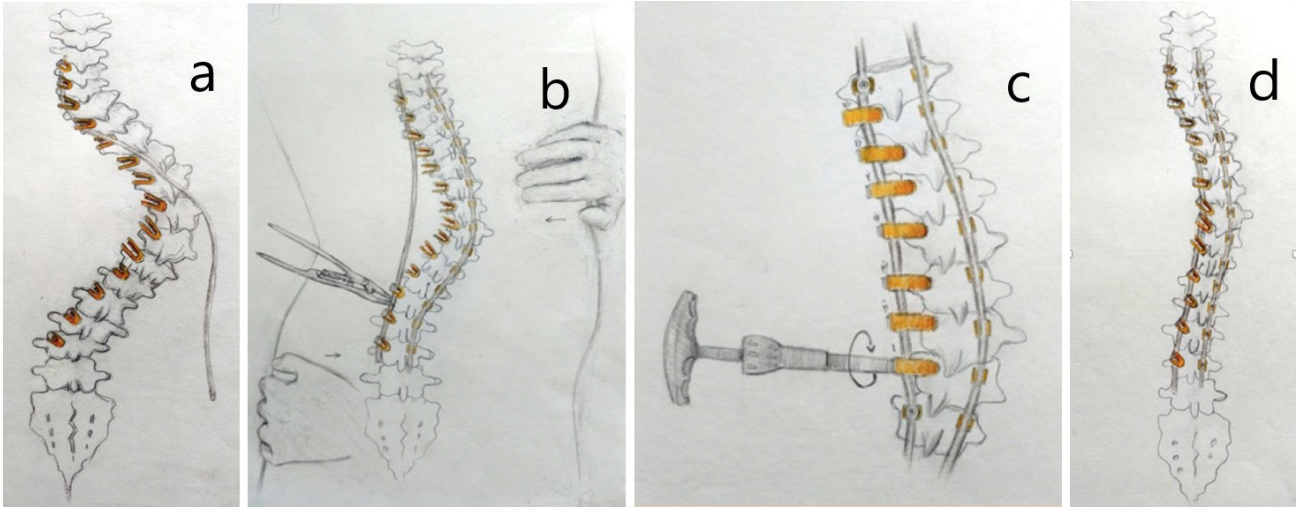

Figure-1. Arc rotation - Cantilever technique, **(a)** Drive the screws from the cranial neutral vertebra to the caudal neutral vertebra, Connect the rod to the 3 cranial neutral vertebra with the long-headed spondylolisthesis screws at the concave side, The rod will stay as shown in the figure, **(b)** Passive correction is performed with the help of the assistant's hand and the rod is inserted into the caudal screws by the operator, **(c)** The screws are placed on the convex side and the rod is placed in a similar way, Then the rod is taken out from the concave side and is put into place after straightening with the help of the rod bender, **(d)** As a result of the straightening and the derotation of the rod on the convex side, the rod reaches the spondylolisthesis screws on the concave side

Clinical example

19 year old boy admitted to the clinic with a large and rigid 123° right-sided thoracic idiopathic scoliosis with 1 cm body imbalance to the right. The main curvature was very rigid, with a total difference of 2 ° from bending radiographs. In postoperative radiographs the deformity was corrected by 57.7°, which means 47 %. The patient is very satisfied with the result (Figure-2).

The second patient, a 14-year-old female, was referred to our clinic with a rigid 110° right-sided chest type idiopathic scoliosis. Patient's body is balanced. The main curve was severely rigid bending radiographs differed by a total of 11.4°. In postoperative radiographs, deformity was corrected by 74.5° after the first operation, which means 68°. After 9 months, the patient was taken to the additional operation for correction and in addition we reduced the curvature of the rods by placing 2 more screws, and by derotation. We obtained an additional 10 ° correction, which means 77.2 %. The patient is very satisfied with the result (Figure-3).

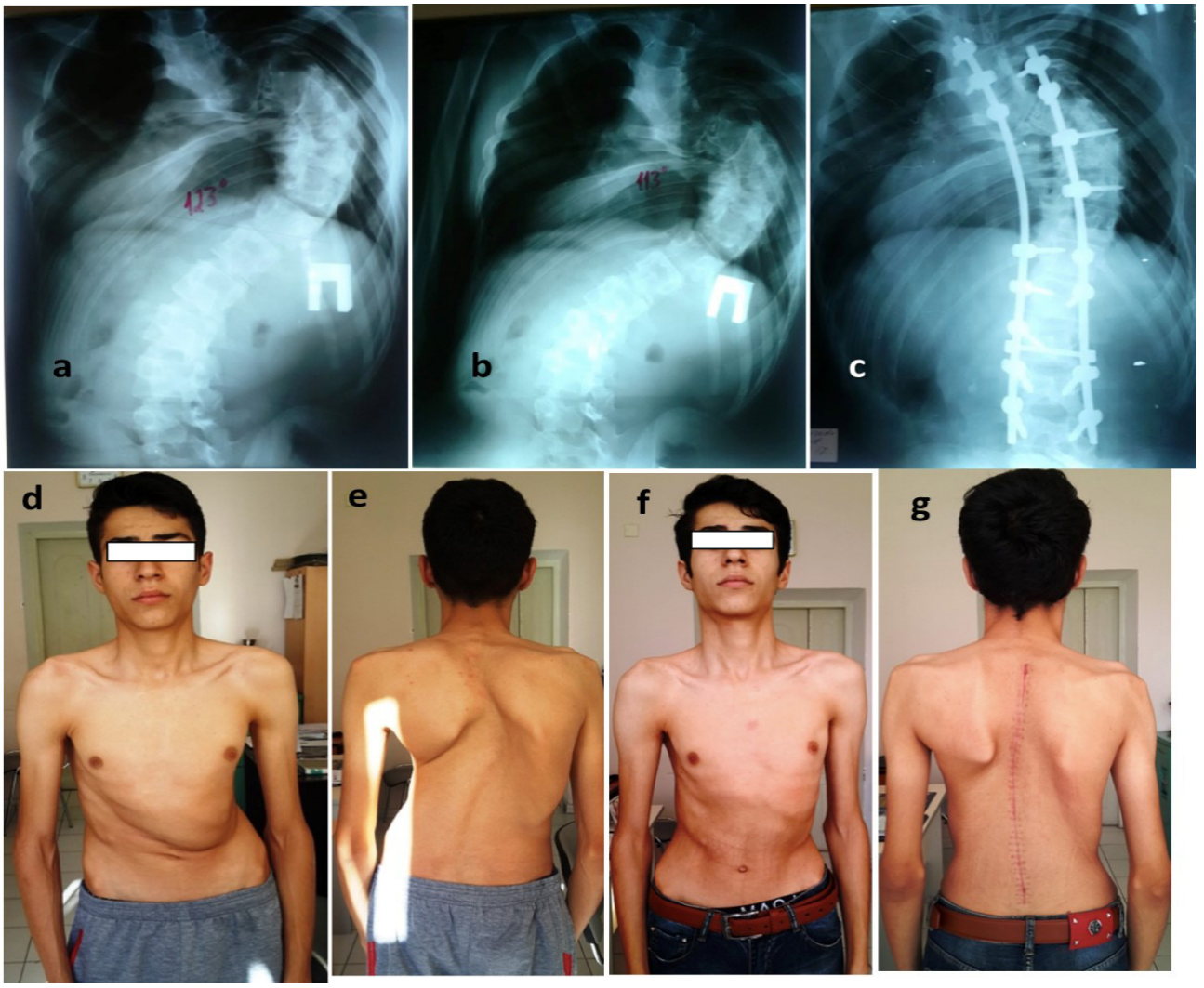

Figure-2. (a) Preoperative AP, **(b)** preoperative bending, **(c)** postoperative AP graphics, **(d)** preoperative clinical presentation from front, **(e)** preoperative clinical presentation from back, **(f)** postoperative clinical presentation from front, and **(g)** postoperative clinical presentation from back

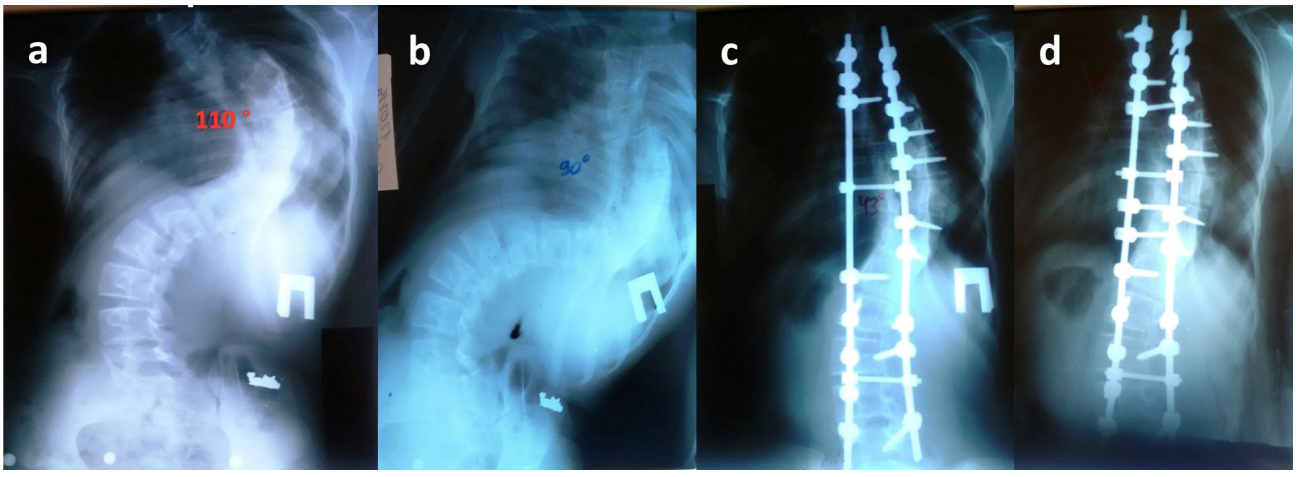

Figure-3. (a) Preoperative AP, **(b)** bending, **(c)** postoperative AP, and **(d)** postoperative AP graphics after the second surgery of the second patient

DISCUSSION

Generally, operative correction of scoliotic deformities by polisegmental transpedicular systems is done by simple rod derotation, 3 rod technique, direct vertebral body derotation, segmental derotation, and complete derotation and cantilever maneuvers [5].

In the maneuver mentioned in the illustrations; firstly; the bending of the rods with the rod bender on the convex side is defined. We think that this will not be effective enough in 90°-120° deformities. Obviously, the traditional cantilever maneuver in rigid scoliosis can eliminate severe operations such as anterior discectomies. We have given the modified maneuver the name Arc Rotation. Here; first movement corrects the deformity in frontal plane which starts from the 3 screws at cranial arc of the deformity and helps repetitive correction by derotation in the frontal plane. We do not use rod bender, we adapt the deformity to the rods as a result of tilting the rods slightly by selecting the correct abutment, by the cranial screws and lateral correction of the assistant. The degree of major curvature was 82.78° ± 19.89° (min. 57°, max. 120°). Major curves of the patients were rigid, the correction of the curves in the bending graphics (% 26.10 ± % 13.69) was not significant statistically ($p > 0.05$). Average correction of the major curves was % 60.49 ± % 14.14 with statistically significance ($p<0.01$). Meanwhile, postoperative correction percentages were higher than the correction of the curves in the bending graphics with statistically significance ($p< 0.01$).

It is possible to obtain sufficient radiological and cosmetic correction by performing this maneuver in concave and convex sides respectively. At this time, it is possible to obtain sufficient correction when passing the spondylolisthesis screws from the concave side vertex.

Correction of rigid scoliosis in the traditional method requires Ponte, PSO or VCR osteotomies, which increases bleeding, operation time and neurological complications risks [1]. According to Saifi, transient neurological complications can reach up to 13.8 % and permanent neurological complications can reach 6.3 % in order to obtain a 50-70 % correction in vertebral column resection in severe scoliosis [15]. In our study, similar correction values were obtained postoperatively and we did not observe any neurologic deficit in our patients.

According to Şenköylü, a number of long-headed new spondylolisthesis screws should be applied to reduce the risk of dislocation during conventional cantilever maneuver [15]. We have tried to show it as a separate maneuver and show the strength of it without osteotomy. It is easy to place the rod during the traction to obtain passive correction. However, at least 2 people are required - one must pull from the axillary region and the other from the legs. We accomplish passive correction by the effect of the assistant's force in the opposite directions (ribs and pelvis) in the frontal plane. We benefit from the help of 1 person successfully. We still apply the assistant's passive correction to reduce the risk of pull out of the screws.

Traction methods have been applied in advanced scoliosis [3,8-9,14,19]. Halo- pelvis traction is used in various modalities, as stage in vertebral osteotomies and as stage after anterior thoracotomy. The negative side of halo-pelvis trauma is long hospitalization. In 2018, Qiao et al proposed 3-phase operational correction for treatment of severe scoliosis [13].

1. Stage-1: instrumentation of vertebras with pedicle screws and Smith ve Petersen type osteotomies.

2. Stage-2: In the second stage, the humerus - thigh traction with large loads continuously
3. Stage-3: Posterior correction and fixation in 3rd stage. 63 patients participated in their research. The main curve's preoperative mean coronal Cobb angle was 118.7°, the postoperative degree of coronal correction was 55 %, and the postoperative mean coronal Cobb angle was 57.3°.

According to Qiao, in the first stage operation, the displacement of 17 screws in 12 patients had been observed, which were corrected during the last operation. In 2 patients, the pleura had been dissected and sutured during the last operation. Pleural discharge occurred in one of 2 patients whose pleura had been dissected and a thoracic closed drain was placed in it. Transient postoperative neurological disorder had been recorded in one patient. In general, postoperative complications were 19.0 % after the first operation and 4.8 % after the last operation. Two patients suffered from paralysis of the brachial plexus and one patient suffered from femoral nerve paralysis. However, complete recovery of nerve functions was achieved. Two patients had a short-term hematuria. One patient had gastrointestinal symptoms, and the symptoms were alleviated after the load for traction had decreased. Two patients had thrombosis of deep veins (DVT) and one patient had a vein filter. Two patients had pin tract infection. Traction related complications are 11.1 % [13]. We have not observed any displacement of screws in modified Cantilever Arc Rotation Technique. And no pleural complication was detected in modified Cantilever Arc Rotation Technique due to the lack of thoracoplasty. No postoperative neurological deficit was detected in the proposed method.

There is a lot of information in literature about the complexity of vertebra osteotomies and the risks of complications including neurological complication risks and blood loss [1,13]. Modi HN and authors have developed and reported results of PMVO for correction of severe idiopathic and neuromuscular scoliosis. Average number of osteotomy was 4.2 ± 0.8 (range 3-5). Average preoperative Cobb angle 99.2°± 29.6° wich improved after surgery to 44.7° ± 12.3°. A 54.3 % correction was achived in coronal plane. Average blood loss and operative time 3015 ± 1213ml and 6.01 ± 1.09 hours respectively. Three patients had postoperative respiratory complications 2 had hemothorax and 1 had atelectasis; none had follow-up consequences. Two patients had complication related with the implants; 1 screw brekage and other screw prominence. There was no neurology injury intraoperatively on motor evoked potentials or clinically after surgery [11]. The prolonged length of bed position gives a great deal of psychological stress in patients [14]. In our study, the arc rotation maneuver can thus be modified as a cantilever maneuver. Because it allows single-stage treatment of scoliosis without osteotomies, it can be considered effective because it provides enough strength to achieve adequate correction. Likewise, minimizing the operation trauma and reducing the risks of the major complications allow success.

The limitation of this study is the lack of psychological status of the patients undergoing the same complex examination and heterogeneity of the study group, insufficient of the patient's number and follow up period.

It is possible to obtain the results by other authors in severe scoliosis with this maneuver, no special training is required. Since there are no osteotomies, it can be applied without neuromonitarization and decreases the operational costs. According to our result, arc rotation technique was successful to correct for the rigid and severe scoliosis was concluded.

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Volume: 30, Issue: 2, April 2019 pp: 93-100 ORIGINAL ARTICLE

RESULTS OF PONTE'S OSTEOTOMY IN THE TREATMENT OF RIGID ADOLESCENT IDIOPATHIC SCOLIOSIS

Sinan YILAR[1]
Ahmet Arif UZUN[2]

[1] *Atatürk University Medical Faculty, Department of Orthopaedics and Traumatology, Erzurum, Turkey.*
[2] *Mareşal Çakmak State Hospital, Erzurum, Turkey.*

ORCID Numbers:
Sinan YILAR: 0000-0002-1268-170X
Ahmet Arif UZUN: 0000-0002-81204114

Address: Sinan Yılar,
Atatürk University Medical Faculty,
Department of Orthopaedics and
Traumatology, Erzurum, Turkey.
Email: sinan_yilar@hotmail.com
Phone: +90 536 248 87 41
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ABSTRACT

Purpose: To evaluate the effectivity of Ponte's osteotomy in the patients of adolescent idiopathic scoliosis (AIS) with rigid curvature.

Method: From 74 patients having severe structural scoliosis, the patients who have curvature above 50° and in whose curvature graphies recovery less than 45 % was ensured and Ponte's osteotomy was applied to different number of levels. From these patients, 23 patients who were followed up for 2 years and above and were included to the study. The surgical details, the complications and the estimated blood loss were recorded. The corrections on the coronal and sagittal plane were radiologically measured and the Scoliosis Research Society-22 survey was applied to the patients.

Results: According to the measurements made preoperatively, the Cobb angle of the main thoracic curvature on the coronal plane was measured as 70.9o (45°-93°) in average and the Cobb angle of the thoracolumbar/lumbar curvature was measured as 520 (16°-99°) in average; in the fulcrum curvature graphies, the flexibility rate was calculated as 36.8 % in the thoracic curvatures and as 32.4 % in the thoracolumbar/lumbar curvatures. In the coronal measurements made after Ponte's osteotomy was applied to our patients at the level of 3.1 (2-7) in average, the main thoracic curvature was calculated as 23.4° and the thoracolumbar curvature was calculated as 18.6° ($p<0.001$). In the measurements made on the sagittal plane, on the other hand, the values found are not statistically significant even though they are successful.

Conclusions: In the rigid AIS patients, Ponte's osteotomy helps to the correction procedure made with pedicle screws. It is an effective and reliable method that can be used in order to increase the correction amount in the rigid AIS patients even though it increases the bleeding amount and the operation period.

Key words: Ponte's osteotomy, adolescent idiopathic scoliosis, pedicle screw.
Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is the most frequently seen scoliosis type and the most frequently seen pediatric deformity [12]. Although considerably good results are obtained since the use of the pedicle screws, many methods are still tried in order to increase the correction amount. For more correction by release especially the hardened vertebra from the anterior or posterior, it is tried to obtain a more flexible spinal column. Within the recent periods, the posterior release surgeries are frequently used.

Firstly, Smith-Petersen described the posterior column osteotomy that he applied from one level for the purpose of correcting the lumbar kyphosis [10]. In this way, it was possible to correct the spinal column in which fusion developed due to ankylosing spondylitis or rheumatoid arthritis even if partially. Alberto Ponte's, on the other hand, applied the procedure in the form of wide posterior release and total facet resection in flexible spines by applying at multiple levels in 1984 [6]. In this way, in Scheuerman Kyphosis patients, the deformity correction was applied successfully by shortening the posterior column.

Ponte's osteotomy is considerably frequently used in the treatment of AIS

within the recent years. Although there are publications stating that it is considerably successful in the coronal and sagittal plane [3,7-8], there are studies arguing that it is ineffective [4]. For this reason, we consider that different studies are still needed in order to prove the effectiveness of Ponte's osteotomy.

In this study, the patients having adolescent idiopathic scoliosis who has severe curvature and in whose fulcrum graphies the flexibility is less than 45 % were evaluated by the same surgery team at the same center for three years. Ponte's osteomoty in the form of total facet resection was applied to the patients along with the wide posterior release. As the instrument, only the pedicle screw was applied. From these patients, those who were followed up for at least 24 months were included to the study. Our hypothesis in this study is that Ponte's osteotomy ensures advanced correction on the sagittal and coronal plane in the AIS patients with rigid curvature. Furthermore, in our study, the surgical details, the complications and the estimated blood loss were recorded. The corrections on the coronal and sagittal plane were radiologically measures and the clinical evaluations of the patients were made by the Scoliosis Research Society-22.

MATERYAL METOD

In this study, 74 Adolescent Idıopathic Scoliosis (AIS) patients with minimum 2-years follow-up after surgical treatment at our clinic were evaluated. From these patients, Ponte's osteotomy was applied to 37 patients whose main curvature is more than 50 degrees and in whose curvature graphies correction less than 45% was ensured. From the patients to whom Ponte's osteotomy was applied, 23 patients who were followed up for 12 months and above and who had preoperative, postoperative and follow-up x-rays taken at good quality were included to the study.

For the posterior enstrumentation of all patients, only the pedicle screws were used. The pedicle screw was tried to be bilaterally placed to all vertebras. In the patients, no sublaminar wire or hood was used. In all patients, the enstrumentation systems of the same company were used and the titanium rod at the thickness of 5,5 mm was used in all patients.

While applying Ponte's osteotomy, the apex and the vertebras in its surrounding were intervened. After the spinous processes were completely taken, the supra and inferior ligament and ligamentum flavum were taken. As the superior facets were already taken during the screwing, the inferior joint was carefully taken with kerrison ronger by inclining towards to the lateral after reaching to durameter and the wide resection was continued until it was seen that the vertebra moved (Figure-1).

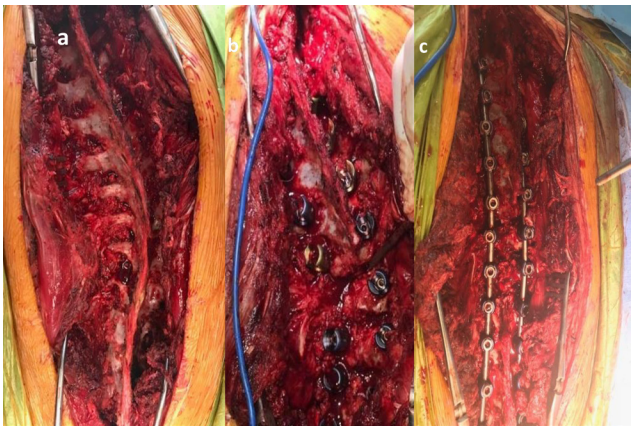

Figure-1. (a) Intraoperative views: after the exposure, **(b)** the ponte osteotomies and **(c)** after the reduction.

In all patients, intraoperative cord monitoring was used. In all patients, somatosensory evoked pottentialis (SSEPs) and transcranial motor evoked potentialis (TcMEPs) were used.

In all patients, the same reduction maneuvers were used: after the rod with appropriate inclination was placed on the concave side, the rod was turned by global rotation. After the rod was fixed from the apex, the curvature was tried to be corrected by making the segmenter derotation, compression and distraction maneuvers.

The surgical intervention of all patients was made by S.Y. and their measurements were made by A.A.U. The data was obtained by examining the anesthesia follow-up chart, the patient medical history form and the survey records in the patient file and by measuring from the PACS system integrated to the hospital data evaluation application.

The bleeding amount during surgical period , the number of vertebras in which fusion was made, the hospitalization period, the complications and the levels at which osteotomy was applied were recorded. The graphies taken preoperatively and postoperatively were recorded by being measured by one physician. The postoperative radiological examinations were evaluated with XR graphies taken 3 days after the initial mobilization of the patient, in the first month after the operation and after the 18th month. On the coronal plane, the Cobb angle of the main thoracic curvature and the thoracolumar/lumbar curvature, the recovery rate of these values and the translation amounts of the apical vertebra were measured. On the sagittal plane, on the other hand, the thoracic kyphosis measurements were made from the range of T5-T12, the lumbar lordosis measurements were made from the range of T12-S1 and the sagittal balance measurements were made according to the distance of the vertical line drawn from the C7 center to the sacrum superior corner. The

flexibility of the curvature was evaluated with the bending graphies taken preoperatively.

