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Corresponding Address:
İ. Teoman BENLİ
Okan University Hospital, Aydıntepe Caddesi, N: 