In the case of correction loss more than 10° as compared with the postoperative graphies or implant insufficiency, psodoarthrosis research was made with the routine tomography controls. For each case, the possible blood loos amounts, the operation periods, the curvature correction on both planes, the neuromonitor signal changes, the postoperative complications and the SRS-22 and survey records were taken. The SRS-22 survey was applied to all of our cases preoperatively, in the 2nd month postoperatively and at the final controls.

For the statistical analysis, the IBM SPSS version 20.0 program was used. While the study data was being evaluated, the Wilcoxon test was used in the comparison of the quantitative data as well as the descriptive statistical methods (average, standard deviation, median, frequency, rate, minimum, maximum). The significancy was evaluated at the levels of $p<0.001$ and $p<0.05$.

For this study, the approval of the ethical committee of our university was obtained.

RESULTS

23 patients complying with the study criteria were included to our study. From these patients, 17 patients (74 %) were female and 6 patients (26 %) were male. The age average was 18.1 (12-35). According to the Lenke classification, there were 12 patients who were Lenke-1, 2 patients who were Lenke-2, 3 patients who were Lenke-3, 3 patients who were Lenke-5 and 3 patients who were Lenke-6. Risser grades were determined as grade-3 in 2 patients; grade-4 in 6 patients; and grade-5 in 15 patients. Lumbar modifier was A in 12 patients, B in 4 patients and C in 7 patients. The thoracic sagittal variable were noted (-) in 6 patients, (N) in 10 patients and (+) in 7 patients. According to the marking made in the patient medical history forms, the reason for the preoperative application was substantially (91 %) the problems related to deformity (posture, walking disorders) and the back-belly pain and the neurological problems (9 %) were less. According to the measurements made preoperatively, the Cobb angle of the coronal main thoracal curvature was measured as 70.9° (45°-93°) in average and the Cobb angle of the thoracolumbar/lumbar curvature was measured as 52° (16°-99°) in average. The flexibility rate in the fulcrum curvature graphies was calculated as 36.8 % in the thoracal curvatures and as 32.4 % in the thoracolumbar/lumbar curvatures. In all of the cases, the secondary sex characters developed and all of the female patients, menarch occurred (Table-1).

Table-1. Patients demographics

Patients	23
Males	6(26(%)
Females	17(74%)
Age at the surgery	18,1(12-35)
Lenke clasification	
Lenke 1	12
Lenke 2	2
Lenke 3	3
Lenke 5	3
Lenke 6	3
Risser clasification	
Risser 3	2
Risser4	6
Risser 5	15
Lumber modification	
A	12
B	4
C	7
Thoracal sagittal modification	
(-)	6
N	10
(+)	7
Coronal mainthoracal cobb angle	70.9° (45°-113°)
Coronal thoracolumbar / lumbal cobb angle	52° (16°-99°)
Flexibility	
Thoracal	36.8 %
Lumbar	32.4 %

Ponte's osteotomy was applied at the level of 3.1 (2-7) in average. The average operation period was 378 (255-512) minutes. Fusion was applied at the level of 11.4 (6-15) in average. The estimated blood loss amount was calculated by counting the aspirates and dirty sponges (less dirty 5, medium dirty 10, wet 15 cc) and is 1571 (524-2829) cc. The intraoperative autotransfusion systems were not used in any case. The patients were followed up for 10.3 (5-17) days in average with the first 24 hours in the intensive care postoperatively.

In all patients, the intraoperative cord monitoring was used. The significant signal changes were seen at the correction stage in only 3 cases and at the screwing stage in 1 patient. These

problems were overcome by the restitution of the procedure that was finally applied and by resending the relevant screw. In a patient with curvature of 99° preoperatively, the T2-L4 posterior segmental instrumentation was made, Ponte's osteotomy was applied at the level 4 to the range of T8-T12 AND signal decrease above 80 % was seen bilaterally during the reduction. After the removal of the rods, the signals reached to the normal level and for this reason, the case was ended to make correction again in the next session by placing only short rods to the patient. In the postoperative scoliosis graphy taken, it was seen that the recovery was sufficient and balanced. The patient was taken to the operation again after 2 weeks and the operation was completed by placing the long rods (Figure-2).

The patients whose lateral plane measurements were hypokyphotic, normokyphotic and hyperkyphotic in the preoperative period were compiled in separate groups and their average was taken. As T2 is not suitable for healthy measurement due to the graphy quality and other reasons in many patients, the thoracal sagittal kyphosis value was calculated by using only the range of T5-T12. There was no significant difference between the preoperative kyphosis angle (27.4°) and the postoperative kyphosis angle (25.1°) of all patients ($p>0.05$). In the hypokyphotic patients (<20°), the lateral cobb angle increased at advance level (10.4°-20.1°). In hyperkyphotic patients, the lateral cobb angle decreased from to 44.8° to 31.1°, in normol kyphotic patients, the lateral cobb angle minimal decreased from 32.1° to 28.8°($p>0.05$) and the main sagittal balance improved from -4.1mm to 6 mm.

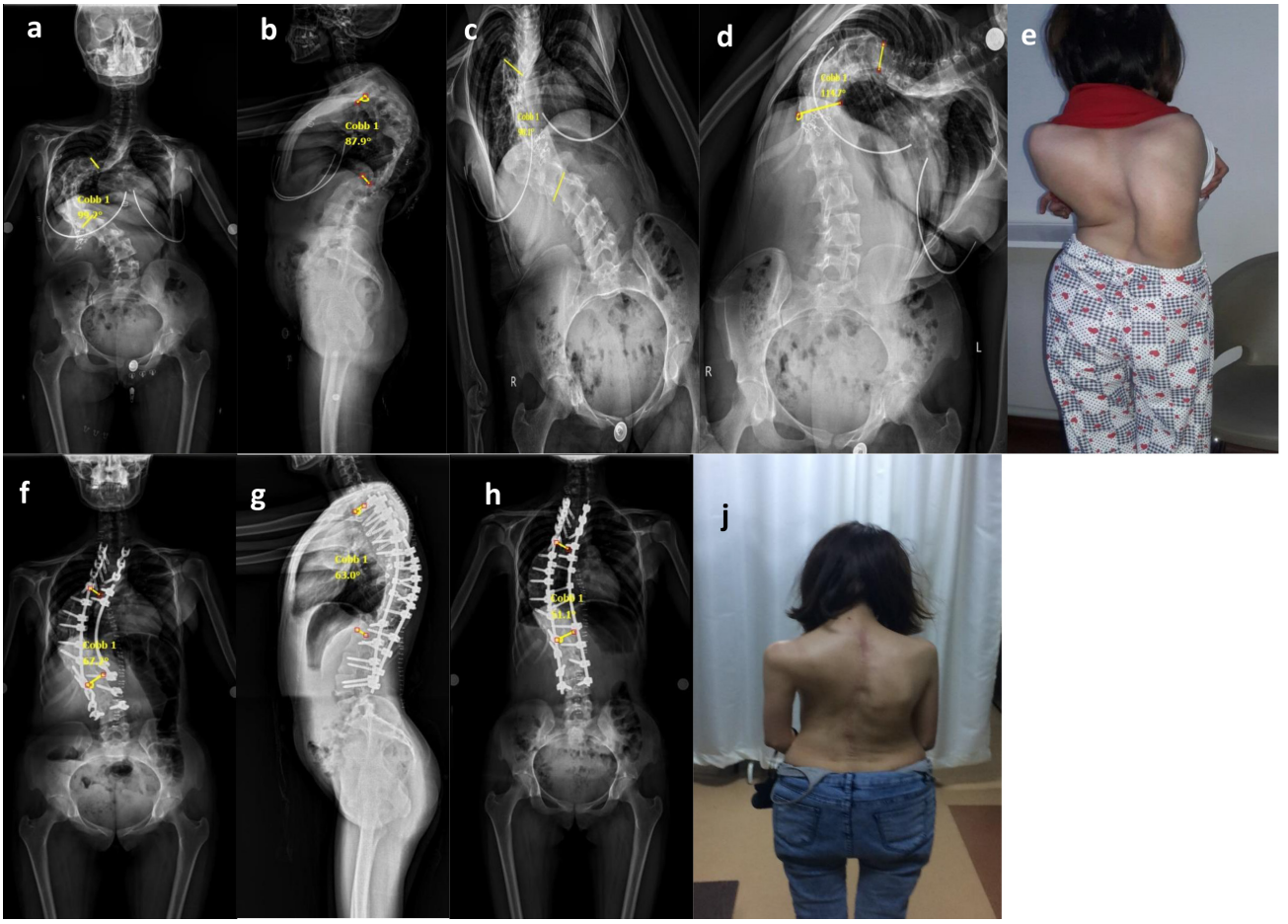

Figure-2. (a) Preoperative posteroanterior (Cobb angle was 99°), and **(b)** preoperative sagittal (T2-T12 kyphosis angle was 87°), **(c-d)** preoperative bending graphies, **(e)** preoperative back photograph of the patient, **(f)** postoperative posteroanterior (T2-L4 posterior segmental instrumentation was made, ponte osteotomy was applied at the four levels to between T8 and T12 at the first operation), **(g-h)** postoperative posterior-anterior and sagital radiographies after the 2nd operation, (Postoperative Cobb angle was 51° and kyphosis angle was 63°) and **(j)** postoperative 2nd years back photo of the a 19 year-old girl with adolescent idiopathic scoliosis were seen in the figures.

Table-2. Coronal radiological measurements

	Preoperatively	Postoperatively	Fist control	Last control	p
Coronal main thoracic cobb angle (°)	70.9	23.4	24.1	27.9	<0.001
Thoracic % Cobb correction	-	% 66.9	% 66	% 60.6	<0.001
Thoracic apical C7 plumbline translation (mm)	47.8	21.3	22.6	23.1	<0.001
Thoracolumbar/lumbar Cobb angle (°)	52	18.6	19.7	20.3	<0.001
Thoracolumbar/lumbar % Cobb correction	-	% 64	% 62.1	% 60.9	<0.001
Thoracolumbar/lumbar apical C7 plumbline translation (mm)	23	12	11	9	<0.001

Table-3. Sagittal radiological measurements

	Preoperatively	Postoperatively	Fist control	Last control	P
Lateral T5-T12 Cobb angle (°)	27.4°	25.1°	25.7°	26.1°	0.301
Lateral T5-T12 Cobb angle (hypokyphosis group< 20°)	10.4°	20.1°	20.3°	21.2°	<0.001
Lateral T5-T12 Cobb angle (normal kyphosis group 20-40°)	32.1°	28.8°	29.1°	29.6°	0.233
Lateral T5-T12 Cobb angle (hyperkyphosis group > 40°)	44.8°	31.1°	31.6°	33.4°	<0.05
Lumber lordosis (T12-S1) (°)	-51.5°	-47°	-47.4°	-46.7°	<0.001
Sagittal balance (C7 plumbline to sacrum) (mm)	-4.1	6	6.8	12.3	0.053

The SRS-22 survey was applied to the cases before the operation and during the follow-ups. The average values of the question subgroups the SRS-22 survey results of which were specified in advance were calculated as listed below. According to these values, whereas there was not significant healing in the initial controls of the patients in the total values, it was seen that the satisfaction values and pains of the patients healed in the second controls (Table-4).

In none of the cases, the late period infection was found. In two patients, superficial wound area infection was considered in the early period and it was folowed up without going beyond the routine antibiothreapy when no reproduction occurred in the cultures taken. None of our cases was taken to a secondary operation due to revision and other reasons during the follow-up period.

Tablo-4. Scoliosis Research Society(SRS)-22questionary results

Pain (1, 2, 8, 11, 17)		p
Preoperative	3.72	
First control	3.64	>0.05
Last control	4.16	<0.05
Mental Health (3, 7, 13, 16, 20)		
Preoperative	3.32	
First control	3.92	>0.05
Last control	4.13	<0.05
Self İmage (4, 6, 10, 14, 19)		
Preoperative	3.22	
First control	4.13	<0.05
Last control	4.43	<0.05
Function (5, 9, 12, 15, 18)		
Preoperative	3.61	
First control	3.12	>0.05
Last control	4.23	>0.05
Satisfaction (21, 22)		
Preoperative	4.05	
First control	4.75	<0.05
Last control	4.85	<0.05
Totaly		
Preoperative	3.52	
First control	3.79	>0.05
Last control	4.29	<0.05

The purpose in the surgical treatment is to obtain a balanced spinal column on the coronal and sagittal planes. The array ensured with the instrumentation systems for this purpose is tried to be maintained by constituting fusion. However, it might be necessary to make the spinal column structure more flexible in order to ensure the required array in certain rigid spinal columns. To ensure the highest correction with the least force possible without causing damage to the neurological and bone structures is possible by making the rigid spinal column bendable. For this purpose, various ligament loosening procedures and osteotomies are applied on the spinal column [2].

The osteotomy techniques described in the correction of the spinal deformities have become one of the important milestones in the achievement of the surgical treatment. Smith Petersen osteotomy which was described by Smith Petersen in 1945 for the first time and which was used in the lumbar kyphosis became widespread by being used in the thoracal kyphosis by Alberto Ponte's. Many studies which were subsequently carried out showed that the osteotomies applied in rigid idiopathic curvatures are effective also on the coronal plane [2-3,8]. In this way, the auxiliary osteotomies applied from posterior have become widely usable in the patients in whom the balance cannot be ensured with the soft tissue manipulations and who have lost their flexibility. The most known osteotomy techniques are Ponte's osteotomy, pedicle substraction osteotomy and posterior vertebral column resection [2].

Ponte's osteotmoy is considerably frequently used in the treatment of AIS within the recent years. Although there are publications expressing that it is considerably successful on the coronal and sagittal planes [3,7-8], there are also studies arguing that it is ineffective [4]. For this reason, we consider that different studies are still necessary in order to prove the effectiveness of poste osteotomy. Halanski et al. [4] applied only inferior facetectomy to 19 patients whereas they applied Ponte's osteotomy to 18 patients. They did not report any significant difference except for that the bleeding amount was higher in the first group. However, their study was carried out with less number of patients who was followed up in short period and there was no randomization between the groups. The use of Ponte's osteotomy in the scoliosis surgery, in contrary to the use of kpyhosis, aims at correcting the hypokyphosis, not shortening the posterior column. It contributes also to the correction on the coronal plane as well as the sagittal balance.

Ponte's osteotomy is a surgical technique that is applied in the form of resection of the soft tissues and bone structures. It starts with the removal of the interspinous ligament together with the spinous protrusions and it is applied with the partial lamina excision over the ligamentum flavum and the removal of the facet joint together with the adjacent structures. The effectiveness of this osteotomy which was already proven in the kyphosis surgery was demonstrated also in the different studies subsequently carried out [7-9]. However, the indication limits are not fully specified in the thoracal scoliosis. The current application is the use of the osteotomy techniques for the patients who have main curvature more than 70° and who showed recovery less than 45 % in the curvature graphies. The certain surgeons, on the other hand, use this technique in all AIS cases routinely. In our study, it was aimed to help to the spine surgeons at the decision-taking stage with evidence-based information. Although there are many techniques for obtaining the curvature graphies, the curvature graphies taken on foot were used because they are practical and there is not need for using auxiliary personnel. By means of these graphies, the flexibility measurements were made. The average flexibility of the thoracic curvatures was measured as 36.8 % and the flexibility of the lumbal area was measured as 32.4 %.

While evaluating the patient on the sagittal plane, the fact that the AIS patients are presented by lordosis in the thoracic area should be remembered. For this reason, while the data was being shared, the data was given in 3 separate groups. While it is possible to intervene by closing the osteotomy line for the hyperkyphotic patient, the distraction needs in the hypohpyhotic patient group strains the cord and increases the psodoartrosis risk. In these patients, it is necessary to be more careful while correcting the deformity.

In the study carried out by Lehman et al., fusion was applied at 10 levels in average to 114 AIS patients at the age of 14.9 in average. It reduced the coronal main curvature from 59.2° to 16.8° in average (71.7 % correction rate) [5]. In this study, they used monoaxial screw in the corrections made with 5.5 mm steel rods. There are also the publications which recommend using 7 mm steel rods for the purpose of ensuring and maintaining the sagittal balance without using osteotomy. We obtained stable balanced spinal column by using titanium rod at the thickness of 5.5 mm after making the corrections on the coronal and sagittal plane. We reduced the thoracal curvature rate which was 70.9° in average to 23.4° postoperatively (66.9 % correction rate). We consider that this result which we obtained by using poliaxial screws was ensured by osteotomy. We saw that there occurred correction loss even if in less amount in the measurements that we made during our follow-ups as in the different studies. However, in order to understand whether this is related to the rod diameter, the long-term studies in which the different rod diameters are compared are required. Another discussion is the possibility of increase in the pseudoarthrosis rate due

to Ponte's osteotomy because wide bone resection, spinous process excision and lower and upper facet resection are made with Ponte's osteotomy and this will reduce the possibility of fusion in the long period. If pseudoarthrosis occurs, this may cause implant fatigue and correction loss in the long period. In order to understand this, the comparative publications with long follow-up period are necessary.

Ponte's osteotomy may cause an increase in the operation period and the bleeding amount. This increase was demonstrated with the comparative publications [3,7,11]. However, in these studies, no serious complication depending on bleeding was reported. At our clinic, we calculated the estimated blood loss by classifying the gauze bandages as less dirty, dirty and very dirty. The average blood loss was 1571 (524 - 2829) cc and we did not encounter any complication depending on bleeding. Also, in the same studies, it was demonstrated that the operation time increased as well. However, in these studies, the rigidity and the curvature degree of the group on which Ponte's osteotomy was applied were higher than the other group and this may increase the operation time by increasing the time necessary for the reduction. In order to be able to understand this, two groups having rigidity and cobb angle at the same degree should be compared because the time lost with osteotomy may provide the surgeon with time at the deformity correction stage.

One complication related to Ponte's osteotomy, on the other hand, is the neurological complications that can develop depending on the increased recovery possibility. Buckland et al. [1] stated that they recorded more intraoperative electrical changes in the patients with Ponte's osteotomy in 2210 disease multicenter studies. We also saw intraoperative electrical changes at the deformity correction stage in only 3 patients. We saw that the electrical changes reached to the normal state a while after withdrawing the final maneuver made and increasing the tension of the patient. In our study, we did not see any change during the deformity correction in our other AIS patients on whom we don't applied Ponte's osteotomy even though we did not compare.

In the osteotomy procedure that we started from the segments adjacent to the apical vertabra, we intervened to both facet joints without making concave/convex side discrimination. Although certain authors argue that the unilateral facet excision is sufficient, we consider that the facet ignored on the concave side will constitute tight band effect at the correction stage. However, the close adjacency of the cord should be paid attention while intervening to the concave side in the apex of the curvature. Especially in the hypokyphotic or lordotic backbones, the attention was drawn to that it is closer to the lamina. In this area, the surgical tools should be carefully used.

Although we consider that our study will help to eliminate the conflicts related to Ponte's osteotomy, we consider that we have certain important deficiencies. The most important one is that we have no control group with which we can compare our results. The second one is that all data cannot be kept in sufficient meticulousness. The third one is that we have no sufficiently long follow-up period for the pseudoarthrosis and correction loss to be able to be sufficiently evaluated.

As a conclusion, in the rigid AIS patients, Ponte's osteotomy helps to the correction procedure made with pedicle screws. It is an effective and reliable method that can be used in order to increase the correction amount in the rigid AIS patients even though it increases the bleeding amount and the operation period. However, the studies which include a control group in which the number of the patients is higher for the purpose of evaluating the complication rates and the results are required.

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Volume: 30, Issue: 2, April 2019 pp: 101-104 ORIGINAL ARTICLE

THE IMPORTANCE OF DIFFUSION MRI IN EVALUATION OF VERTEBRAL METASTASES

Elif Evrim EKİN[1]
Zehra Hilal ADIBELLİ[2]

[1]*GOP Taksim Training and Research Hospital of Radiology, İstanbul, Turkey*
[2]*İzmir Bozyaka Training and Research Hospital of Radiology, İzmir, Turkey.*

ORCID Numbers:
Elif Evrim EKİN: 0000-0003-1290-6291
Zehra Hilal ADIBELLİ:
0000-0001-9265-8114

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Address: Elif Evrim EKİN,
GOP Taksim Eğitim ve Araştırma Hastanesi, Radyoloji Kliniği, Mevlana Mahallesi, Hızırefendi Cd., 34255 Gaziosmanpaşa, İstanbul, Turkey
Phone: 0532 3763069
E-mail: drelifevrimekin@gmail.com
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ABSTRACT

Objective: The contribution of diffusion-weighted MRI to differential diagnosis between metastasis-pathologic vertebral fracture and osteoporotic vertebral fracture was investigated.

Materials and Method: This study included (group-1) 14 benign vertebral fractures and (group-2) 42 vertebral metastases, all patients were investigated with vertebral X-ray, spine MRI and diffusion MRI and followed up for 1 year. Scintigraphy examination of the second group of patients were available.

Results: In group-1, all compression fractures were no restricted diffusion and hypointensity on MRI. In the second group, 25 vertebral lesions were detected hyperintense, 6 moderate hyperintense, and 11 hypointense signals. Diffusion MRI hyperintensity was detected significant in metastatic lesions ($p < 0.001$). Group 2 was separated as lytic and sclerotic subgroups. Diffusion restriction, hyperintensity signal was significantly higher in lytic metastases ($p < 0.001$).

Conclusion: Diffusion-weighted MRI contribute to the conventional MR sequences in the case of lytic vertebral metastasis. Diffusion-weighted imaging has limited diagnostic value in sclerotic metastases.

Keywords: Metastases, vertebra, diffusion MRI, sclerotic metastases, lytic metastases.
Level of evidence: Retrospective clinical study, Level III.

INTRODUCTION

Vertebral metastasis is observed in 10% of all malignant neoplasms [(7)]. The diagnosis of vertebral metastasis is important to guide the patient's treatment. For the diagnosis of vertebral metastasis, scintigraphy, X-ray, CT and especially MRI are used. Scintigraphy is not sufficient to differentiate between degeneration and inflammation-metastasis [(6,8)]. Metastasis can be detected on X-ray and scintigraphy only when cortical destruction occurs in the vertebra [(9)]. Before the development of cortical destruction, bone marrow eudema can be shown by MRI. In addition, soft tissue coexistence and extension can be detected due to high soft tissue resolution.

The differential diagnosis of vertebral height loss due to vertebral metastasis and osteoporotic vertebral fracture can be difficult despite all the diagnostic methods. These two types of vertebral fractures are seen in the same age group. When the vertebral fractures occur in osteoporotic patients with malignancy, the distinction between benign and malignant fractures becomes more difficult. The morphological differences in the differentiation of benign and malignant vertebral fractures (MVF) have been described in detail. In osteoporotic or traumatic benign vertebral fractures (BVF), pedicle and posterior arch are normal, epidural soft tissue mass is not expected [(5)]. The presence of an avulsion fracture at the posterior vertebral corner on CT is characteristic for BVF. Chronic phase BVF is shown isointense signal on T1W and T2W, and no contrast enhancement on the MRI [(1)]. Acute phase BVF, due to edema in the bone marrow, is shown T1W hypointense-

T2W hyperintense signals, and homogeneous contrast enhancement. Therefore, acute BVF and MVF signals are similar and may be difficult to discriminate based on signal characteristics. In MVF, an epidural mass-pedicle-posterior arch invasion are expected and T1W hypointensity, T2W hyper-iso-hypointensity signals, heterogeneous enhancement on MRI [1-3].

We investigated the contribution of diffusion-weighted MRI to the differential diagnosis of BVF from known metastatic vertebral lesions and malign vertebral fractures.

MATERIALS AND METHODS

A total of 30 patients were included in the study between 2001 and 2003.

Grou-1 consisted of 14 patients with acute OVF. None of the patients had known malignancy. Patients who were diagnosed with osteoporosis with bone densitometry and medication for the last 3 months due to severe back pain were followed up for 1 year. No malignancy was detected during follow-up.

Group-2, a total of 42 vertebrae metastases were detected in 18 patients, 12 breast cancer, 2 prostate cancer, 2 lung cancer, 2 patients with unknown of primary malignancy with multiple organ metastasis. In these patients with known primary malignancy or multiple metastasis, invasion of pedicle-posterior arch and soft tissue coexistence were determined as the main criteria. The patients were followed up for at least 1 year.

Exclusion criteria:

Patients with suspected metastasis and without histopathologic diagnosis, patients without follow-up.

1.5 Tesla Philips Gyroscan ACS-NT MR and spinal coil are used. Sagittal T1W-T2W FSE-Diffusion (EPI b: 600) and Ax T2-W FSE images were obtained. Sagittal T1-W FSE (425/7 repetition time/echo time, 320x256 matrix, 300-mm field of view and 4-mm section thickness, NEX 3), T2-W frFSE and an axial T2-W frFSE (3357/120 repetition time/echo time, 320x256 matrix, 300-mm field of view and 4-mm section thickness, NEX 3) was imaged for the study. In addition, thoracic and lumbar X-ray were performed.

The number of affected vertebrae, vertebral shape, vertebral region (corpus-posterior component involvement), T1W-T2W-diffusion MR signals were recorded in each patient.

In the comparison of the two groups, age variable was compared with independent samples *t*-test. Nominal variable was compared by Chi-square with Yates correction and Fisher's exact probability tests. $P < 0.05$ was considered statistically significant. NCSS (10 http://vassarstats.net/fisher2x4.html) was used for analysis.

RESULTS

Group-1 (BVF): A total of 14 patients; 8 female and 4 males, mean age 64.91 (minimum 49, maximum 78 years). In 14 patients, 10 BVF was defined as an acute period (less than 3 months pain, trauma history) and 4 BVF was defined as a chronic period (longer than 3 months).

In the first group, there was a loss of height above 15% in all vertebrae, biconcave or anterior wedge shape. MRI showed all of them hypointense on T1W images, 10 BVF was hyperintense and 4 BVF was isointense on T2W images. All the diffusion MRI was low-signal, not restricted diffusion (Figure-1).

No epidural, paravertebral soft tissue mass, no invasion of pedicle or posterior arch was observed in any of them (Table-1).

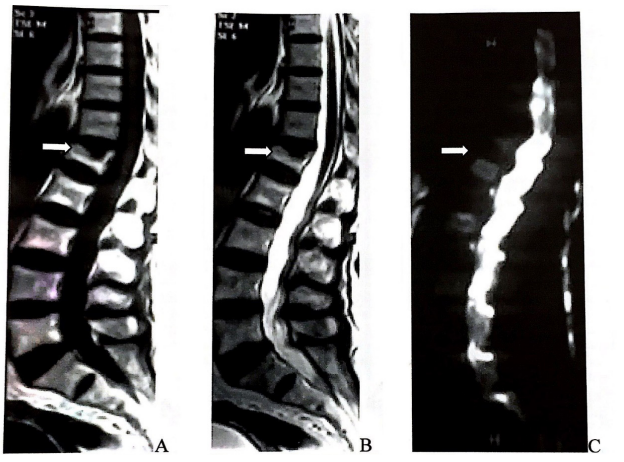

Figure-1. A 71-years-old female patient without malignancy **(a)** Sagittal T1W MRI, vertebral height loss was detected on first lumbar vertebra and isointense signal**. (b)** Sagittal T2W MRI showed loss of height in the L1 vertebra and isointense signal. **(c)** Diffusion MRI, L1 vertebra is isointense, there is no diffusion restriction: evaluated as a chronic stage benign vertebral fracture.

Table-1. Comparison of diffusion restriction between group 1 and group 2. (DR: diffusion restriction, P, Fisher exact probability test).

	DR (-)	DR (+)	DR (mildly hyperintense)
GROUP 1 (n=14)	14	0	0
GROUP 2 (n=38)	11	21	6
p		<0.001	

Group-2 (metastasis and malignant vertebral fractures): 14 women and 4 men, 18 patients had 42 vertebral lesions. Average age 58,27 (minimum 40, maximum 86 years). 4 vertebrae were followed by malignant fracture and 20 vertebrae had a loss of height below 10%. In all cases, cortical destruction, invasion of pedicle or posterior arch, soft tissue mass, existence of multisite were present at least one.

After the MRI and X-ray correlation, 38 lytic and 14 sclerotic metastases were defined. All of the metastases were hypointense signal on T1W, 25 hyperintense lesions and 17 hypointense lesions were seen on T2W MRI. Of these 17 hypointense lesions, 14 lesions were sclerotic.

In the evaluation for 4 malign vertebral fractures, all of them was detected hypointense signal on T1W, hyperintense signal on T2W and restricted diffusion (hyperintense) on MRI (Figure-2).

Other 38 metastatic lesions in the second group, diffusion MRI signals differ in vertebral metastasis. For lytic metastases, twenty-one of 24 lytic metastases were restricted diffusion, while 3 lytic metastases were mildly hyperintense. For sclerotic metastases, eleven of 14 sclerotic metastases were hypointense, no restriction in diffusion MRI and 3 mildly hyperintense signals (Figure-3).

In patients with multiple vertebrae metastasis, millimetric nodular lesions which do not show pedicle involvement were accepted as metastasis. An invasion of pedicle was detected in all MVF and in %68 of the metastases (Table-2).

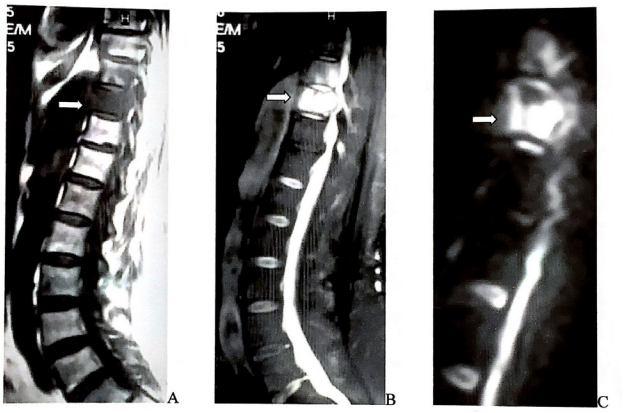

Figure-2. A 53-years-old female patient with lung cancer, **(a)** T9 and T10 vertebra vertebra were hypointense and minimal height decrease on T1W sagittal image. **(b)** T2W sagittal image showed hyperintensity in T9 and T10 vertebrae. **(c)** Diffusion restriction was observed, evaluated as metastasis.

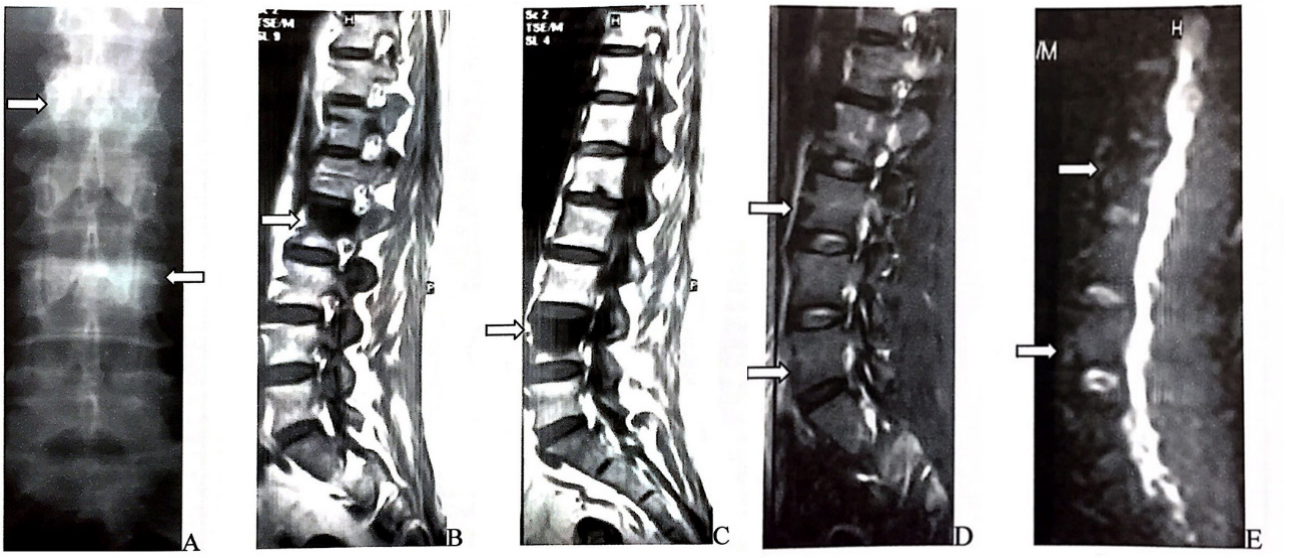

Figure-3. A 53-years-old female patient with breast cancer; **(a)** on the lumbar X-ray were detected sclerotic lesions on the pedicles of L2 and L4 vertebrae. **(b)** T1W sagittal image showed a iso-hypointense lesion on the L2 vertebra. **(c)** T1W sagittal image showed a iso-hypointense lesion on the L4 vertebra. **(d)** L2 and L4 vertebrae were isointense on T2W sagittal image.

Table-2. Comparison of diffusion restriction of lytic and sclerotic metastases in the group 2. (DR: diffusion restriction, P, Fisher exact probability test).

GROUP 2 (n=38)	DR (-)	DR (+)	DR (mildly hyperintense)
Lytic (n=24)	0	21	3
Sclerotic (n=14)	11	0	3
p		<0.001	

Restricted diffusion, hyperintensity was significantly higher in metastatic lesions compared to BVF (p<0.001, Fisher exact probability test).

Restricted diffusion was significantly higher in lytic metastases (p<0.001).

Restricted diffusion, hyperintensity was significantly higher in lytic metastasis than sclerotic metastases (p<0.001, Fisher exact probability test).

DISCUSSION

In our study, T1W hypointensity and T2W hyperintensity were detected in all acute period BVF due to marrow edema. In all chronic period BVF was observed T1W and T2W isointensity. Due to these signal characteristics, the chronic period BVF can be easily diagnosed, but the acute BVF and MVF differentiation cannot be performed according to the T1W-T2W signals, because of the same signal on T1W-T2W MRI can be seen in MVF. Considering the diffusion MRI, in our study, all MVF showed diffusion restriction; any of BVF showed no diffusion restriction.

Diffusion MRI was found to be useful in the differentiation of MVF and BVF. Consistent with our study, Baur et al. [2] reported pathologic diffusion restriction in all MVF and suggesting that diffusion MRI was a very good method in the differentiation of BVF and MVF. Zhou et al. [10] reported that the diffusion MRI and ADC evaluation were useful in differential diagnosis of metastasis with BVF. On the other hand, Castillo et al. [4] reported that diffusion MRI was not superior to T1W image in their study. One of the reasons for differences that lytic and sclerotic metastasis were not separated in the study. In our study, in all 24 lytic metastases, 21 lytic metastases were shown restricted diffusion on MRI, while mildly hyperintense were shown in 3 lytic metastases. Eleven of 14 sclerotic metastases were hypointense and 3 mild hyperintense on diffusion MRI. In our study, the distinction of lytic vertebral metastases could be performed on diffusion MRI. On the other hand, diffusion MRI is not useful in the differentiation of sclerotic metastasis from BVF.

Our limitations; increasing the number of patients can be done in larger series.

In conclusion, the signal characteristics of T1W-T2W sequences overlap in acute BVF and MVF. Diffusion-weighted imaging is guiding in the differential diagnosis of acute BVF and MVF. Diffusion restriction is not detected in acute BVF but detected in MVF. It should be kept in mind that sclerotic metastases may not appear diffusion restriction while lytic vertebral metastases may have diffusion restriction.

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Volume: 30, Issue: 2, April 2019 pp: 105-110 ORIGINAL ARTICLE

FOLLOW-UP OF THE DEGENERATIVE PROCESS WITH MRI AFTER ANTERIOR CERVICAL DISC SURGERY

Muhittin Emre ALTUNRENDE[1]
Elif Evrim EKİN[2]

[1]*GOP Taksim Training and Research Hospital, Department of Neurosurgery, Istanbul, Turkey.*
[2]*GOP Taksim Training and Research Hospital, Radiology, Istanbul, Turkey.*

ORCID Numbers:
Muhittin Emre ALTUNRENDE: 0000-0003-3345-5821
Elif Evrim EKİN: 0000-0003-1290-6291

Address: Muhittin Emre ALTUNRENDE, GOP Taksim Training and Research Hospital, Deparment of Neurosurgery, Istanbul,Turkey.
Phone: +90 5323623854
E-Mail: mealtunrende@msn.com
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ABSTRACT

Objective: Anterior cervical discectomy is a common procedure in neurosurgery. MRI can be used for the diagnosis of the disease and follow up. This study aimed to evaluate postoperative period and adjacent segment disease with MRI after the anterior cervical disc surgery.

Material and Methods: Thirty consecutive patients include 44 segments with anterior cervical discectomy from 2014-2015 were invited to follow-up and investigated with preoperative and postoperative MRI. Median follow-up was 19 months.

Results: Prevalence of Modic changes and uncovertebral hypertrophy were higher in the postoperative period (P<0.001). Degeneration of the adjacent segments were seen 22.7% postoperatively. The adjacent segments degeneration was higher in blade-peek cage than peek cage (P=0.026). All patients showed type 3 Modic changes after 30 months and uncovertebral hypertrophy was detected after 36 months in the postoperative period.

Conclusion: After the anterior cervical disc surgery, degenerative endplate changes and uncovertebral hypertrophy increase in course of time. Type 3 Modic changes and uncovertebral hypertrophy occur in all patients at the end of the 3 years after the surgery. Degeneration of the adjacent segment is seen almost 1/5, which has a higher prevalence in used blade-peek cage.

Key Words: Anterior cervical discectomy, Modic Change, Uncovertebral hypertrophy, Adjacent segment degeneration, Peek cage, Blade-Peek cage.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Cervical vertebrae degeneration includes disc herniation, spondylosis and end plate changes. This entity can present with neck pain, radiculopathy and myelopathy. Decompression and stabilization techniques are used when patients do not benefit from medical or physical therapies [25]. Anterior microdiscectomy and fusion are the most preferred types of procedures for cervical disc herniation treatment. Anterior cervical discectomy (ACD) is a common procedure in neurosurgery practice upon and is also adequately documented. Complication rates are slightly low [27].

MRI, CT and X-ray can be used for the diagnosis of the disease, treatment and follow up. AP-lateral X-rays, as well as oblique X-ray can show bony narrowing of the foramen. CT scans can evaluate bony structures, disc and vertebrae degeneration, width of the foramen and spinal canal [25]. MRIs are used to assess preoperative diagnosis, postoperative follow up to the nerve roots, spinal cord and end plates. MRI is preferred because not use any ionizing radiation and it has high soft tissue resolution [4].

In this study we aimed to compare pre- and postoperative end plate changes, uncovertebral joint (UV) and adjacent segment degeneration and to help understand the postoperative period. The relation between end plate changes and uncovertebral hypertrophy (UVH)

was specifically discussed in order to evaluate cervical fusion with a different point of view.

MATERIALS AND METHODS

This is a retrospective study. 30 consecutive patients, who had been operated for 44 segments in total between December 2014 and 2015, were reviewed. Pre- and postoperative cervical MRIs and X rays were done. Operated segments and the adjacent segments (one segment above and below of the operated segment) were evaluated for end plate changes and hypertrophy of uncial joint. Patients operated via posterior approach, trauma patients, oncology patients were excluded from the study.

Evaluation Criteria

Ethical commitee of GOP Taksim Training and Research Hospital (27.01.2016 / 54) gave approval prior to the study. Informed consent taken from patients. Radiological imaging domains were accepted as: end plate changes, degeneration of uncovertebral joint and disc degeneration. Operated segment and adjacent segments were compared pre- and postoperatively with MRI. Modic classification was used to assess end plate degenerations on MRI [12-13].

Modic changes: (type 0) normal, (type 1) hypointense in T1-weighted (W) images and hyperintense in T2-W images, (type 2) hyperintense in both T1-W and T2-W images, (type3) hypointense in both T1-W and T2-W images. MRI and X-ray findings were correlated for uncovertebral joint degeneration, which was classified as no degeneration, low grade degeneration and high grade degeneration, visually. Disc degeneration was recorded according with Miyazaki Grading System, pre- and postoperatively [11]. All radiological evaluations were made by an experienced musculoskeletal radiologist.

MRI imaging; 1.5 T MR Unit (Signa HDxt; GE, USA) and body surfacecoilwereused. Sagittal T1W FSE, T2W FSE and an axial T2W FSE (3680/128 repetition time/echo time, 256x256 matrix, 280-mm field of viewand 4-mm sectionthickness, NEX 2) was used for imaging.

Surgical procedure; all patients underwent same surgical procedure and different fusion materials were used. The fusion materials to be used were decided on case-by-case basis. 2 patients have undergone simple discectomy, 22 patients have undergone peekcage (PC), 19 patients have undergone blade-peekcage (BPC) and disc prothesis was used in 1 patient. Anterior cervical discectomy via microsurgical technique was used in all patients. Anulus fibrosus and endplates were shaved with curette. After adequate decompression, selected fusion material was placed. Hydroxyapatite filling were put inside cages and then placed in the disc space. No complications were faced during pre- and postoperative period and there was not any blood transfusion. Patients were discharged in 3 +/- 1days.

Our datas were presented as mean, median frequency and percentage values. Categorical variants were compared by Fisher's exact test. Pre- and postoperative Modic and UVH changes were evaluated by Mc Nemar Bowker test. Median follow up time for Modic and UVH were calculated by Kaplan Meier survival analysis. Age and sex factors, which were taught to be effective on degeneration, were assessed by cox regression analysis. Two tailed significance level was accepted to $p < 0.05$. NCSS10 software (2015 NCSS, LLC, Kaysville, Utah, USA) was used for all statistical analyses.

RESULTS

30 patients (24 women, 6 men) with 44 different operation segments were included in the study. Mean age was 45.86±8.5, mean follow-up time was 18±7.4 months.

4 C4-5 intervertebral segments, 25 C5-6 segments, 15 C6-7 segments were operated. Operated segments and the procedures were checked from the operation reports of every patient.

Preoperative cervical vertebrae MRI evaluation: 36 (81.8 %) of 44 segments didn't show any Modic changes. Modic type 1 changes were detected in 5 segments (11.4 %), while type 2 changes were found in 2 segments (4.5 %) and type 3 in 1 segment (2.3 %). Evaluation for UVH didn't show any degeneration in 10 segments (22.7 %). 33 segments (75 %) showed slight hypertrophy whereas 1 segment (2.3%) was high degenerated.

Postoperative cervical vertebrae MRI evaluation: Only 1 patient (2.3 %) showed no signs of Modic degeneration, while type 1 changes were found in 4 segments (9.1 %), type 2 changes in 15 segments (34.1 %) and type 3 changes in 24 segments (54.5 %). 2 patients, in whom no UVH was found preoperatively also showed no signs of UVH postoperatively. Slight hypertrophy was found in 20 patients (45.5 %) and high grade hypertrophy was found in 22 patients (50 %). (Figure-1)

Postoperative adjacent segment evaluation: In 10 segments (22.7 %) were found to have new changes such as Modic changes, disc degeneration and UVH. Postoperative Modic degeneration rates on adjacent segment were higher than preoperative rates significantly ($P<0.001$, McNemar-Bowker test). Statistically, UVH was higher postoperatively than preoperatively ($p<0.001$, McNemar-Bowker test).

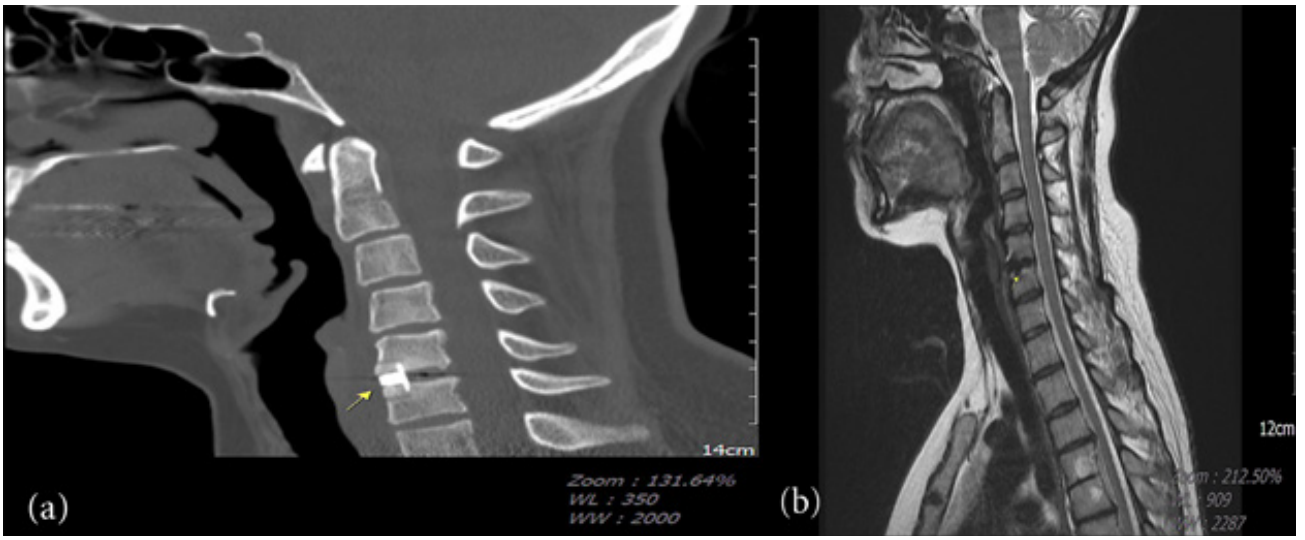

Figure-1. 37-years-old female patient after the anterior cervical discectomy **(a)** on the midsagittal 2D reformate CT, the cage material at C5-C6 level is shown (arrow). **(b)** In the same patient is detected negligible signal loss and magnetic susceptibility artefacts in the operated segment on midsagittal T2-W MRI image.

Evaluation of the operation material: Adjacent segment degeneration was frequent in patients operated with BPC compared to the patients operated with PC (p=0.026, Fisher's exact test). Simple discectomy and protesis procedures couldn't be compared due to lack of patients.

Time-dependent degeneration analysis in postoperative period: As the follow up periods differed from patient to patient, Modic changes and UVH were assessed according to the follow up period (Kaplan-Meier survey analyses, Table-1).

Table-1. 'Evaluation of postoperative Modic changes related to time' shows increase in Modic changes rates in the follow up period.

Time table (month)	the rate of Modic in time	Standard error
7	10%	0.04
12	33%	0.07
18	45%	0.07
24	77%	0.06
30	100%	0

Patients with preoperative type 3 Modic changes and high grade UVH were excluded from this evaluation, considering that these degenerations would not progress. Degenerative changes that were stabile were coded "0" while progressing degeneration was coded "1". Median follow-up was nearly 19 months and the longest follow up period was 36 months, standard error ±0.65 (95 % confidence interval 17.72-20.28).

With this evaluation we found that 10 % patients showed newly onset or progressing Modic changes at 7th month, as well as type 3 Modic changes were found in all patients at 36 months postoperatively (Figure-2).

Similar assessments for UVH showed in the postoperative 7th month only 5 % of the patients have UV degenerations whereas in the 36th month nearly all patients have high grade degeneration (Table-2).

Effect of age and sex on Modic changes: Evaluated seperately, age and sex have no effect on Modic changes (Age: P=0.173, HR=1.045, Sex: P=0.07, HR=0.003, Cox regression test). However, age and sex are evaluated together, it is effective on MC (P=0.041, HR=1.142, Cox regression test).

Effect of age and sex on UVH: Separately, age and sex also have no effect on UVH (Age P=0.237, Sex P=0.141, Cox regression test). Also, age and sex are evaluated together, they were not effective on UVH (P=0.092, Cox regression test).

Table-2. 'Evaluation of uncovertebral joint degeneration related to time' shows an increase in UV degeneration during follow-up

Time table (month)	the rate of UV degeneration in time	Standard error
7	5%	0.03
12	20%	0.06
18	26%	0.07
24	51%	0.09
36	100%	0

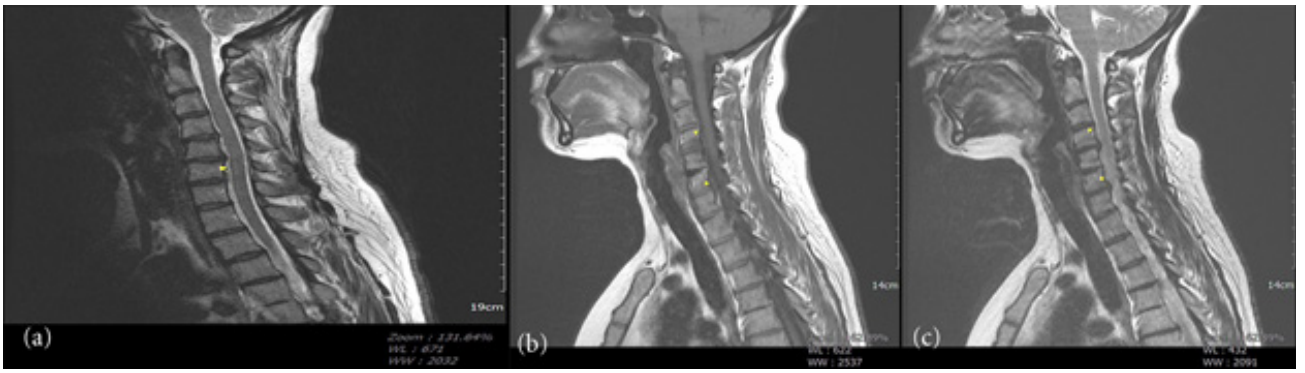

Figure-2. 37-years-old female patient, preoperative cervical MRI evaluation **(a)** on midsagittal T2-W image is shown that there is signal loss and central protrusion on C5-C6 intervertebral disc but no end-plate degeneration (arrow). Degenerative signal loss is detected on C4-C5, C6-C7 intervertebral disc space, too. She has also foraminal disc protrusion (not shown). 18 months after the surgery **(b)** On midsagittal T2-W image is shown that hypointensity and vertical high loss in the C5-C6 intervertebral disc due to anterior cervical discectomy are detected. Hyperintense signal due to type 2 Modic change is also detected on the same level (long arrow). Additionally, the hypointense signal due to type 3 Modic change is detected on the end-plates of C4-C5 level (arrow head). The increase in disc degeneration on the other levels is remarkable. **(c)** Band-shaped hyperintensities on C5-C6 end-plates and the hypointensities on C4-C5 end-plates are seen on sagittal T1-W MRI.

DISCUSSION

Cervical anterior procedure is used to neurosurgery practice, consists of decompression and fusion [1]. There are many studies discussing the operation material, arthrodesis and arthroplasty. Recently, otologue bone grafts and plate-screw systems were used in anterior cervical discectomy with fusion [11,21-23]. Fusion aims to prevent abnormal motion and to maintain stability. However, range of motion is limited in the adjacent segment as well as the operated segment due to fusion. Fusion and stability are still accepted worldwide, on the other hand, protecting the motion to operated segment is more highlighted. That is why, material such as PC and disc prothesis are replacing bone grafts [5,7]. There are studies claiming that hydroxyapatite, known as composite graft and osteocondoctive, is procuring fusion equivalent to otologue bone grafts [2,10,16]. In our series, mainly PCs and BPCs are used.

X-rays, CTs and MRIs can be used for postoperative imaging in patients with ACD. In our study, we used MRI for defining changes in the operated and adjacent segments. We detected negligible signal loss and artefacts in all operated segments (Figs 1a, b). In the literature, it is also revealed that MRI is the most suitable technique for follow up of ACD [14,24]. Also, studies which are evaluating anterior discectomy without fusion, emphasize that the most common postoperative sign is signal loss in intervertebral space in T2-weighted images [24].

Arunkumar and Rajshekhar [1] showed in their 2-patient case series that postoperative microparticle in the operation area can cause hypointensity due to susceptibility artefact. In the literature, it is noted that besides signal loss and artefacts, asymptomatic kyphosis, adjacent segment degeneration and new disc herniation are the most common findings [6,17,19-20]. Adjacent segment degeneration is believed to be a result of spondylolysis rather than fusion [17]. We showed in our study, MD and UVD is progressive in the adjacent segment as well as the operated segment in the postoperative period. Adjacent segment degeneration developed in every one of five patients. In our study, we found that age is not effective on MD and UVH in the operated and adjacent segments. Due to, adjacent segment degeneration might be a result of operative trauma, sagittal balance problems and damage of the functional motion unit besides spondylolysis. Also, we found in our study that the adjacent segment degeneration is related to the type of the operation materials. Adjacent segment degeneration was significantly higher BPC than used PC (p=0.026, Fisher's exact test).

Different studies have evaluated the postoperative MRI changes in the operated segments. Li et al [8] reported that type 2 Modic changes in the operated segments are not effective on fusion. Van de Kelft et al [24] claimed that the T2 weighted signal loss in the intervertebral space is referring to bone fusion. In cervical disc herniation surgery, end plates are curated in order to help to maintain fusion. It is possible to follow the post-operative process by evaluated the end plate signal on MRI. End plate inflammation, lipid degeneration and sclerosis are continuing processes and these could define

the healing process. In our studies, from the 7th month after the operation, Modic changes begin to emerge (10 %) and 30 months later all patients showed type 3 Modic changes. Are type 3 Modic sclerotic bands, which are determined terminal changes, showing fusion? This question can be answered by new studies that type 3 Modic changes together with functional X-rays or postmortem analyses.

Uncovertebral joint is first defined by Luschka [9]. Some authors claimed that this entity is not a real joint but a degenerative change [15,18]. Facets and uncovertebral joints are restricting sliding and extreme movement while permitting a little flexion and extension [26]. Our study showed that postoperative UVH rates are significantly higher than the preoperative period (P<0.001, McNemar-Bowker test). 7 months later in the follow-up period, only 5 % of the patients showed UVH, while all patients showed high grade degeneration at the 36th months postoperatively. Age and sex factors have no effect on UVH (respectively P=0.237, P=0.141, Cox regression test). On this basis, we can claim that uncovertebral joint is quite sensitive to disc and end plate degeneration as well as UVH may develop due to deterioration of the sagittal imbalance in postoperative period, and thus it can aggravate clinical symptoms.

Our limitation, despite small patient group, statistical evaluation in terms of MD and UVH was possible for the entire study. However, use of different materials in the operations are our limitation. Since simple discectomy and pro techniques was not performed adequately, these techniques could not be compared postoperatively. Lastly, dynamic imaging could not be added to the study to evaluate fusion since retrospective study.

Conclusions

In postoperative period after the anterior cervical discectomy, end plate changes and uncovertebral degeneration are increasing by time. Approximately 3 years after the surgery, all patients show type 3 Modic changes and high grade UVH. Also, adjacent segment degeneration is developing in 1/5 of the patients. Adjacent segment degeneration is more common in patients operated with BPC than PC.

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Volume: 30, Issue: 2, April 2019 pp: 111-116 ORIGINAL ARTICLE

SURGICAL PRINCIPLES IN POSTERIOR TRANSPEDICULAR SCREW FIXATION AND FUSION FOR TREATMENT OF SPONDYLOLISTHESIS: RETROSPECTIVE EVALUATION OF 77 CASES

Güray BULUT[1]
Murat Hamit AYTAR[2]
Abuzer GÜNGÖR[3]

[1]*Medipol Üniversitesi, Nisa Hastanesi Nöroşirurji Kliniği, İstanbul, Turkey.*

[2]*Acıbadem Mehmet Ali Aydınlar Üniversitesi, Sağlık Hizmetleri Meslek Yüksekokulu, İlk ve Acil Yardım Bölümü, İstanbul, Turkey.*

[3]*Acıbadem Mehmet Ali Aydınlar Üniversitesi, Tıp Fakültesi, Nöroşirurji Anabilim Dalı, İstanbul, Turkey.*

ORCID Numbers:
Güray BULUT: 0000 0002 9318 4800
Murat Hamit AYTAR: 0000 0002 4323 542X
Abuzer GÜNGÖR: 0000 0002 2792 7610

Address: Murat Hamit Aytar, Özel Acıbadem Kozyatağı Hastanesi, Nöroşirürji Kliniği, İnönü Cd, Okur sk, No: 20, Kozyatağı, İstanbul, Turkey.
Mobile: +90 533 231 88 01
Tel: +90 216 571 44 66
E-mail: hamit.aytar@acibadem.edu.tr
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ABSTRACT

Aim: This study aimed to report our surgical principles and outcomes in patients who had posterior transpedicular screw fixation and fusion operation with a diagnosis of spondylolisthesis at our department between 2014 and 2017.

Method: Seventy-seven patients who had internal fixation and posterolateral fusion operation using lumbar posterior transpedicular screw systems were retrospectively evaluated. All patients were assessed by dynamic lumbar graphics, computerized tomography and magnetic resonance imaging prior to surgery. Posterior decompression, internal fixation with posterior interpeduncular screw, and posterolateral fusion were applied to all patients. Stabilization systems were evaluated by lumbar graphics and computerized tomography at the postoperative first day.

Results: All patients who had clinical and radiological evidences of lumbar spinal instability also had lumbar and/or leg pain and varying levels of neurological deficits. Mean age of the patients was 52.6 (19-74) years, of whom 10 were male and 67 were females. Sixty-nine patients had grade I, and 8 patients had grade II spondylolisthesis according to the Meyerding classification. Nine patients were operated for L3-4, 36 were operated for L4-5, 30 were operated for L5-S1 spondylolisthesis, and 2 patients had 2 levels of spondylolisthesis. Complaints were decreased postoperatively in all patients. One patient was reoperated due to a screw on L5, which was out of the pedicle and caused symptoms. Another 3 patients were reoperated due to breaking of a unilateral S1 screw.

Conclusion: Internal fixation with posterior transpedicular screw and posterolateral fusion applications should be preferred for surgical treatment of patients who have symptomatic and neurologic-deficit causing lumbar spondylolisthesis.

Keywords: Spondylolisthesis, spinal instrumentation, posterolateral fusion.

Level of Evidence: Retrospective Clinical Study, Level III.

INTRODUCTION

Spondylolisthesis is a significant etiological factor for lumbar pain that commonly seen in daily living of the patients. Pain that not responds to conservative treatment, radicular compression, and increased deformity are the indications for surgical treatment [8,25-26]. Non-instrumental posterior or posterolateral fusion applications for surgical treatment of spondylolisthesis are now disfavored due to need for long-term immobilization and high rates of pseudoarthrosis [10,13]. Fixation applications using transpedicular screws are the most appropriate internal fixation methods for lumbar spinal fusion in the treatment of lumbar spondylolisthesis [4,11,14,18,20]. This technique provides higher bone fusion rates and strong vertebral segmental fixation [5,9,17,21].

Transpedicular screw systems were found to provide much better segmental fixation compared to other posterior instrumentation systems like laminar hook-rod or segmental wire-rod [1,16]. Three-column stabilization provides prevention of adjacent mobile normal segments, and also prevents from mechanical pain syndromes [11-12].

Successful application of transpedicular screw systems necessitates a complete

knowledge of pedicular anatomy as well as biomechanical features of instrumentation, and also a meticulous surgical preliminary preparation [5].

MATERIALS AND METHODS

In this study, a total of 77 patients with spondylolisthesis whom were operated for stabilization and posterolateral fusion using posterior transpedicular screw-rod system between 2014 and 2017 at our department were retrospectively evaluated.

All patients had clinical and radiological evidences of lumbar spinal instability, lumbar and/or leg pain, and neurological deficits of varying levels. Surgery was not applied solely for pain treatment in any of the cases.

Four-way lumbosacral vertebrae graphics, hyperflexion-hyperextension graphic, lumbar vertebrae computerized tomography (CT) imaging, and lumbar vertebrae magnetic resonance imaging (MRI) studies were performed prior to surgery in all cases. Additionally, cases with suspected osteoporosis in direct graphies were evaluated with bone densitometry, and cases with multiple lesions in vertebras were evaluated with bone scintigraphy (Figure-1).

Pedicle diameters and corpus depths were controlled on lumbar CT axial images, and screw projections in planned levels were marked on images in all cases prior to surgery (Figure-2).

Fluoroscopy was used for visualizing the lumbar lordosis and vertebrae in supine position in all cases, and visualizations were compared with preoperative graphics. Medial, superior and inferior surfaces of the pedicle was controlled from the hole probes after determining the pedicle projections and decorticating the facet. Images were taken using c-arm fluoroscopy following administration of the screws (Figure-3).

Each screw on L1, L2, L3, L4 and L5 were placed according to 2/3 of the total corpus height, and each screw on the sacrum were placed by targeting promontory. Decompression laminectomy was applied to all cases, and every upper radicle were essentially decompressed.

Autogenous grafts were used after facet decortication. Hemostatic sponge was placed on laminectomy area in all cases, and grafts were not used in laminectomy fields. Extra effort was not applied in any case for the sake of reduction.

All cases were mobilized in same day postoperatively using steel underwire lumbosacral corset. Control assessments were done by direct graphies on the postoperative 1st day (Figure-4).

Figure-1. Preoperative roentgenogram

Figure-2. Corpus length and pedicle diameters were calculated in preoperative Lomber CTs

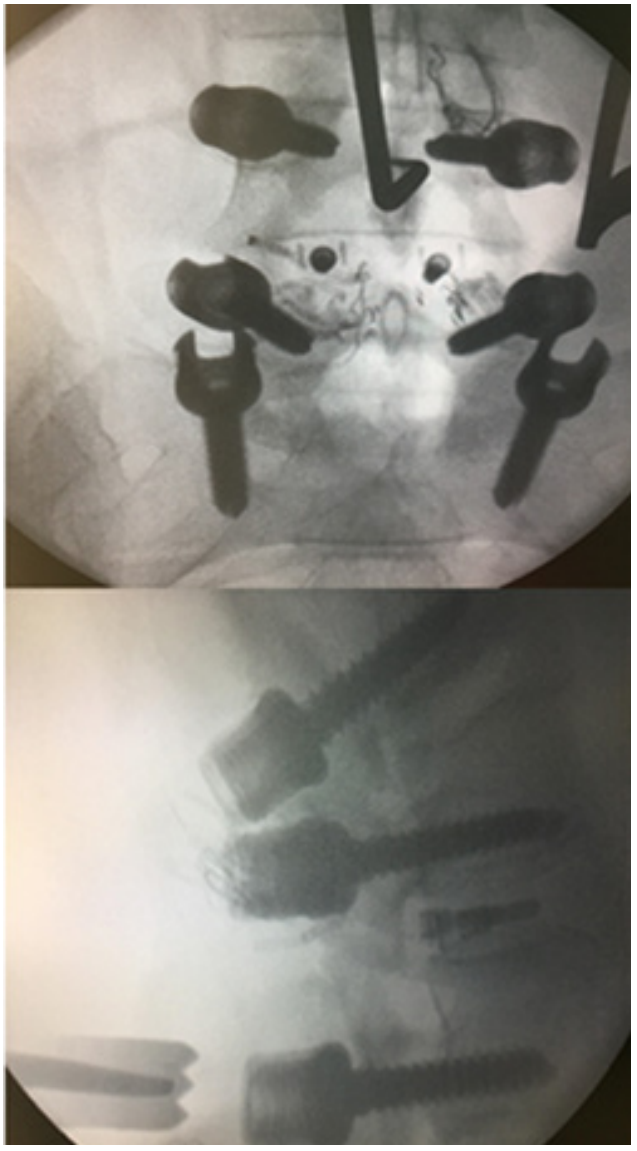

Figure-3. Lateral and AP images at C-arm fluoroscopy during operation

RESULTS

Sixty-seven of the patients were females, and 10 were males (Table-1).

Mean age of the patients was 52.3 (19-74) years, and distribution according to age groups was presented in Table-2.

Mean duration between first symptoms and admission was 67 months (1-240 months). Five patients had a trauma history due to fall, but none of the cases had a history of major trauma. Six patients had previously operated for lumbar disc hernia in other healthcare centers, and the spondylolisthesis was in close proximity to the operation site in 5 cases. Sixty-nine cases had grade I, 8 had grade II spondylolisthesis according to the Meyerding classification (Table-3).

Figure-4. Control radiological images in two patients at postoperative 1st day.

Table-1. Sex distribution of the patients

	Number of patients	%
Male	10	12,99
Female	67	87,01

Table-2. Distribution of patients in age groups

	Number of patients	%
10-29 ages	2	2,60
30-49 ages	22	28,57
50 ages and over	53	68,83

Nine patients were operated due to spondylolisthesis on L3-4 level, 36 patients on L4-5 level, 30 patients on L5-S1 level, and 2 patients on 2 levels (Table-4).

All cases had varying levels of lumbar and/or leg pain symptoms at admission. Moreover, all patients had varying levels of neurological deficits, and operation was not administered for pain treatment solely in any case (Table-5).

Table-3. Distribution of patients in Meyerding categories

Meyerding	Frequency	%
Grade I	69	89,6
Grade II	8	10,4
Grade III	-	-
Grade IV	-	-

Table-4. Distribution of patients in shift levels

Level	Frequency	%
L3-4	9	11,69
L4-L5	36	46,75
L5-S1	30	38,96
Two levels	2	2,6

Table-5. Physical examination results of the patients before surgery

	Number of patients	%
Motor deficit	25	32,47
Reflex alterations	52	67,53
Sensorial alterations	47	61,04
Laseque test positivity	72	93,51
Femoral strain test positivity	10	12,99
Neurogenic claudication	15	19,48

Prophylactic antibiotics were given to each patient, one dose in the morning of operation, and 2 doses postoperatively. Skin was irrigated with antiseptic solution for 5 minutes. Distance measurements were performed essentially using perioperative fluoroscopy. Radixes and dural sac decompressed in all cases by operation microscope. One unit of erythrocyte suspension of own blood-type was given to patients. Diameters and lengths of the screws were calculated by preoperative CT and MRI. Screws of a mean diameter of 6 mm were used in L1, L2, and L3 pedicles, 6.2 mm were used in L4 and L5 pedicles, and 7 mm were used in S1 pedicle, and these screw diameters were suitable for both sexes.

Dura was repaired primarily in 2 cases that had dura injury during operation. No cases had postoperative cerebrospinal fluid (CSF) fistula. Nevertheless, 3 cases without dura repair and without macroscopic dura damage intraoperatively had subcutaneous CSF collection. These 3 patients were managed by serial cutaneous aspirations and compression dressings without a need for reoperation. One patient had a superficial skin infection, and treated with appropriate antibiotic therapy. Control CT assessment was performed for one patient due to postoperative radicular pain. This patient was reoperated one day after due to symptomatic misplacement of the screw out pf the pedicle on L5, and the placement of the screw was adjusted. Three cases had unilateral S1 screw breakage due to fall in their daily life in the postoperative first year, and they were reoperated due to their symptoms and the screws were replaced with steady ones (Table-6).

Patients were followed-up according to the postoperative Prolo follow-up scale. Our surgical outcomes were perfect in 19 cases (24.68 %), good in 54 cases (70.12 %), moderate in 2 cases (2.6 %), and poor in 2 cases (2.6 %) (Table-7).

Table-6. Complications

	Number of patients	%
Dura injury	2	2,6
Subcutaneous CSF collection	3	3,9
Superficial cutaneous infection	1	1,3
Screw breakage	3	3,9
Reoperation	1	1,3

Table-7. Clinical outcomes according to Prolo follow-up criteria

	Number of patients	%
Perfect	19	24,68
Good	54	70,12
Moderate	2	2,60
Poor	2	2,60

Perfect outcome stands for complete recovery of complaints and gaining the daily life activities back. Good outcome means that patients can get back to their work and daily activities, but may sometimes have mild complaints. Moderate outcome defines patients who cannot get back to their work, but to lighter works. And, poor outcomes include patients who do not benefit from surgery and still have the same complaints. Among our cases, 94 % stated that they had benefit from the surgery. Patients were followed-up for a mean of 7.73 (3-30) months. Any of our cases had pseudoarthrosis during the follow-ups.

DISCUSSION

Aim of the spondylolisthesis surgery should be applying fusion to the least number of segments to decrease shifts, applying adequate decompression, fixing the sagittal axis, and obtaining a fusion [27]. Posterior transpedicular screw applications have several pros and cons compared to other stabilization systems (hook and wire) in the lumbar region. Pedicular screws are much more efficient and advantageous than other instrumentation systems due to efficiently and rigidly fixing the spine, being able to be used in vertebrae with laminectomy, keeping the instrumentation level short, being an appropriate method for instrumentation of the sacrum, and keeping the normal curvature of the spine [1-2,6,11-12,24].

Necessity of reduction in stabilization applications using transpedicular screw and rod systems is a controversial topic. A generally accepted approach is that reduction is not needed in symptomatic grade I and grade II cases [5,15]. But, reduction can be applied in grade III and grade IV cases [3,19]. Discectomy should be applied in cases that reduction is considered [7]. Since all of our cases are Grade I and II, reduction was not applied and discectomy was not administered unless necessary.

Some complications of pedicular screw applications include inadequate instrumentation, wound infection, elongated operation times, and massive bleeding, but most important complication is the misplacement of the screw. Radix, dura, cauda equine or the spine can be injured in these occasions. For minimizing or eliminating this risk, a very-well preoperative plan and meticulous surgery is needed [22-23]. Surgical technic, experience, utilization of fluoroscopy, and anatomical correlation minimizes the complications in posterior transpedicular screw applications. Lumbar CT and direct graphics with screw localizations in early postoperative periods helps surgeons for prediction [7-8]. In one of our cases, a misplaced screw on L5 through out of the pedicle caused symptoms, and the patient was reoperated. Other complications are lower than reported in the literature and in accordance with currently available data. We think that utilization of microscope during spinal decompression and obeying the surgical principles decreased our complication rates.

Conclusion

We think that internal fixation and posterolateral fusion applications using transpedicular screws should be preferred for the treatment of symptomatic lumbar spondylolisthesis due to several reasons including early postoperative mobilization of all patients who underwent posterior transpedicular fixation and posterolateral fusion for the treatment of spondylolisthesis, almost no significant complications by applying meticulous and careful surgery, low risk for development of pseudoarthrosis, obtaining favorable outcomes in majority of the cases, and literature data that favor the applications using these methods.

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Volume: 30, Issue: 2, April 2019 pp: 117-120 ORIGINAL ARTICLE

EARLY RESULTS OF ANTERIOR CERVICAL DISCECTOMY AND FUSION WITH INTERBODY CAGES

Burcu GÖKER[1]

[1]*Department of Neurosurgery, Istinye University Medical Faculty, Liv Hospital Ulus, Istanbul, Turkey.*

ORCID Numbers:
Burcu GÖKER: 0000-0002-6084-8690

Address: Burcu Göker,
Department of Neurosurgery, Istinye University Medical Faculty, Istanbul, Turkey.
Phone: +90 532 641 98 22
E-mail: burcugoker79@yahoo.com
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ABSTRACT

Introduction: Anterior cervical discectomy and fusion (ACDF) with interbody cages has been widely used for cervical degenerative disc disease (DDD) along with the other procedures (simple discectomy, cervical disc arthroplasty, ACDF with plating etc.) The aim of the study is to analyze the clinical outcomes measured by Visual Analog Scale (VAS) scores and Odom's criteria after ACDF with blade polyetheretherketone (PEEK) cage plus bioactive bone graft substitute.

Materials and Methods: 83 patients operated by a single neurosurgeon on for singel-level or multi-level ACDF with bladed PEEK cage was evaluated retrospectively. Clinical outcome scores measured by VAS scores and Odom's criteria; postoperative fusion rates were analyzed on postoperative cervical radiographs. Early postoperative complications, implant failures and progression to adjacent segment disease were investigated.

Results: In our study, one-level ACDF was performed on 51 patients, two-level ACDF was performed on 29 patients and three level ACDF was performed on 3 patients. 91.6 % (76 patients) of the patients presented with radiculopathy, whereas, 8.4 % (7 patients) of the patients presented with radiculomyelopathy. Mean follow-up is 18 months (range 1-32 months). VAS scores were improved in 97.6 % of the patients. According to Odom's criteria, 95 % of the patients evaluated the surgery success as excellent; 5% of the patients evaluated the surgery success as good. All of the patients with radiculopathic symptoms fully recovered, whereas, 4 patients (57.2 %) with radiculomyelopathy had improved, whereas in 3 patients (42.8 %) neurological status did not changed postoperatively. Symptomatic adjacent segment disease was not encountered in any of the cases. As for early postoperative complications, one patient had a cerebro-spinal fluid (CSF) fistula which required second operation along with a lumbar drainage, 30 % of the patients had transient difficulty of swallowing which resolved in 2-3 days, in 92 % of patients fusion was achived. No mortality was noted.

Conclusions: ACDF procedure is an effective treatment for cervical DDD. ACDF with bladed cages have higher fusion rates and less implant subsidence. Our study has favorable fusion results with acceptable complication rates.

Keywords: Cervical disc herniation, Anterior cervical discectomy and fusion, Polyetheretherketone cage, Outcome assesment

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Cervical DDD are commonly encountered during daily practice. Until 1950, posterior approaches were popular for cervical DDDs. However, on 1958, after Smith and Robinson introduced the technique of anterior cervical discectomy with autologous graft, anterior techniques were preferred generally over posterior techniques [3,13]. Nowadays, there are several options for cervical decompression for these cases such as ACDF, simple discectomy, cervical disc arthroplasty, ACDF with plating. Nonetheless, there has not been an established gold standard treatment for these patients. In some studies, simple discectomy was favored amongst other techniques, whereas some authors claimed better clinical and radiological

results with ACDF procedures which restore neural foramen height [2,9,16]. In general, simple discectomy is preferred for cases with soft and novel disc herniations, whereas, ACDF is favored for hard disc herniations with DDD. Nowadays, cages with blades and artificial grafts are being used instead of autologous grafts because of the shortened operating time, reduced complication rate along with an adequate fusion. It has been stated that cages with blades had favorable fusion outcomes without the need of plating in single level herniations [4]. Even though, the fusion methods had favorable outcomes, there has been some complications regarding the graft material, such as the loss of cervical alignment and implant subsidence. Fusion with plating was suggested in order to enhance fusion and avoid these complications, especially for multilevel disc herniations. But this technique also had its downfalls, such as, loosening and breakage of the screws, increased rate of postoperative dysphagia, especially with multilevel ACDF procedures [6,14]. Novel techniques, such as, ACDF with blade stand-alone PEEK cage has been described in the literature which enables adequate fusion without plating and its additional complications [10].

In this study, early results of ACDF with bladed PEEK cages were analyzed according to VAS scores, Odom's criteria and postoperative lordosis angle measurements.

MATERIALS AND METHODS

Patient Selection

Between May 2015 and March 2018, 83 patients with cervical DDD, had a single level or multi-level ACDF procedure with bladed PEEK cages using bioactive bone graft substitute (putty) at the Neurosurgical Department. We have retrospectively collected all of the patients' data.

Inclusion criterias were; having cervical DDD with radiculopathy or radiculomyelopathy, not being responsive to 6 weeks of conservative treatment or patients presented with neurogical deficits. Exclusion criterias were; previous cervical spine surgery, history of trauma or tumor. Informed consent was obtained from every patient.

Evaluation

As an outcome measure, VAS scores and Odom's criteria were used and radiological studies for each patient were analyzed retrospectively. Demographic data, postoperative surgery-related complications were noted.

VAS scores ranged from 1-10 measuring pain relief after the surgery. Each patient was asked to define a spesific score pre and postoperatively. Odom's criteria was graded as poor, fair, good, excellent, depending on the satisfactory results of the surgery.

Antero-posterior and lateral cervical x-ray and cervical magnetic resonance imaging (MRI), were performed on all patients preoperatively **(Figure-1).**

Evaluation of the implants and fusion were made with anteroposterior and lateral radiographs postoperatively **(Figure-2).**

Degenerative changes in the adjacent segments were evaluated with MRI during follow-up visits. Implant failure or subsidence was noted if existed.

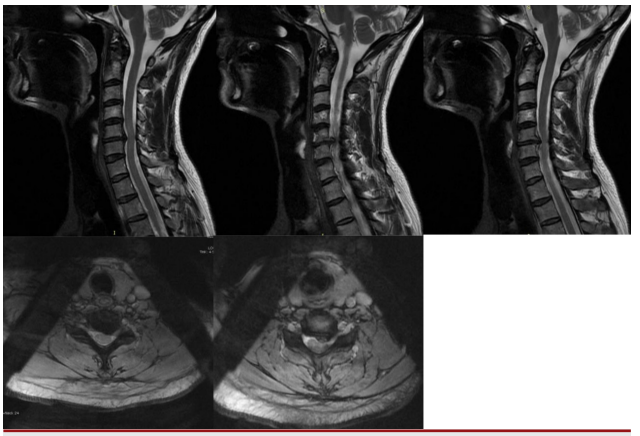

Figure-1. Preoperative T2-weighted sagittal-axial MRI revealing disc prolapse and spinal cord compression at the C5-C6 level.

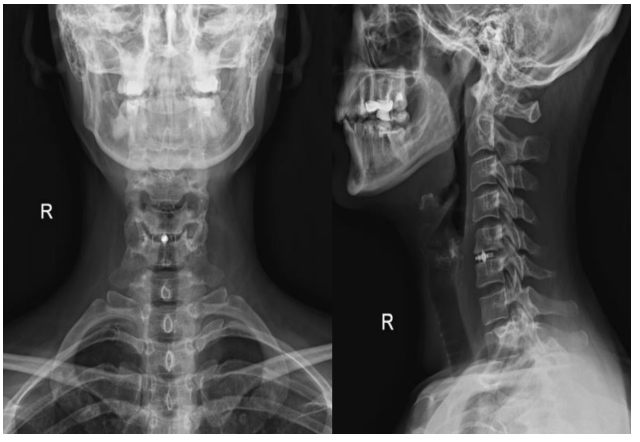

Figure-2. Postoperative antero-posterior and lateral plain X-ray at 12 months presenting the implant

Operative Technique

Under intratracheal general anesthesia in a supine position with the head slightly extended, the platysma was cut in a

standard fashion, and a blunt dissection was made to the anterior aspects of the cervical vertebrae. After verifying the vertebral level with fluoroscopic control, anterior cervical microdiscectomy was made under the operating microscope. The posterior longitudinal ligament was opened and the dura was seen. Both endplates were scratched out by curettes. In cases with hard disc herniations, posterior part of the inferior and superior corpus was drilled in each level. After measurement of the height and depth of the intervertebral space, an appropriate lordotic blade PEEK cage (LorX®, Tria Spine, Germany) was inserted into the intervertebral space with 1 mL demineralized bone matrix inside it and cage was locked to upper and lower vertebra by turning a screw 90 degree clockwise. With the aid of the fluoroscopic control, cage dimensions and proper cage localization was verified. After the hemostasis, wound was closed in a standard fashion. Neuromonitoring was used for the patients presented with myelopathy clinically or if spinal cord T2 hyperintensity changes were seen on MRI.

RESULTS

The mean age of the patients was 46.5 years (range, 25 to 74 years). The study included 47 (56.6 %) female and 36 (43.4 %) male patients. Radiculopathy was the leading symptom in this series. 76 patients were presented with radiculopathy (91.6 %), whereas, seven patients were presented with myelopathy (8.4 %). Interestingly, preoperative motor weakness of triceps muscle was noted in the C6-7 disc herniations, whereas in the other segments the incidence of motor weakness is low (C4-5, C5-6). The mean duration of symptoms was 6 weeks (between 1 week and 9 months). The mean follow-up time was 18 months.

72 % of the patients had soft disc herniation. C5-6 disc level was found to be the most common level amongst others (**Table-1**).

Table-1. Patients distrubation according to operated levels.

Operated Levels	Number
C3-4	1
C4-5	2
C5-6	30
C6-7	18
C4-5, C5-6	11
C5-6, C6-7	18
C4-5, C5-6, C6-7	3

One-level ACDF was performed on 51 of the patients, two-level ACDF was performed on 29 patients and three level ACDF was performed on 3 patients.

VAS scores were obtained on 1st and 3th month of the follow-up visits. VAS scores of 3th month follow-up controls, decreased in 81 patients (97.6 %) when compared with the preoperative VAS scores. The mean preoperative VAS score was found 8.7, whereas it was found 2.9 postoperatively. It was noted that these results were correlated with the final radiographic results. 95 % of the patients evaluated surgery's success as excellent according to Odom's criteria, 5 % of the patients rated the surgery's success as good. None of the patients had kyphotic or lordotic deformity on follow-up visits. On postoperative plain radiographs, there was no sign of implant failure or implant subsidence in any of the cases. Furthermore, follow-up MRI revealed that there was no serious progression of adjacent segment disease along with the adequate fusion in the fused levels in all of the patients.

As for early postoperative complications, one patient had CSF fistula which required second operation along with a lumbar drainage. 30 % of the patients had a transient difficulty in swallowing which resolved in 3 days' time. No wound infection and mortality was noted.

DISCUSSION

Nowadays, anterior cervical procedures differ as a means of technical approach (simple discectomy, anterior cervical discectomy + fusion with autologous graft (Cloward and Smith-Robinson technique) anterior cervical discectomy + fusion with cage, anterior cervical discectomy + disc arthroplasty with disc prosthesis, anterior cervical discectomy + fusion with plating with or without corpectomy etc.) and surgical indications.

Regarding anterior cervical procedures, most common topic under discussion is whether to perform fusion along with the anterior cervical discectomy. Simple discectomy without fusion has lots of advantages, in addition to its certain disadvantages. Advantages of simple discectomy includes, simplicity of the procedure, shortened time of surgery, less complication rates when compared to surgery with fusion techniques and cost-effectiveness of the procedure [5]. Disadvantages of simple discectomy are, postoperative segmental kyphosis, loss of cervical lordosis, alteration of cervical alignment and consequently axial neck pain [17]. Besides, Aydın et al, reported that it is advisable to preserve the disc material subtotally in order to maintain disc height, in their study of anterior contralateral cervical discectomy approach [1]. This approach may be an alternative for

simple discectomy procedure, especially for soft, lateral and paramedian located disc herniations.

There are some controversial studies showing different fusion rates after simple discectomy and discectomy with fusion. In a prospective study, same fusion rates were encoutered (approximately 40 %) when one level simple discectomy cases were compared to the cases of fusion + autologous graft w/o plating [12]. On the other hand, another study claims to have better fusion results after ACDF procedures [15]. Fraser et al, demonstrated the fusion rates to be 92.1 %, 79.9 %, and 65 % for one-level, two-level, and three-level ACDF, respectively, in a meta-analysis of 2682 patients [6]. In our study, fusion rates were consistent with the recent literature.

However, ACDF techniques, especially with plating, have their disadvantages like implant dislodgement, dysphagia and adjacent segment disease along with some important advantages like improved sagittal alignment and stability [15]. Most common complication after ACDF operation is dysphagia occurring almost in 21 % of patients after ACDF procedures [7]. In our study, dysphagia rates were similar when compared to recent literature (30 %). In all cases dysphagia resolved in one week.

Regarding all of these advantages and disadvantages of ACDF and simple discectomy techniques, anterior cervical discectomy + disc arthroplasty with disc prosthesis has become popular among surgeons [8,11]. Since cervical disc arthroplasty preserves motion better than ACDF procedures and prevents fusion related complications, it is advantageous amongst other procedures. Because of these reasons, patients may have early mobilization and gain early functional mobility.

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EVALUATION OF THE DEMOGRAPHIC AND SOCIOECONOMIC FACTORS AFFECTING RECURRENCE OF LUMBAR DISC HERNIATION: A PROSPECTIVE STUDY*

Anas ABDALLAH[1]
Mehmet Hakan SEYİTHANOĞLU[1]

[1]*Department of Neurosurgery, Bezmialem Vakif University, Vatan Street, 34093 Fatih, Istanbul, Turkey.*

ORCID Number:
Anas ABDALLAH: 0000-0003-3600-089X
Mehmet Hakan SEYİTHANOĞLU: 0000-0002-6072-0347

*This study was approved under decision number: (14207/2015) by the medical ethics committee of Health Science University, Bakırköy Research and Training Hospital for Neurology Neurosurgery, and Psychiatry (BRSHH) in Istanbul-Turkey.

Address: Department of Neurosurgery, Bezmialem Vakif University, Vatan Street, 34093 Fatih, Istanbul, Turkey.
E-mail: abdallahanas@hotmail.com; aabdallah@bezmialem.edu.tr
Phone: +90 212 523 22 88 / 2175
Cell-Phone: +90 553 223 35 35
Fax: +90 212 453 17 00
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ABSTRACT

Aim: Reherniation is the experience of another lumbar disc herniation (LDH) at the same level and same side after a pain-free period. In this study, socioeconomic factors affecting reherniation after discectomy prospectively have been investigated.

Material and Methods: 816 patients were underwent discectomy surgery at Neurosurgery department of BRSHH between the years 2014 and 2015, the patients who followed up at least 36-month and appropriate to our study criteria were included. The patients' demographic characteristics such as age, gender, job, BMI, clinical presentations were recorded. The patients were divided into who had recurrent LDH (RLDH) and others (control group) and the comparison had been performed between both groups using all above parameters prospectively.

Results: 816 (430 women, 386 men) patients were underwent discectomy for LDH. 842 disc levels were operated. The mean age was 46.9 (17-82). The mean follow-up period was 47.8 (36-61) months. The mean of preoperative leg and back VAS score were 8.9 and 3.1, respectively. The mean of 12th and 24th month postoperative leg and back VAS score were 1.9, 1.64, 1.9, and 1.82, respectively. The mean of preoperative ODI, 12th and 24th month postoperative ODI were 73.3, 15, and 18.2, respectively. Gender, age, symptom's duration, surgery condition and period, trauma, comorbidities, smoking, and early returning to duties are not related to recurrence of LDH in our patients.

Conclusion: Motor deficits on presentation may reduce RLDH risk. Intact neurologic examination may increase the RLDH risk. Select the correct patient may lead to reduce the risk of RLDH.

Key Words: Lumbar disc herniation, recurrent lumbar disc herniation, risk factors, clinical presentation, socioeconomic factors.

Level of Evidence: Prospective clinical study, Level II.

INTRODUCTION

Lumbar disc herniation (LDH) is one of the most common diseases can affect adults. Lumbar discectomy is the most common surgical operation applied for patients with back and low extremity symptoms [6]. The proportion of patients undergoing surgery to treat sciatica from LDH varies from 2 % to 10 % [14]. Despite the fact that most symptomatic patients whom treated with discectomy had recovered from their symptoms, reherniation is still serious entity.

Reherniation is the experience of another LDH at the same level and same side after a pain-free period [7]. Reherniation is a challenging problem for both of neurosurgeon and patient. The rate of reherniation is accounting for 7-26 % of the patients who underwent discectomy surgery [5]. Causes for a recurrent disc can be multifactorial. Several estimated risk factors for RLDH, such as age, gender, job, body mass index, presence of chronic diseases, and herniation type, are increasingly being investigated in previous studies [2-3,9]. However, there was no always consistent between the results of these studies.

In the literature, many reherniation's risk factors had been described [1,7]. In this study, clinical presentations and

socioeconomic factors affecting reherniation after discectomy prospectively have been investigated.

MATERIAL AND METHODS

Patient data, study design and study criteria

Medical data and demographic characteristics were prospectively recorded for LDH cases which diagnosed and underwent surgery in Department of Neurosurgery from 2014 to 2015. The patients who underwent only first-time discectomy constituted the core sample for this study.

Inclusion criteria were: 1) patient who underwent surgical discectomy for defined side and level herniated LDH causing refractory radiculopathy (bilateral discectomy to the same level cases were excluded); 2) a diagnosis of sciatica was supported with magnetic resonance imaging (MRI) or computerized tomography (CT) findings in line with predominantly radicular symptoms, such as lower extremity symptoms being greater than back or buttock symptoms; 3) presence of preoperative neurologic deficit or failure of conservative treatment for at least three months; and 4) no age restriction.

Exclusion criteria were: 1) patients who underewent total laminectomy, posterior instrumentation or posterior fusion with arthrodesis inside discectomy; 2) a history of one or more of spinal abnormalities such as scoliosis, kyphosis, spondylolysis, spondylolisthesis, inflammatory arthritis, and metabolic bone disease; 3) a history of any infection or tumor in whole the body; 4) a history of a previous back surgery; 5) patients were operated for an acute LDH casing neurologic deficits (i.e., cauda equina and conus medullaris syndromes); 6) presence of contraindication for performing MRI; 7) patients who underwent bilateral discectomy to the same level; and 8) an extraspinal cause of neurologic deficits or sciatica.

The patients were divided into two groups recurrent LDH (cohort) group and others (control). The comparison had been prospectively performed between both groups using preoperative MRI findings, radiographic parameters and intraoperative LDH types.

816 patients were underwent discectomy surgery at Neurosurgery department of BRSHH between the years 2014 and 2015, the patients who followed up at least thirty-six months and appropriate to our study criteria were included. The patients' demographic characteristics such as age, gender, job, BMI, clinical presentations, chronic diseases, cigarette smoking and pre- and postoperative clinical status had been evaluated via Oswestry Disability Index (ODI) scale and the visual analog scale (VAS) for low back pain and leg pain scores [9]. The patients were divided into who had recurrent LDH (study group) and others (control group) and the comparison had been performed between both groups using all above parameters prospectively.

This prospective study was approved by the medical ethics committee of our hospital under decision number 14207/2015.

Clinical outcomes mesures and patient follow-up

Postoperative clinical outcomes had been evaluated using ODI scale and VAS for low back pain and leg pain scores at early postoperative, 6 weeks, 3, 6, 9, 12, 24, and 36 months after surgery. For patients who were followed up more than 30 months, yearly follow-up was applied. In the case of presence of the same intensity of preoperative pain on early postoperative (< one month), the patients underwent MRI of the lumbar spine with and without gadolinium contrast. If there were residue fragments, the patients were accepted to have residual LDH and were excluded from this study. If the patients had not experienced any new neurological deficits or serious radicular pain similar to their preoperative pain intensity, the patients underwent MRI without gadolinium contrast yearly after surgery. Patients experiencing symptoms indicative for RLDH underwent MRI with and without gadolinium contrast at the time of symptom onset to assess for same-level and same-side reherniation.

Patients were recommended to reoperation only when: 1) same-level and same-side RLDH was present and localized to the patient's recurrent symptoms, and 2) failure of 6 weeks conservative management which followed by foraminal and cuadal steroid injection.

Statistical analysis

All data are expressed as the median or mean ± standard deviation with the range shown in parentheses. Univariate analyses are conducted to examine the association between radiological and histopathological features. Differences between groups were assessed by a one-way analysis of variance (ANOVA) using the SPSS 21.0 statistical package. Significance in the multivariate model was determined using a p value of < 0.05, and trend-level effects were defined as $p = 0.05–0.10$. All p values were presented with an odds ratio (OR). When OR could not be calculated, relative/risk ratio (RR) was calculated. The corresponding 95% confidence intervals (CIs) were obtained. All tests were two tailed.

Surgery

The patient is placed in the prone position on the operation table. Fluoroscopy is used for localization. A 2 to 3 cm midline incision is made. A subperiosteal dissection of

tissue from spinous process and lamina on the ipsilateral side is performed. Supraspinous and interspinous ligaments should be preserved. A Taylor retractor is placed. To get better brightness, the operative microscope is brought over the field. Using a high-speed drill or kerrison rongeurs, a hemilaminectomy is performed by drilling the inferior part of the superior level. Ligamentum flavum is removed. If our purpose is preserving the ligamentum flavum to reduce the extent of postoperative adhesion, the superficial layer of the ligament is removed by horizontal splitting. Additional horizontal splitting of the ligament yields a paper-thin deep layer. Lateral vertical splitting and retraction is then carried out to provide a sufficient operative window. The split ligament returns to its original position after releasing the retraction, thereby closing the operative window. So, ligamentum flavum acts as a physical protective barrier. The nerve sleeve and dura are gently retracted medially. The nerve and the thecal sac is padded to preserve it, herniated disc is exposed. The posterior longitudinal ligament and annulus fibrosus are incised and disc material is removed [4].

RESULTS

Patients characteristics and operated levels

816 (430 women, 386 men) patients were underwent discectomy for LDH. 842 disc levels were operated. 58 (30 women, 28 men) patients (7.0 %) were experienced recurrent LDH (study group). The remaining (400 women, 358 men) patients (93.0%) were control group. The mean age was 46.9 (17-82) (Figure-1 and Figure-2).

The mean follow-up period was 47.8 (36-61) months. The most operated level was L4-5 level which was operated on 414 patients from control group versus 39 patients from study group (Figure-3).

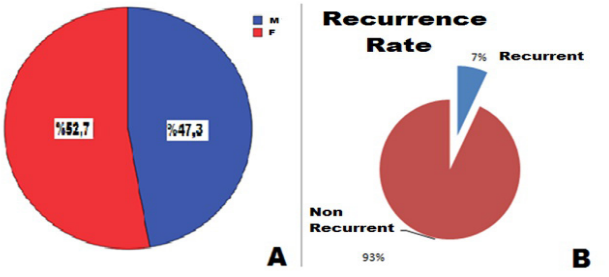

Figure-1. (a) Gender distribution of our operated LDH patients**; (b)** Recurrence rate of our operated LDH patients

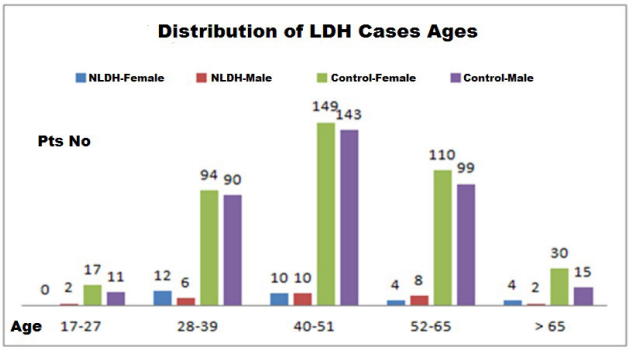

Figure-2. Distribution of LDH cases to age groups.

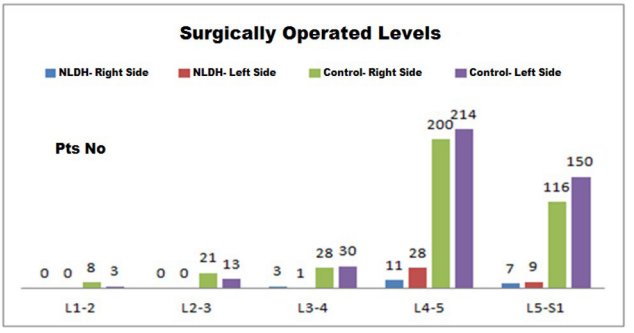

Figure-3. Surgically operated levels.

Clinical presentation, neurological examination, socioeconomic factors (occupational work), and comorbidities

The most common symptom for all patients was leg pain (100 %). Between presenting symptoms there were three symptoms (motor deficit, loss of sensation, and neuropathic pain) showed association with recurrence of LDH. Presentation with motor deficits, loss of sensation, and neuropathic pain are independent risk factors for reducing recurrence of LDH (OR 0.3 (0.2 – 0.6); $p < 0.001$)); (OR 0.3 (0.16 – 0.55); $p < 0.001$)); and (OR 0.42 (0.2 – 0.85); $p = 0.013$)), respectively. Comparison of presenting symptoms between recurrent LDH and control group is given in Table-1.

Motor paresis/plagia, and painful walleix points in neurological examination are independent risk factors for reducing recurrence of LDH (OR 0.3 (0.2 – 0.6); $p < 0.001$)); and (OR 0.35 (0.19 – 0.6); $p < 0.001$)), respectively. Comparison of neurological examination between both groups is given in Table-2.

Cigarette smoking was an independent factor associated with increasing risk of recurrent LDH but only with trend-level significance (OR 1.7 (1.0 – 2.8); $p = 0.07$)). Heavy physical labor leads work (Hard occupational) was an independent factor associated with increasing risk of recurrent LDH

but only with trend-level significance (OR 0.6 (0.35 – 1.1); p = 0.097)). Comparison of socioeconomic factors and comorbidities is given in Table 3. Gender, age, symptom's duration, surgery condition (urgent vs elective) and surgical duration, history of trauma, comorbidities, smoking, and early returning to occupational works are not related to recurrence of LDH in our patients.

Table-1. Comparison of demographic characteristics and presenting symptoms between recurrent LDH and control group.

	Is there recurrent LDH?					
	Yes		**No**		**t**	**P**
Age (M±SD)	46.2	11.9	47.0	12.1	0.688	0.968
Clinic Course (M±SD)*	26.4	36.3	33.0	49.6	0.582	0.296
Follow Up (M±SD)*	47.9	7.7	47.8	7.2	0.588	0.680
	N	**%**	**N**	**%**	**X^2**	**P**
Gender						
Female	30	51.7	400	52.8	FET	0.892
Male	28	48.3	358	47.2		
Symptoms						
1. Leg pain	58	100	758	100	0.000	1.000
2. Low back pain	50	86.2	711	93.8	0.543	0.46
3. Loss of sensation	19	32.8	457	60.3	11.22	***< 0.001***
4. Motor deficit	13	22.4	377	49.7	13.57	***< 0.001***
5. Neuropathic pain	10	17.2	251	33.0	6.88	***0.013***
6. Loss of sphincter	5	8.6	42	5.5	1.34	0.25
7. ECS	3	5.2	29	3.8	0.44	0.51

p>0,05; M: Mean; SD: standard deviation; N: number of patients * Clinic course and follow-up period were given in months; ECS: equina cauda syndrome, t: t test, X^2: Chi-Square test, FET: Fisher's exact test

Table-2. Comparison of findings in neurological examination between recurrent LDH and control group.

	Is there recurrent LDH?					
	Yes		**No**		**t**	**P**
Age (M±SD)	46.2	11.9	47.0	12.1	0.688	0.968
Clinic Course (M±SD)*	26.4	36.3	33.0	49.6	0.582	0.296
Follow Up (M±SD)*	47.9	7.7	47.8	7.2	0.588	0.680
	N	**%**	**N**	**%**	**X^2**	**P**
Finding						
1. Straight leg test	47	81.0	517	68.2	2.382	0.12
2. Hypoesthesia	31	53.4	445	58.7	0.414	0.52
3. Walleix points (+)	16	30.2	406	53.6	9.01	***< 0.001****
4. Motor deficit	13	22.4	377	49.7	15.12	***< 0.001****
5. Contra-laseque	9	15.5	67	8.8	4.16	1.0
6. Loss of sphincter	5	8.6	42	5.5	1.34	0.25
7. Atrophy	0	0.0	21	2.8	0.014	0.91
8. No finding	4	6.9	21	2.8	FET	0.1

p>0,05; M: Mean; SD: standard deviation; N: number of patients * Clinic course and follow-up period were given in months; ECS: equina cauda syndrome; Walleix point (+): painful walleix points; Contra-laseque: straight leg test positive on the opposite side; Motor paresis/plagia, and painful walleix points in neurological examination are independent risk factors for reducing recurrence of LDH.
X^2: Chi-Square test
FET: Fisher's exact test

Table-3. Comparison of occupational work, smoking cigarette, obesity (body mass index), history of trauma, and chronic diseases between recurrent LDH and control group.

	Is there recurrent LDH?					
	Yes		No			
	N	%	N	%	X^2	P
Occupational Work						
1. Housewife	24	41.4	298	39.32	0.094	0.76
2. Slogger (Hard)	18	31.0	324	42.74	2.848	**0.097***
3. Conform work	16	27.6	152	17.94	4.334	0.18
Smoking cigarette						
Yes	31	53.4	447	58.97	FET	**0.07***
No	27	46.6	311	41.03		
BMI(M±SD)	25.13	3.07	25,23	2.88	0.0104	0.919
DM	11	19.0	107	14.11	FET	0.110
HT	13	22.4	253	33.38	FET	0.331
Thyroid dysfunction	8	13.7	91	12.0	FET	0.676
CAD	5	8.6	96	12.66	FET	0.533

p>0,05; M: Mean; SD: standard deviation; N: number of patients; CAD, coronary artery diseases; DM, diabetes mellitus; HT, hypertension; BMI: body mass index; * Cigarette smoking and hard occupational works were independent factors associated with increasing risk of recurrent LDH but only with trend-level significance.
X^2: Chi-Square test
FET: Fisher's exact test

Surgical Outcomes

The mean of preoperative leg and back VAS score were 8.9 (7-10) and 3.1 (1-6), respectively. The mean of 12th and 24th month postoperative leg and back VAS score were 1.9 (1-3), 1.64 (0-4), 1.9 (1-3), and 1.82 (0-5), respectively. The mean of preoperative ODI, 12th and 24th month postoperative ODI were 73.3 (52-88), 15 (0-24), and 18.2 (0-26), respectively.

DISCUSSION

In the neurosurgical practice the lumbar microdiscectomy is the most commonly used surgical approach. It is a safe and effective procedure when symptomatic herniated lumbar disc is found. The aim of our prospective study was to investigate the relation between demographic characteristics as risk factors for RLDH. Previously published studies have explored many potential risk factors for RLDH, such as age, gender, BMI, smoking, chronic diseases such as diabetes, type of LDH, occupational work [1-3,5,7,9,14].

Recently published systematic metaanalysis showed that smoking, disc protrusion, and diabetes had significantly association with RLDH [7]. The exact mechanism of smoking how leads to RLDH is still incompletely understood. Some studies have suggested the potential mechanism. Toxins generated by cigarette smoking may impair or delay tissue repairing which is a normal condition [7,11]. After discectomy procedure, healing of annular defects in normal physiological condition is usual, but with smoking the defect in the annulus fibrosus and posterior longitudinal ligament may be delayed with cigaratte smoking. One study showed that nicotine affected disc annulus nutrition and oxygenation [15]. Our study showed that smoking was a factor associated with increasing risk of recurrent LDH but only with trend-level significance.

One systematic review showed that diabetes mellitus disease (DM) correlated with RLDH, with the pooled OR 1.19 (95 % CI, 1.06 - 1.32) [7]. Kim et al. study showed that the weight may be another risk factor for RLDH [8]. In effort to understand the mechanisms of this negative impact of DM, Robinson et al. conducted comparison of the intervertebral discs between nondiabetic and diabetic patients using discarded discs from discectomies. They found that the proteoglycans from diabetic cases were banded at a lower buoyant density, which indicated a lowered glycosylation rate and a lower number of sugar side chains per core protein. The same study also suggested that there was a slight increase in the chain length of chondroitin sulfate in the diabetic patients and further analysis of the glycosaminoglycan chains demonstrated a decreased amount of keratan sulfate glycosaminoglycan [12]. The study concluded that these changes might lead to increased susceptibility to disc prolapse. For diabetic patients, annulus fibrosis healing might take longer time and not be as sturdy as nondiabetic patients [7].

There are several other reported risk factors such as age, gender, BMI, occupational work, level of disc herniation, and thyroid dysfunction. However, the results were not significant when combined with cohort studies [7]. BMI was another widely concerned risk factor for RLDH. Most published studies compared BMI as baseline data and these inconsistent results could not come to a conclusion. The combined OR of BMI > 25 by 2 case-control studies still found no significant relations between BMI and RLDH. According to our study there was no association between all of these demographic characteristics and chronic diseases.

With respect to occupational works, it is generally accepted that heavy physical labor leads to increased loading of lumbar disc, which may contribute to RLDH [10,13]. According to previous published studies we aimed to divided our patients to three groups: sloggers who involved with hard occupational and heavy physical labor leads, second group the patients who work in conform duties and did not involve with heavy physical labor leads. The third group is housewife who can involve with both hard and conform works. According to our results we found that slogger group may under high risk of recurrent LDH but only with trend-level significance.

The study has two limitations: first, the follow-up period is short. Second, the results are a single center results. Further prospective studies with large size and long follow-up period are necessary to systematically investigate these findings.

Conclusions

Selection of the correct candidate for discectomy depends on clinical presentation that supported with correlation of neurological examination and MRI findings, may be one of the best ways to reduce recurrence risk of LDH. Motor deficits on presentation may reduce RLDH risk. Intact neurologic examination may increase the RLDH risk. Select the correct patient may lead to reduce the risk of RLDH.

Disclosure of Potential Conflicts of Interest

The authors declare that they have no conflict of interest.

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PRELIMINARY RESULTS OF ADDING DYNAMIC SCREWS TO UPPER FUSION SEGMENT IN PATIENTS WITH DEGENERATIVE LUMBAR SPINE

Erdinç ÖZEK[1]
Anas ABDALLAH[1]

[1] *Department of Neurosurgery, Bezmialem Vakif University, Istanbul, Turkey.*

ORCID Numbers:
Anas ABDALLAH: 0000-0003-3600-089X
Erdinç ÖZEK: 0000-0003-1860-4534

Address: Anas Abdallah, Department of Neurosurgery, Bezmialem Vakif University, Vatan Street, 34093 Fatih, Istanbul, Turkey.
E-mail: abdallahanas@hotmail.com; aabdallah@bezmialem.edu.tr
Phone: +90 212 5232288-2175
Cell-Phone: +90 553 223 35 35
Fax: +90 212 4531700
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ABSTRACT

Aim: To assess sufficiency of dynamic screw addition to instrumented fusion segment to prevent development of the adjacent segment disease (ASD).

Material and Methods: Medical records were retrospectively reviewed for degenerative lumbar spine surgery from 2016 to 2018. Patients with degenerative lumbar spinal disease constituted the core sample for this study. To obtain homogeneity of both groups only patients involved with degenerative lumbar spine disease were included. All surgeries were performed by the same spine surgeon (EO).

Results: This series included 87 (66 female, 21 male) patients, with a median age of 56 years. Mean follow-up period was 10.24 months for dynamic screw added patients and 16.06 months for only fusion patients. Eleven patients with adjacent level disease were diagnosed only in alone fusion group (17.7 %) and no adjacent level disease was diagnosed in upper level dynamic screw added group. Adjacent level disease is statistically significant in alone fusion group (p = 0.03).

Conclusions: In our study, there is a statistically significant difference between only fusion instrumentation and dynamic screw added fusion in radiologic and clinical adjacent segment disease. Although long-term followed-up, studies are needed to assess the sufficiency of dynamic screw addition to instrumented fusion segment to prevent the adjacent segment disease.

Key words: Dynamic screws; adjacent segment disease; fusion; degenerative lumbar spine
Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Lumbar spine surgeries involving posterior instrumentation lead to risk of adjacent segment disease (ASD). ASD may occur because of overload on the adjacent segments. ASD can be explained by the adjacent segments have to compensate for the lost range of movement after undergoing fusion, resulting in exposure of those segments to overload and shear forces [3,7]. In one review of literature, the authors found that ASD might develop with the incidence of 30 % [11] after spinal fusion strategies, in another series this ratio was reported as 18.5 % [13].

Various risk factors have been reported such as fusion length, preoperative sagittal balance, intraoperative facet injury, age, increased body mass index, and preoperative radiologically illustrated upper ASD [10,12,14,17-18]. Various dynamic screw and rod systems had been developed to prevent ADS [5,8]. Dynamic posterior lumbar stabilization without fusion versus hybrid instrumentation effect on adjacent level disease is still controversial.

The current study investigated whether the addition of dynamic pedicle screws with hinged screw head to the fusion segment was effective in preventing ASD in patients who underwent lumbar segmental spinal fusion for degenerative lumbar spine diseases.

MATERIAL AND METHODS

This retrospective study was approved

by the medical ethics committee of our hospital. Written informed consent was obtained from the patients for the publication of their cases and accompanying images.

Medical records were retrospectively reviewed for degenerative lumbar spine (DLS) surgery from 2016 to 2018. Isthmic Spondylolisthesis, recurrent disc herniation, degenerative scoliosis patients and long segment posterior instrumented (over 6 segments) patients were excluded from the study. All patients were operated by the same surgeon (EO). Adult patients (age > 18 years) who followed up at least six months constituted the core sample for this study.

Pre- and postoperative clinical status had been evaluated using Oswestry disability index (ODI) scale and visual analog score (VAS) scores. The patients were divided into two groups; patients whom dynamic screws were added to the posterior instrumentation system from the cranial (upper) ends (dynamic group) and others who had underwent posterolateral fusion patients stabilized only with a stable posterior instrumentation system without adding dynamic screws (control group) and the comparison had been performed between both groups. For both groups, the patients' sex, age, symptoms, preoperative course, surgical outcomes, and complications had been compared.

Patients Characteristics

This series included a total of eighty-seven patients. Sixty-six females and twenty-one males were diagnosed as degenerative lumbar spine patients using lumbar MRI, and CT. Dynamic group included 25 patients (17 females and 8 males). Control group included 62 patients (49 femlaes and 13 males). The mean age of both groups were 58.9±19.1 (47-68) and 55.2±17.8 (49-64), respectively. The mean of preoperative course between the first symptom and surgery was 14.6±32.0 (6-72) months for dynmaic group and 16.2±28.0 (6-60) months for alone fusion (control) group.

Surgery

In alone fusion group (control group), polyaxial pedicle screws were placed and laminectomy was performed under surgical microscope, and posterolateral fusion was provided by autogreft or allograft. In dynamic screw added patients (dynamic group), dynamic screws were placed to just cranial end of fusion segment with the care of facet joints. No allo or auto-grefts were used on upper last segment. All standard polyaxial and dynamic pedicle screws were placed to vertebral body under assistance of C-armed fluoroscopy.

Follow-up

As a part of standard care, the patients undergoing surgical intervention for DLS diseases using posterior instrumentation received routine clinical evaluations and serial postoperative early computerized tomography (CT) as well as during their follow-up visits at 6 weeks, 3, 6, 12, and 24 months x-rays were performed. Postoperative lumbar MRIs were planned depending on the patients' complaints. However, if there was no additional new deficit or pain, MRIs were performed at 6, 12 and 24 months. ASD was diagnosed clinically or radiologically. Clinical ASD was evaluated according to whether there was symptomatic spinal stenosis, mechanical low back pain, or sacral or coronal imbalance after the procedures. Radiological ASD diagnosed by standard lumbar MRI. Postoperative CT were obtained at 12, 18 and 24 months to investigate the status of fusion (Fig. 1).

Figure-1. Sagittal T2-weighted MR image shows adjacent segment disease on postoperative 14th month.

Statistical analysis

All data are expressed as the mean ± standard deviation with the range shown in parentheses. Differences between groups were assessed by a one-way analysis of variance (ANOVA) using the SPSS 21.0 statistical package. Significance in the multivariate model was determined using a p value of < 0.05, and a trend-level effect was assigned to a p = 0.05–0.10. All p values were presented with an odds ratio (OR). OR are presented with the 95 % confidential interval (CI). When OR could not be calculated, risk ratio (RR) was calculated. All tests were two tailed.

RESULTS

The most common symptoms were leg pain and low back pain (100 %), followed by weakness of lower extremities was recorded in 16 of 25 dynamic group patients and 41 of 62 fusion alone group patients, loss of sensation was recorded in 14 of 25 and 37 of 62, neurogenic claudication (< 20 meters, or inability of standing up for 10 minutes) in 4 of 25 and 15 of 62, and urine incontinence were recorded in two out of 25 and five in 62 patients, respectively (Table-1).

The median of instrumented levels was 4 (2-5) levels for both groups. All patients were discharged on postoperative third day with recommendation of physical therapy. The mean follow-up periods were 10.2 ± 8.3 (6-27), and 16.1 ± 7.8 (7-29) months, respectively.

Table-1. Comparison between 'Dynamic' and 'Alone Fusion' Groups

	Dynamic Group	Alone Fusion Group	P	OR
No of patients	25	62	-	-
Age (years)*	58.9±19.1 (47-68)	55.2±17.8 (49-64)	0.68	-
Gender (F/M)	17/8	49/13	0.41	1.8 (0.6-5.0)
Preoperative course**	14.6±32.0 (6-72)	16.2±28.0 (6-60)	0.77	-
Symptoms				
- Leg pain	25 (100%)	62 (100%)	1	-
- Low back pain	25 (100%)	62 (100%)	1	-
- Muscular weakness	16 (64%)	41 (66.1%)	1	0.9 (0.3-2.4)
- Loss of sensation	14 (56%)	37 (59.7%)	0.81	0.9 (0.3-2.2)
- Neurogenic claudication	4 (16%)	15 (24.2%)	0.67	0.6 (0.2-2.0)
- Urine incontinence	2 (8%)	5 (8.1%)	1	1 (0.2-5.5)
VAS (Pre/PO)				
- Leg	7.2 (5-8)/ 1.8 (1-3)	6.8 (6-9)/ 2.2 (1-3)	0.6	0.8 (0.4-1.6)
- Back	7.8 (7-9)/ 2.5 (1-3)	8.3 (7-9)/ 2.6 (1-4)	1	1.02 (0.5-1.9)
ODI (Pre/PO)	61.2 (42-68)/ 18.8 (16-36)	58.2 (32-64)/ 17.8 (10-34)	1	1.0 (0.48-2.1)
Surgical Complication				
- ASD	0	11	**0.03****	**RR = 1.5 (1.3-1.7)**
- Reoperation	1	3	1	1.2 (0.12-12.3)
- Dural Tear	1	2	1	0.8 (0.07-9.2)
- CSF Fistula	0	1	1	RR = 1.4 (1.2-1.6)

p < 0.05 is significant. * The mean and range of values were given; ** Preoperative course was given by months; Pre: preoperative; PO: postoperative; ASD: Adjacent segment disease; VAS: Visual analog score; ODI: Oswestry disability index, p: Probability value; OR: Odd ratio; RR: risk ratio.

Surgical Complications and Outcomes

The mean of preoperative leg and back VAS score were 7.2 (5-8), 7.8 (7-9) for dynamic group and 6.8 (6-9), 8.3 (7-9) for control group, respectively. The mean of postoperative leg and back VAS scores were 1.8 (1-3), 2.5 (1-3), 2.2 (1-3), and 2.6 (1-4), respectively. The mean of pre- and postoperative ODI were 61.2 (42-68), 18.8 (16-36) for dynamic group, and 58.2 (32-64), 17.8 (10-34) for control group, respectively. In both groups, there was a significant decrease in postoperative back VAS ($p = 0.01$), and leg VAS ($p = 0.02$) values of the cases. The differences between both groups in improvement are not statistically significant.

Up to last analysis date, ASD was seen in eleven patients (17.7 %) from control (alone fusion) group and no ASD was diagnosed in dynamic group. Of those patients who diagnosed as ASD six patients were diagnosed as clinical and radiological ASD whereas five patients were diagnosed clinically. The patients who diagnosed clinically and diagnosis was supported radiologically (n = 6) were reoperated (Fig. 2).

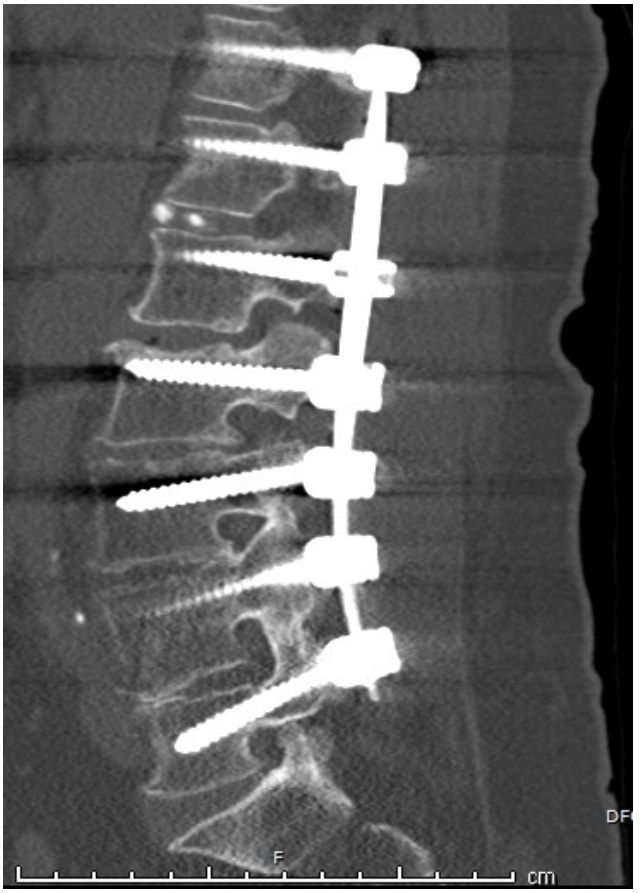

Figure-2. Sagittal CT image shows early postoperative extension using pedicle screws and fusion for the same patient in figure-1.

Clinically diagnosed five patients were treated conservatively. ASD is statistically significant in alone fusion group ($p = 0.03$). Reoperation for malposition was applied in one patient from dynamic group and three patients from alone fusion group. Dural tear was seen in one patient from dynamic group and two patients from control group and all these patients were handled preoperatively using fibrin sealant product after primary sutured using 0.5 absorbable sutures. From these three patients, CSF fistula was seen in one patient from control group and were treated using lumbar drainage for five days and prophylactic antibiotics. Except for ADS complication, the differences between both groups in complications are not statistically significant.

DISCUSSION

ASD is a serious challenging complication of posterior instrumentation and fusion surgery [7,9]. ASD occurs due to transmission of compensatory compression such as flexion-extension strength and forces from fused segment to facet joints and disc space, these conditions are concluded extensive loading on adjacent segment and degenerative process has been started [4,15].

Various non-fusion systems using dynamic screws and non-rigid rod systems have developed to prevent ASD. These systems are successful for pain relief, quality of life and motion preserving. Although non-fusion systems prevention of ASD is still controversial. According to St-Pierre et al. study ADS rate is higher in alone dynamic stabilization when compared to classic fusion (5.2 % versus 16.5 %) systems at a 5-year follow-up period [16].

To prevent the adjacent segment disease hybrid systems are recently developed. Hybrid system is started used for the rigid stabilization of multilevel spinal degeneration while allowing for a limited degree of motion in the adjacent dynamically instrumented segments [6]. Formica et al. found that no significant degenerative changes in adjacent segments at two-year follow-up of 41 patients treated with hybrid stabilization when compare classic fusion surgery [1].

In the current study, we used dynamic polyaxial dynamic screws that allow motion in only one plane with hinged joint. These dynamic screws provide mobility in sagittal plane however causes high degree stability on rotational forces. The dynamic system we used was developed to reduce compressive loading forces on dynamic screws' head and to allow flexion and extension on certain extent, although system does not allow rotational movement. Flexible rods with dynamic screws allow rotational movement that provides to protect from shear forces and rotational stability, which effect the adjacent disc and facet degeneration.

In this study, we aim to prevent ASD by using dynamic rod-screws system that allows moving segment on sagittal plane and concluding to share the extensive loading on adjacent segment. Previous similar study performed by Hayati et al. founded that there was no statistically significant difference between dynamic screws added stabilization and alone fusion when compared radiologic ASD and clinical ASD [(2)]. However they had founded that adding dynamic screw to fused segment has an effect on radiologic ASD that could not supported statistically.

The study has several limitations: first, it is a retrospective study that may suffer from the inherent bias. Second, the sample size of our cohort is small and follow-up period is short to generalize. Third, the results are a single center and a single surgeon results.

Conclusions

Despite the fact that our follow-up period is short and our sample size is small to generalize, this our preliminary study shows that the addition of dynamic screws had beneficial effects to prevent both clinical and radiologic ASD in patients who had LDS disease and treating with the posterior instrumentation systems. Further prospective studies with larger sample size are needed to validate our results.

Disclosure of Potential Conflicts of Interest

The authors declare that they have no conflict of interest.

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Volume: 30, Issue: 2, April 2019 pp: 133-138 ORIGINAL ARTICLE

THORACIC AND LUMBAR SPINE FRACTURES: A RETROSPECTIVE STUDY

Hüseyin DOĞU[1]
İrfan ÇINAR[2]

[1]*Atlas University, Department of Neurosurgery, Medicine Hospital, İstanbul.*

[2]*Aile Hastanesi, Department of Neurosurgery, İstanbul.*

ORCID Numbers:
Hüseyin DOĞU: 0000-0002-7754-4984
İrfan ÇINAR: 0000-0001-9973-7130

Address: Hüseyin DOĞU, Marenegro sitesi, 345/14, Kilyos, Sarıyer, İstanbul.
Phone: +90 542 651 41 36
E-Mail: huseyindogu@gmail.com
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ABSTRACT

Purpose: To analyze the existing medical literature on thoracic and lumbar spine fractures.

Material and Method: In this study, 41 patients with thoracic and lumbar fractures who were operated between 2007 and 2017 were retrospectively inspected. Posterior pedicle screw fixation, decompression, vertebroplasty, and fusion were performed in the patients. The patients were evaluated according to their age, gender, type and level of trauma, neurological state, surgery duration, stay duration in the hospital, and kyphosis angles. SPSS 21 was used for statistical analysis. Student's t-test was used to compare different variables. P values less than 0.05 was considered as significant.

Results: A total of 41 patients were enrolled in this study. The mean age was 50.60 ± 19.45 years (range: 15–87 years). Among the patients, 23/41 (56.11 %) were males and 18/41 (43.90 %) were females. The most common cause of thoracolumbar fracture was osteoporosis (14/41 patients, 34.15 %). The most frequently affected vertebra was vertebra L1 (14/41 patients, 34.15 %). Compression was the most common type of vertebra fracture (32/41 patients, 78.05 %). The mean duration of the operation was 189.37 ± 54.89 min (duration range: 125–330 min). The mean time of stay in the hospital was 6.39 ± 5.20 days (range: 3–35 days). Among the patients, 10/41 (24.39 %) had neurologic deficit. Screws were implanted in the fractured segment of 5 patients. Vertebroplasty was performed in 3 patients. The kyphosis angles of the patients at the preoperative stage were 20.1, at early postoperative stage 12.4, and at first postoperative year 13.1.

Conclusion: The major cause of thoracolumbar fracture was osteoporosis mostly affecting the elderly population. The most common type of thoracolumbar fracture was compression and the L1 was the mostly affected region. Our review cumulatively suggests that stabilization with posterior pedicle screw fixation is a surgical technique with good outcomes and minimal complications when performed under favorable conditions.

Key words: thoracic fracture, lumbar spine fracture, osteoporosis

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Thoracic and lumbar fractures constitute 6.9 % of all cases of blunt traumas admitted to the emergency clinic [(14)]. Unstable thoracic and lumbar fractures are critical reasons for morbidity among cases of spinal fractures [(4)]. Thoracic and lumber fractures occur most commonly in the thoracolumbar (T10–L2) area. These fractures can be caused by high-energy trauma, such as traffic accidents, falls, work accidents, sports injuries as well as minor trauma in patients with osteoporosis and malignity [(13)].

Stable fractures can be taken under control with the conservative treatment [(16)]. However, unstable fractures can only be treated with surgery [(28)]. In case an unstable fracture is left untreated, it can progress to neurological damage, immobility, and deformity. The purpose of the treatment is to decompress the neural elements, protect the vertebra corpus heights, correct the deformity, assure stabilization, early mobilization, reduction of pain, facilitation in going

back to work, and improvement in the quality of life. Although the goal of the treatment is to protect the neural elements, no neurological damage has been reported in the majority of the patients [10]. Therefore, the goal of the present study was to reduce pain through extended stability and through facilitating daily activities by ensuring mobility. Presently, posterior stabilization is the most common surgical procedure in patients with thoracic and lumbar fractures. Endoscopic and radiological developments have created different alternative surgical routes, such as thoracoscopy and percutaneous stabilization. Methods such as short-segment posterior instrumentation, stabilization without fusion, and posterior fixation including the fractured vertebra have recently gained popularity. The existence of different alternatives makes it difficult to form a consensus about the management of thoracic and lumbar fractures [21].

MATERIALS AND METHODS

A total of 41 patients with thoracic and lumbar fractures operated during 2007–2017 were retrospectively inspected. Data were collected from the patients' medical records. Posterior pedicle screw fixation, decompression, vertebroplasty, and fusion were applied to the patients (Figures 1–3). The patients were evaluated according to their age, gender, type and level of trauma, neurological state, duration of the operation, time of stay in the hospital, and kyphosis angles.

Figure-1. A 16-year-old patient had suffered falling from high. She complained of low back pain and was neurologically intact. Preoperative sagittal and axial computed tomography image of lumbar fracture.

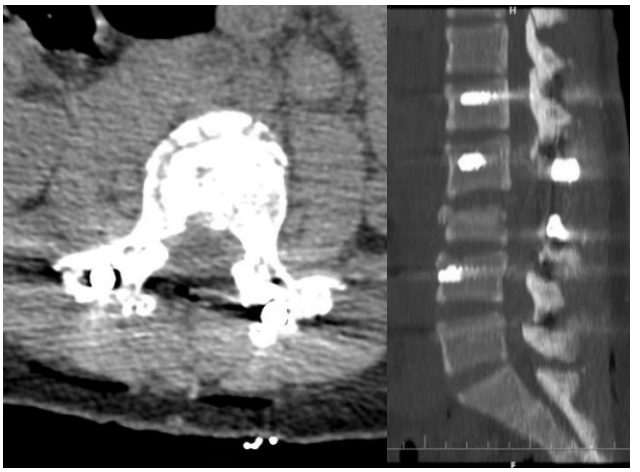

Figure-2. Postoperative sagittal and axial computed tomography image of lumbar fracture.

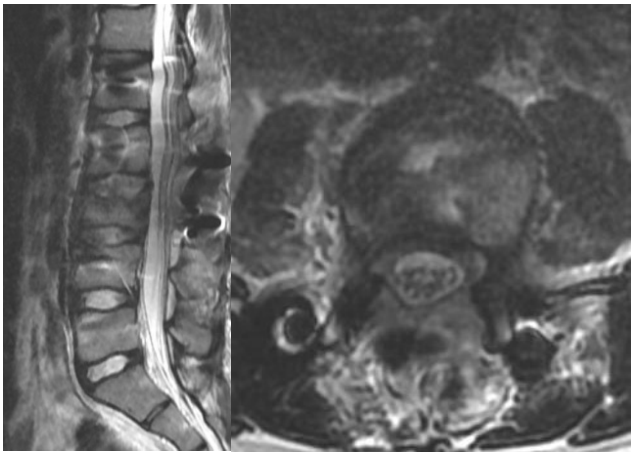

Figure-3. Postoperative sagittal and axial magnetic resonance image of lumbar fracture.

Statistical analysis:

Data was analyzed by SPSS 21 and presented in Mean (SD) and frequency (%). Continuous variables following the normal distribution were compared by independent t-test. Categorical variables were compared by χ^2/Fisher's exact test. P value less than 0.05 was considered as statistically significant.

RESULTS

A total of 41 patients were enrolled in this study. The mean age was 50.60 ± 19.45 years (range: 15–87 years). Among the patients, 23/41 (56.11%) were males and 18/41 (43.90%) were females. The mean age of the females (57.05 ± 20.60 years) (range: 15-87 years) was significantly higher than the males (45.56 ± 17.30 years) (range: 17-79 years) (p=0.01). The most common cause of thoracolumbar fracture was osteoporosis

(14/41 patients, 34.15 %), followed by falls (12/41 patients, 29.27 %). The most frequently affected vertebra was vertebra L1 (14/41 patients, 34.15 %), followed by vertebra L3 (7/41 patients, 17.07 %). Compression was the most common type of vertebra fracture (32/41 patients, 78.05 %), followed by burst fracture (8/41 patients, 19.51 %), and compression dislocation (1/41 patient, 2.44 %). The mean duration of the operation was 189.37 ± 54.89 min (duration range: 125–330 min). The mean time of stay in the hospital was 6.39 ± 5.20 days (range: 3–35 days) (Table-1).

Table-1. Demographic and clinical characteristics of patients (n=41). Data presented as Mean (SD) and frequency (%).

Demographic and clinical characteristics of patients (n=41)	
Age (Mean ± SD)	50.60 ± 19.45
Gender	
Male	23 (56.11%)
Female	18 (43.90%)
Cause of admission	
Falling down	12 (29.27%)
Work accident	6 (14.63%)
Traffic accident	6 (14.63%)
Malignancy	3 (7.32%)
Osteoporosis	14 (34.15%)
Level	
D4	1 (2.44%)
D5	1 (2.44%)
D6	3 (7.32%)
D7	1 (2.44%)
D8	0 (0%)
D9	2 (4.88%)
D10	4 (9.76%)
D11	1 (2.44%)
D12	3 (7.32%)
L1	14 (34.15%)
L2	3 (7.32%)
L3	7 (17.07%)
L4	2 (4.88%)
L5	3 (7.32%)
Type of fracture	
Compression	32 (78.05%)
Burst fracture	8 (19.51%)
Compression dislocation	1 (2.44%)
Additional surgery	
Screws at the fracture level	5 (12.21%)
Vertebroplasty	3 (7.32%)
Neurologic deficit	10 (24.39%)
Duration of operation, min	189.37 ± 54.89
Time of stay in the hospital, days	6.39 ± 5.20

The most common cause of thoracolumbar fracture in the females was osteoporosis (10/18 females, 55.56 %) while falls were the most common cause in the males (7/23 males, 30.43 %). Significantly higher number of females (55.56 %) were admitted due to osteoporosis as compared to the males (17.39 %) (p=0.01). The most frequently affected vertebra in both females (6/18, 33.33 %) and males (8/23, 34.78 %) was L1. Compression was the most common type of vertebra fracture in both females (15/18, 83.33 %) and males (17/23, 73.91 %). There was no significant difference in the mean duration of operation (186.33 ± 60.13 Vs. 194.44 ± 47.85 min, p=0.28) and mean time of stay in the hospital (7.26 ± 6.64 Vs. 5.27 ± 2.29 days, p=0.06) between the males and females (Table-2).

Since the most common cause of thoracolumbar fracture was osteoporosis, the patients with osteoporosis were compared with the patients without osteoporosis. Among the patients with osteoporosis, 4/14 (28.57 %) were males and 10/14 (71.43 %) were females. The mean age of the patients with osteoporosis (69.5 ± 13.42 years) was significantly higher (p<0.0001) as compared to the patients without osteoporosis (40.80 ± 14.15 years).

Among the patients, 10/41 (24.39 %) had neurologic deficit. The postoperative conditions of these patients with neurological deficit were better. Paraplegic-operated patients did not undergo any change. Screws were implanted in the fractured segment of 5 patients. Vertebroplasty was performed in 3 patients. The kyphosis angles of the patients at the preoperative stage were 20.1, at early postoperative stage 12.4, and at first postoperative year 13.1.

The fractures occurred most commonly by major trauma in the younger patients and by minor trauma in older patients. None of the patients required screw reposition due to malposition. No significant complications developed in the early period. However, in the late-term, one patient who was operated for osteoporotic fracture had screw loosening. Loose screw and instrument were removed due to fusion in the fractured segment. Instrument was extended to one more segment and the screw system was strengthened with cement in another obese patient with osteoporosis due to pull out in the upper segment screws. In the early and late periods, the patients were examined both clinically and radiologically. The average follow-up duration after the surgery was 5 years, and it ranged from 1 year to 10 years. One patient was lost in the follow-up due to malignancy and two patients of ages 87 and 68 years were lost due to other reasons.

DISCUSSION

Thoracic and lumbar fractures are the important types of injury that affect the movement of patients. Fractures in this area can be classified according to their formation mechanisms as compression, burst, flexion-dislocation, and fracture-dislocation. Radiologically, the kyphosis angle of >30 degrees, the collapse of the vertebral body by >50 %, the contraction of the spinal canal by >50 %, and fractures causing fracture subluxation and dislocation are considered unstable [25].

The common treatment option for unstable fractures is surgery [24]. The purpose of surgery in such cases is to stabilize the spinal system [16]. Stabilization with pedicle screw is a common technique that has been used for a long time. Anterior approach became an alternative to the posterior approach or was used in combination [5,11]. In the late period, anterior approach was used less frequently owing to the advantage of applying strengthening with cement and repositioning of the bone fragments via laminectomy and minimal facetectomy as well as due to fewer complications [16,28].

Table-2. Gender wise comparison of demographic and clinical characteristics of patients (N:41)

	Males (n=23)	Females (n=18)	p value
Age (Mean ± SD)	45.56 ± 17.30	57.05 ± 20.60	0.01
Cause of admission			
Falls	7 (30.43%)	5 (27.78%)	0.85
Work accident	5 (21.74%)	1 (5.56%)	0.15
Traffic accident	5 (21.74%)	1 (5.56%)	0.15
Malignancy	1 (4.35%)	2 (11.11%)	0.41
Osteoporosis	4 (17.39%)	10 (55.56%)	0.01
Type of fracture			
Compression	17 (73.91%)	15 (83.33%)	0.47
Burst fracture	5 (21.74%)	3 (16.67%)	0.68
Compression dislocation	1 (4.35%)	0 (0%)	NA
Duration of operation	186.33 ± 60.13	194.44 ± 47.85	0.28
Time of stay in the hospital	7.26 ± 6.64	5.27 ± 2.29	0.06

Some studies have reported how short-segment fixation can give comparably good outcomes than that of long-segment fixation [1,2,3,7,9 26]. However, in the short-segment series, the average age is low and fractures due to osteoporosis are absent or fewer in number. Despite of the 55 % failure rate in the short-segment treatment, the operation is longer and there is more blood loss in the long segment. According to some articles, there is no significant difference in the results between short-segment and long-segment operations [26]. Short segment can be applied to select cases [22,27]. In fact, a series of cases with screws in the fractured segment have been reported [12,20]. The same studies reported no difference in the results between cases with screws in the fractured segment and in those without screws in the fractured segment. In the present study, screw was put in the fractured segment in five (12.2 %) of the 41 cases. Minimally invasive techniques such as thoracoscopic techniques were used as an alternative [8,18,23]. Bone strengthening has been performed with transpedicular bone graft [1,17,19]. Some studies have described good outcomes with stabilization operations using pedicle screw without fusion but with bone graft [6-7].

Majority of the spine fractures are localized to the thoracolumbar region [10]. The thoracolumbar region mostly involved is reported to be at T11 to L2 level as these regions are relatively weaker than the other parts of the thoracolumbar region [24]. In the present study also, it was found that the most commonly affected vertebra was L1 in the patients.

The causes of thoracolumbar fracture depend on patient's age. It has been reported that in younger people, it requires high impact trauma to cause a fracture but in elderly individuals even a very low grade trauma can induce thoracolumbar fractures [13]. Consistent with these reports, in the present study we observed that the fractures occurred most commonly by major trauma in the younger patients and by minor trauma in older patients. These older patients had osteoporosis in common. In the present study, it was observed that the most common cause of thoracolumbar fracture in the females was osteoporosis (10/18 females, 55.56 %) while falls were the most common cause in the males (7/23 males, 30.43 %). The elderly women who have attained menopause are at high risk of developing osteoporosis and consequently are more prone to have thoracolumbar fracture even due to a low impact trauma. This can be explained by the observation that after menopause the hormone estrogen that keeps the bones strong and healthy falls sharply [15]. Twenty to forty percent of fractures are associated with neurologic injuries [10]. Consistently, in the present study, 24.39% patients had neurological deficit.

A limitation of our study was the small number of cases. Studies on more number of patients are required to provide better objective results. Stabilization with posterior pedicle screw fixation surgical technique resulted in good outcomes and minimal complications when performed under favorable conditions. Although different methods have been developed, this method using posterior pedicle screw fixation continues to be the most common and reliable method.

CONCLUSION

This study suggests that the most common cause of thoracolumbar fracture was osteoporosis, the most common type of fracture was compression, and the most affected vertebrae was L1. Literature review suggests that stabilization with posterior pedicle screw fixation is a surgical technique with good outcomes and minimal complications when performed under favorable conditions.

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Volume: 30, Issue: 2, April 2019 pp: 139-143 ORIGINAL ARTICLE

POSTERIOR APPROACH IN TRAUMATIC THORACIC AND THORACOLUMBAR SPONDYLOPTOSIS

Ömer POLAT[1]
Mehmet SEÇER[2]
Kadir ÇINAR[3]
Murat ULUTAŞ[3]
Oğuz Durmuş KARAKOYUN[2]

[1]*Düzce University Medicine Faculty, Department of Neurosurgery, Düzce, Turkey*
[2]*Ersin Arslan Training and Reseacrh Hospital, Department of Neurosurgery, Gaziantep, Turkey*
[3]*Sanko University Konukoglu Hospital Department of Neurosurgery, Gaziantep, Turkey*

ORCID Numbers:
***Ömer POLAT*:** 0000-0003-4521-4312
Mehmet SEÇER: 0000-0001-9521-2476
Kadir ÇINAR: 0000-0002-4517-3808
Murat ULUTAŞ: 0000-0001-8156-5393
Oğuz Durmuş KARAKOYUN
0000-0002-1306-7584

Address: Dr. Ömer Polat,
Düzce University, Faculty of Medicine,
Konuralp yerleşkesi, Düzce, Turkey
Phone: +90 532 695 3088
Fax: +90 380 542 13 02
E-mail: polatnrs@gmail.com
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ABSTRACT

Objective: Traumatic spondyloptosis a 100 % or more subluxation of a vertebral unit over another inferior unit in the sagittal or coronal plane is a very rare pathology. In this study, clinical findings and follow-up results of 12 patients with spondyloptosis that occurred after a high-energy trauma were evaluated.

Material and Methods: Twelve cases with the thoracic and thoracolumbar region traumatic spondyloptosis at two separate centres in the city of Gaziantep between 2010 and 2016 were examined retrospectively. The clinical and radiological results, additional system injuries and long-term results of the patients were evaluated.

Results: The mean age of the patients (9 men and 3 women) was 30.4. The causes of trauma were falling down from a height (8 cases) and a traffic accident (4 cases). Spondyloptosis was detected at the upper thoracic level in two cases (Th3-4 and Th4-5); Th9-10, one case; Th10- 11, four cases; Th11-12, three cases and Th12-L1, two cases. Pre- and postoperative neurological status of all cases was ASIA A. In all cases, 5 levels of fixation were performed after reduction with posterior intervention. In addition, 2 patients died; specifically, one patient with thoracic trauma and one with embolism due to deep vein thrombosis at the third month post-op. Severe fusion was observed in 9 of our living patients and 1 had a moderate fusion.

Conclusion: Acute thoracolumbar spondyloptosis can only be achieved via a posterior approach. The intense intercostal area can be used for a fusion bed.

Keywords: Spondyloptosis, trauma, surgery, fusion

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Traumatic spondyloptosis is a very rare pathology that is defined as a 100 % or more subluxation of a vertebral unit over an inferior unit in the sagittal or coronal plane following high-energy trauma, such as a traffic accident or falling down from a height. Generally, together with dural tear, it causes complete transection of the spinal cord, paraplegia, and additional organ injuries, resulting in death [4,6,8,11,15].

Correction of vertebral alignment and stabilisation can be provided via an anterior or posterior approach or a combination thereof. Correction of traumatic spondyloptosis affecting the thoracic vertebrae via only the anterior approach has difficulties (e.g., failure to repair dural tear and failure to provide reduction), and it may also cause morbidity and complications [10]. It may be necessary to add a posterior approach due to accompanying fracture and/or compression in adjacent or non-adjacent vertebrae.

Unfortunately, these patients have to live with permanent neurological deficits as the integrity of the spinal cord is impaired, and their treatment management is very important. The treatment is primarily targeted towards resolving the pulmonary complications arising due to the thoracic trauma, correcting vertebral alignment, repairing dural tear as well as achieving stabilisation and fusion [4,8,10]. As long-segment stabilisation is usually required, insufficient fusion during rehabilitation may cause implant dysfunction, and additional interventions may be required.

In this study, we retrospectively examined cases with traumatic thoracic and thoracolumbar spondyloptosis, where the vertebral alignment was corrected via the posterior approach only and stabilisation was achieved using pedicle screws.

MATERIALS AND METHODS

Twelve cases with traumatic thoracic and thoracolumbar spondyloptosis from three separate centres in the city of Gaziantep between 2010 and 2016 were examined retrospectively. In the images obtained through preoperative sagittal and coronal reconstruction, these cases where a vertebra shifted over an adjacent vertebra with a degree of 100 % or more **(Figure-1)** were evaluated as traumatic spondyloptosis [4,6,8,10-11,15]. Age, sex, trauma patterns, neurological status, additional organ injuries as well as factors causing morbidity and mortality were analysed retrospectively. Management of the cases, preoperative computed tomography (CT) and magnetic resonance imaging (MRI), and their CT taken during postoperative follow-up were evaluated. The American Spinal Injury Association (ASIA) scoring was used to determine the neurological deficit of all cases with spinal trauma, while the thoracolumbar injury classification and severity (TLICS) scale was used to determine the severity of trauma [12]. For evaluation of posterolateral fusion, the classification of no fusion, mild (less than 50 %), moderate (more than 50 %), severe (100 % fusion), suggested by Lowery et al., [7] was used.

RESULTS

The mean age of the patients (9 men and 3 women) was 30.4. The causes of trauma were falling down from a height (8 cases) and a traffic accident (4 cases). Spondyloptosis was detected at the upper thoracic level in two cases (Th3-4 and Th4-5); Th9-10, one case; Th10- 11, four cases; Th11-12, three cases and Th12-L1, two cases. In one case with Th10-11 spondyloptosis, burst fracture and traumatic spondylolisthesis was detected at L1 in addition to fragmented fractures of the T10 and T11 vertebrae. The TLIC score was 8 in all cases (3 morphology, 3 posterior ligamentous complex, and 2 complete transection of the cord). The pre- and postoperative neurological status of all cases was ASIA grade A. Six patients without additional organ injury were operated within the first 2 hours. The 6 patients with polytrauma were operated within 10 days after haemodynamic improvement; in them, spinal injury was accompanied by pneumothorax, haemothorax, lung contusion, head trauma, extremity fractures and/or intraabdominal injury. After emergency medical intervention, especially for thorax and abdominal injuries, surgical procedures were performed for spondyloptosis **(Table-1).**

Table-1. Patients' clinicodemographic data.

Case No	Age Sex	Causal İnjury	Level	Dural Tear	Additional Injury	Treatment	Follow-up	Result	Fusion
1	27 F	Fall From height	Th 10-11	Present	-	Th9-L1 PSF	6 years	NI	Intense
2	50 M	Fall From height	Th 10-11	Present	Head trauma, pneumo-thorax	Th9-L1 PSF	5 years	NI	Intense
3	26 M	Fall From height	Th 3-4	Present	Pneumo-throax	Th2-6 PSF	4 years	NI	Intense
4	24 M	Fall From height	Th 9-10	Not Present	-	Th8-12 PSF	3 years	NI	Intense
5	27 M	Traffic accident	Th 12-L1	Not Present	-	Th11-L3 PSF	3 years	NI	Intense
6	32 M	Fall From height	Th 10-11	Present	Burst, calcenous fracture at L1 vertebra	Th8-L3 PSF	3 years	NI	Intense
7	31 M	Fall From height	Th 12-L1	Present	-	Th11-L3 PSF	2 years	NI	Intense
8	32 M	Traffic accident	Th 11-12	Not Present	Femur fracture	TH10-L2 PSF	2 years	NI	Intense
9	30 M	Fall From height	Th 11-12	Not Present	-	TH10-L2 PSF	2 years	NI	Intense
10	31 M	Traffic accident	Th 10-11	Present	-	Th9-L1 PSF	1 year	NI	Moderate
11	30 F	Fall From height	Th 11-12	Present	Retro-peritenal bleeding, pelvis fracture	TH10-L2 PSF	1 month	Death	None
12	25 F	Traffic accident	Th 4-5	Present	Hemo-thorax, pneumo-throax and lung contusion	Th3-7 PSF	3 months	Death	None

NI: No improvement

Reduction and stabilization

In all cases, reduction, decompression and stabilisation were achieved via the posterior approach only **(Figure-1).**

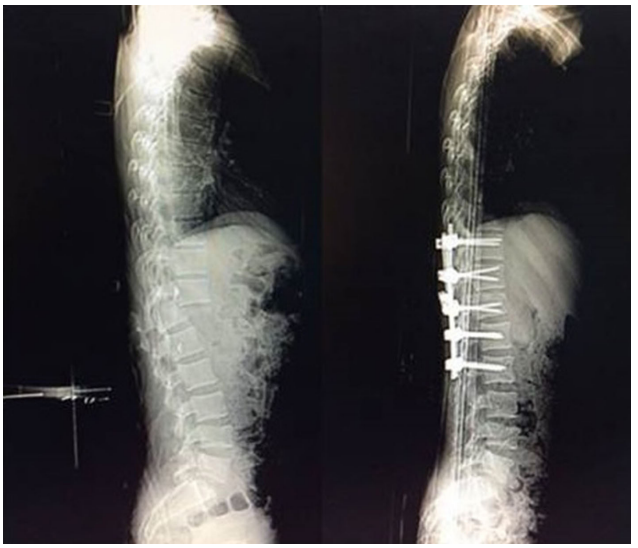

Figure-1. Spondyloptosis at Th 11-12 level.

First, pedicle screws were placed in the cranial and caudal vertebrae at the spondyloptosis level. In order to move the caudal and cranial vertebrae of the spondyloptosis level in a block-like manner, a rod was secured to each screw in the caudal and cranial region on both sides. Reduction was achieved through traction and rotation movements, if necessary, in simultaneous and block-like manner, of the cranial and caudal vertebrae bilaterally using scopy with the help of the rod holders. The facts that all three columns were damaged and that there was no delay in treatment were the most important factors facilitating realisation of reduction. After reduction was achieved, while the vertebrae were kept aligned with the help of two separate rods, the rods on the opposite sides were removed and a single long rod was secured. After unilateral stabilisation was realised, the rods on the other side were removed and replaced by a single rod. After ensuring reduction and stabilisation, laminectomy was performed for decompression. Eight cases had dural laceration, and there was either complete or almost complete transection of the spinal cord. Laminectomy was widened until normal dura was observed, and dura repair was performed in a water proof manner. The facet joints and ribs were decorticated and autografts (laminectomy and iliac wing-derived autograft) were laid on these wide fusion areas. Low- molecular-weight heparin was administered 24 hours postoperatively, they were put on anti- emboligenic surgical stocking and an in-bed rehabilitation program was started at early stage. In 11 cases where corpus integrity at the spondyloptosis level was preserved, 5 levels including the ptotic segment were fixated. In one case, 8 levels were fixated as there was an instable fracture in 2 vertebrae below the ptotic level.

One patient with haemothorax, pneumothorax and lung contusion died of lung infection and acute respiratory distress syndrome that developed while he was being followed up postoperatively with prolonged respiratory support, and one patient died of embolism associated with deep vein thrombosis third month postoperatively. In the other 10 cases, the follow-up period ranged from 1 year to 6 years Problems related to spinal instrumentation (loosening, screw or rod breakage) were not observed in cases where only the posterior approach was used. In the living patients, severe fusion was observed in 9 and moderate fusion in one **(Figure-2).**

Figure-2. Thoracic spondyloptosis where fusion developed posterolaterally at the 24th month.

DISCUSSION

Traumatic thoracic and thoracolumbar spondyloptosis is very rare and results in a permanent and complete neurological loss below the level of trauma. Often accompanied by thoracic injury, it may cause additional morbidity or even death. It should be ensured that cases with persistent neurological deficit become self-sufficient with rehabilitation and education to adapt to their new lives. Therefore, managing these cases in a hospital is very important.

Performing restoration of vertebral alignment, decompression, and achievement of fusion by stabilisation through repair of the dural injury and instrumentation in a single session is very important [4,8,10]. Usually, long-segment stabilisation is required; and because development of a deformation due to pseudoarthrosis and insufficient reduction requires additional surgical interventions, the success of the first surgery is very important for the quality of the new and disabled life style of these patients. Our study showed that thoracic and thoracolumbar spondyloptosis can be stabilised through reduction via the posterior approach in a single session. The intense intercostal area can be used for a fusion bed.

Traumatic spondyloptosis cases are categorised as fracture dislocation according to the Dennis spinal fracture classification, and they are considered unstable as all 3 columns are affected [5,8]. The aim of management of spondyloptosis is reduction, restoration of alignment and stabilisation [3,9]. For this purpose, reduction via the posterior approach only and stabilisation, corpectomy with anterolateral approach and anterior support, spondilectomy from posterior and posterior stabilisation are the surgical approaches [1-2,13-15]. There is no consensus in the literature on which approach should be used. Ramizadeh et al. reported that classifying a case as correctable or uncorrectable is important in determining the approach. They reported that in correctable cases, reduction can be easily achieved by performing distraction with posterior approach; but this approach is insufficient in chronic cases, where serious adhesion and scar tissue develop in uncorrectable spondyloptosis [9]. Because all of our patients had acute spondyloptosis and all the ligaments were damaged, reduction could be achieved through bilateral manipulation of the cranial and caudal vertebrae of spondyloptosis in a single session.

While some authors suggest stabilisation at 2-level below, 2-level above in traumatic spondyloptosis cases [8], some others suggest stabilisation at 3-level below, 3-level above [10]. Mishra et al. used posterior approach in 19 of 20 patients with spondyloptosis and placed corpectomy cage after transpedicular corpectomy in 7 patients [8]. There is controversy about whether or not corpectomy is needed before or after reduction in the treatment of traumatic spondyloptosis, how many levels should be included in stabilisation, the need for anterior support. For this reason, the patient's neurological damage level, level of spondyloptosis, presence of multilevel vertebra fractures accompanying spondyloptosis and post-traumatic time as it primarily leads to tissue healing and even development of abnormal fusion are very important in determining what approach should be followed.

Between 80 % and 100 % of spondyloptosis cases are associated with complex neurological deficits [8,11]. All of our patients had complex neurological deficits below the level of trauma. An in-bed rehabilitation program should be initiated primarily because of patients' limited mobility, long hospital stay and continuous bed rest. We believe that this measure prevents formation of a vectorial pressure that could lead to an implant failure. Therefore, posterior transpedicular stabilisation can provide adequate stabilisation for fusion development with the need for anterior support.

Interbody and posterolateral fusion facilitates arthrodesis [9]. In our patients, since spondyloptosis was present in the thoracic region, the intensely vascularised posterolateral intercostal region contributed to the formation of a large area for fusion. The thoracic vertebrae have less facet surface than the lumbar vertebrae. For this reason, in instabilities such as spondyloptosis especially where all three columns are damaged, formation of fusion in addition to achieving stabilisation is the most critical issue and it requires additional surgical procedures to obtain intervertebral fusion. With laminectomy and iliac wing-derived autografts, formation of fusion at posterolateral and intercostal distances to the thoracic vertebrae was achieved with the need of additional surgery. In our patients, corpus integrity at the spondyloptosis level was preserved in 11 cases, and 5 levels including the ptotic segment were fixated. In one case, 8 levels were fixated as there was an instable fracture in 2 vertebrae below the ptotic level.

Conclusion

Acute thoracolumbar spondyloptosis can only be achieved via a posterior approach. The intense intercostal area can be used for a fusion bed. This single-seam surgery can provide early mobilization and quality of life for patients.

Conflict of Interest Statement

The authors declare there are no conflicts of interest-financial or otherwise-related to the material presented here in.

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Volume: 30, Issue: 2, April 2019 pp: 145-149 CASE REPORT

MULTIPLE SPINAL METASTASIS OF COLORECTAL ADENOCARCINOMA; CASE REPORT AND LITERATURE REVIEW

Muhittin Emre ALTUNRENDE[1]
Elif Evrim EKİN[2]

[1]*Health Science University, Clinic of Neurosurgery, GOP Taksim Training and Research Hospital, İstanbul*

[2]*Health Science University, Department of Radiology, GOP Taksim Training and Research Hospital, İstanbul.*

ORCID Numbers:
Muhittin Emre ALTUNRENDE: 0000-0003-3345-5821
Elif Evrim EKİN: 0000-0003-1290-6291

Address: Muhittin Emre ALTUNRENDE, MD, University of Health Sciences, GOP Taksim Training and Research Hospital, Neurosurgery, Istanbul, Turkey,
Phone: +90 5323623854,
E-mail: mealtunrende@msn.com
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ABSTRACT

Gastrointestinal adenocarcinomas are very aggressive tumors. In the later stages of the disease, widespread metastases may occur. Bone metastases of colorectal cancers are usually osteolytic lesions. Multiple spinal metastases are very rare at the stage of diagnosis. We present a case of colorectal adenocarcinoma with multiple spinal metastasis which was operated due to C7 cervical pathological compression fracture and accompanied by literature review.

Keywords: Colorectal adenocarcinoma, cervical spine, metastasis, surgery

Level of Evidence: Case report, Level IV.

INTRODUCTION

Metastases constitute the majority of spinal cancers [22]. Spinal vertebrae metastasis, cysts, pathological fracture could make spinal cord compression, persistent pain, sensory deficit, and / or paralysis [2,26-27]. Operations in these patients are palliative and are usually done for symptomatic relief [1,18,24]. Gastrointestinal metastatic spinal lesions are aggressive tumors and mean survival after diagnosis is 2.6 months [18]. Colorectal cancer metastasis are regional lymph nodes, liver, lung, and the peritoneum [7,11,14,15,19,21]. Bone metastases of colorectal cancers are rare especially multiple ones and usually shows osteolytic form. Spinal metastases frequency; lumbar 36 % to 75 % and thoracic spine 17 % to 61 %, followed by sacral 6 % to 35 % and cervical vertebrae 2 % to 7 % [7-8,12,16,23]. Approximately 16 % of patients with spinal metastasis have a pathological compression fracture and spinal cord compression [20]. A case of colonic adenocarcinoma operated for multiple spinal metastasis and C7 cervical pathological compression fracture was presented with a literature scan. In this case, adenocarcinoma which is widespread in the body has been detected in the advanced tests performed as a result of pathological compression fracture in C7.

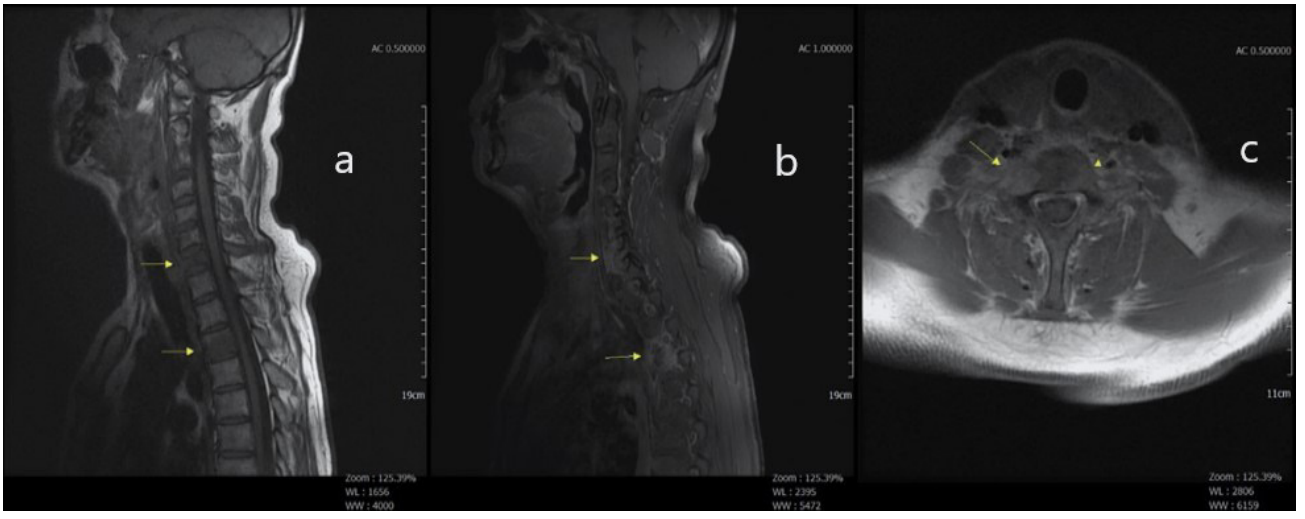
CASE REPORT

A 51- year old man presented to our emergency department with neck pain and right arm weakness. Neurological examination revealed increased reflexes, monoparesis in the right upper extremity. He hasn't got trauma history. These findings were compatible with upper motor neuron disease, cervical disc pathology. Whole spine magnetic resonance imaging (MRI) and cervical spine computed tomography (CT) studies showed a lesion which was invading and destructing C7 vertebral body, narrowing the spinal channel and compressing the spinal cord (Figure-1 and 2).

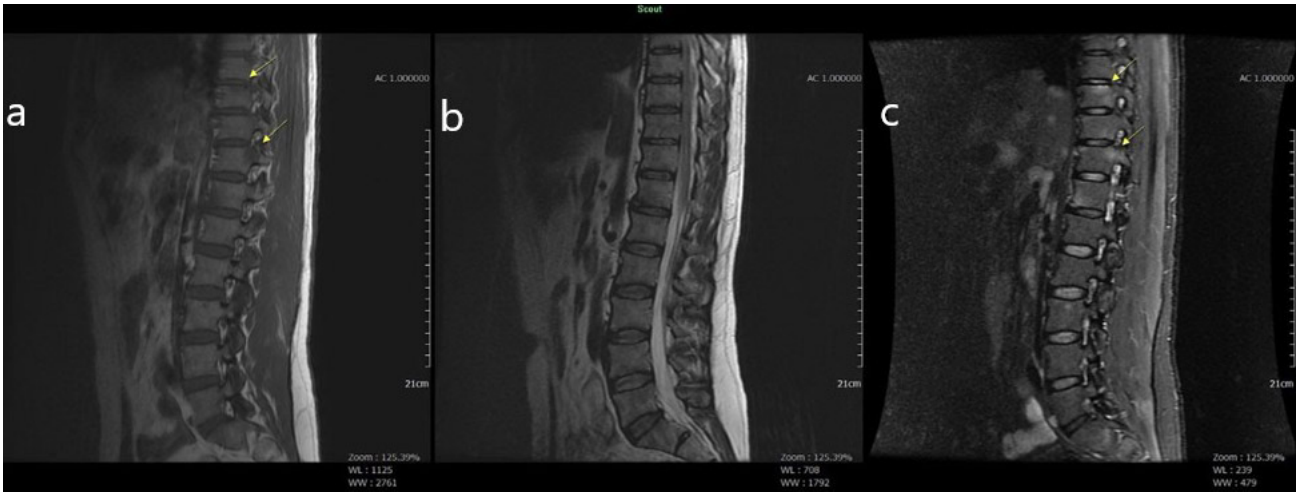
Our differential diagnosis was included primary bone tumor and metastatic tumor. All spinal MRI showed compression fracture in C7 vertebrae, diffuse bone marrow edema and posterior contrast mass in the right lateral vertebral body. In addition, extensive bone marrow edema was observed in T3, T5, T6, T10, T12, L1, L4, L5 vertebrae corpus and diffuse homogeneous enhancement in

post contrast series. In the differential diagnosis, the first line of metastasis is considered, but there are active schmorl nodules, Anderson lesions and seronegative spondyloarthropathies. In abdominal and thorax CT examinations performed for metastatic tumor, irregular tumoral wall thickness increase along the 6 cm segment starting from 2 cm proximal to the anal tax and spicular extension to perirectal oily planes were observed. The largest in the liver was 2 cm in diameter and metastatic foci in the right lung. C7 metastasis-associated pathological compression fracture confirmed patient underwent anterior cervical corpectomy and stabilization operation. Histopathological examination revealed a metastatic lesion of adenocarcinoma. The patient was discharged 1 week later with his deficit improved.

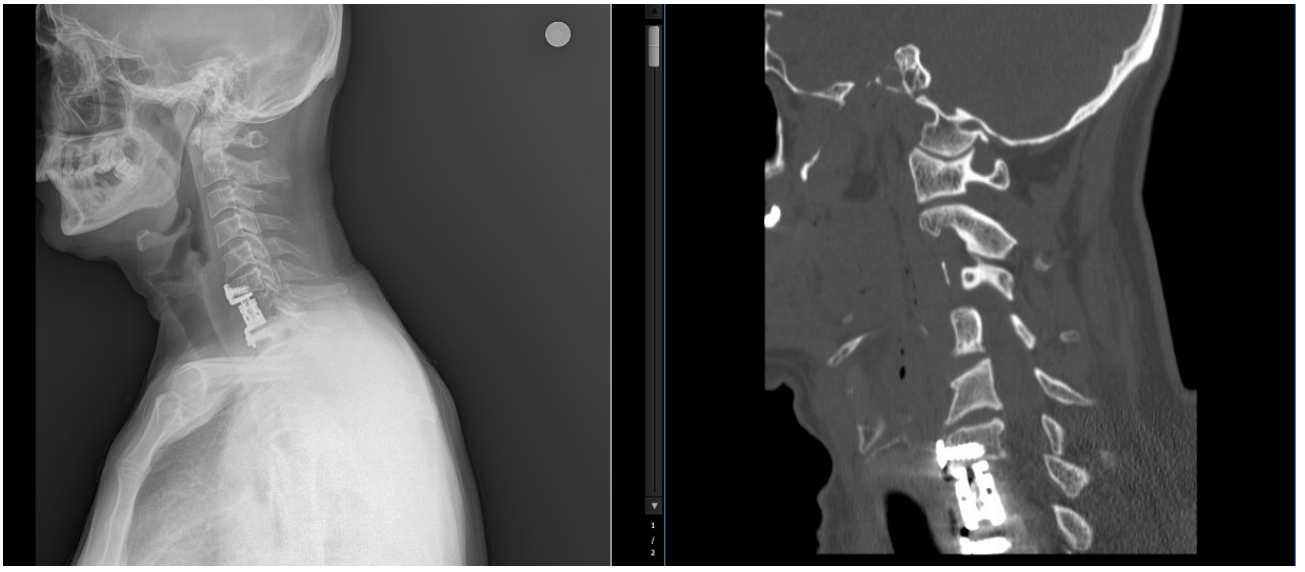
Figures-1. (a) Sagittal reformat of CT scan shows that C7 compression fracture. Other cervical vertebral corpus are preserved. **(b)** Vertebral corpus destruction is diagnosed on axial CT image at the level of C7 vertebra.



Figures-2. (a) Midsagittal T1-W MRI shows that C7 compression fracture and loss signal of C7 and third thoracic vertebras. **(b)** Parasagittal postcontrast T1-W MRI, the neural foramens are obliterated with soft tissue. **(c)** Postcontrast transverse T1-W MRI, the right neural foramen is obliterated with soft tissue and seen destruction of C7 corpus.



Figures-3. Lumbar spine of the same patient, **(a)** parasagittal T1-W MRI, multiple hypointense metastatic lesions are seen. **(b)** Midsagittal T2-W MRI, no sign of compression fracture or soft tissue mass. **(c)** Parasagittal STIR MRI sequance, multiple hyperintense metastatic lesions are seen.



Figures-4. (a) Lateral cervical spine radiography, anterior cervical corpectomy, and fusion with instrumentation and loss of cervical lordosis are seen. **(b)** Parasagittal reformate CT, postoperative instrumentation materials are demonstrated.

DISCUSSION

Previously reported colorectal-induced spinal metastases were located in the sacrum and thoracic spine, mainly in the lumbar spine [14,20,23]. Metastasis was thought to be the result of direct vascular access from the pelvis [25]. It is thought to be responsible for spinal metastases of the vertebral venous plexus defined by Batson in 1940 and shown using radiographic methods by contrast material by Coman and Delong [5,10]. By this mechanism, it is likely that prostate cancer will often spread to the lumbar spine and sacrum [12]. Cervical spine metastases have not been identified as a common in colorectal carcinoma and are not likely to occur with vertebral plexus of Batson in the absence of lumbar spine or sacral metastasis [12]. Bayraklı et al. reported a case of colon cancer that metastasized to the cervical spine without metastasizing to the liver and regional lymph nodes [6]. In our case, there was liver, lung and diffuse vertebral spread. Despite widespread involvement, the patient's right arm was diagnosed after pain and weakness. Colorectal adenocarcinoma usually has insidious onset and indicates progressive. Advances in medical treatment have improved survival in patients with

colorectal metastasis. However, long survival caused an increase in bone metastasis [17].

Radiotherapy and / or chemotherapy have limited benefit in gastrointestinal metastases. Several studies have shown that only a small number of patients with colorectal origin of metastatic spinal disease gain benefit only after chemo-radiotherapy treatment [25]. However, as adjuvant therapy, these modalities play an important role in the treatment of these patients [13]. Vertebroplasty and radiotherapy are alternatives for patients with a presumed short survival or those who cannot tolerate surgery [26].

The main objectives of surgery in patients with spinal metastasis are pain reduction, prevention of neurological deficit, protection and recovery of spinal stability.

In the literature, there are few case reports and small case series evaluating the surgical treatment of these patients [4,9,23,25]. Leach et al. reported that long-term survival and symptomatic recovery were possible in some cases with metastatic spinal lesions of colorectal origin, but survival was poor in most cases [17]. In our case, there was pain and monoparesis in the right arm due to C7 compression fracture. In the advanced radiological imaging, widespread spinal metastases as well as extensive organ metastases were detected. The patient underwent corpectomy and stabilization with anterior approach and improved his neurological deficit and mobilization.

In conclusion, in patients with metastatic spinal fractures with or without neurological deficits, radiographically imaging should not be limited with a single region, whole spinal column should be screened. It should be kept in mind that surgical decompression and stabilization contribute to mobilization and quality of life, especially in patients with neurological deficits.

Conflict of interest:

The authors declare that there are no conflicts of interest.

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MEA wrote and prepared the manuscript, and all of the authors participated in the study design. All authors have read, reviewed, and approved the article.

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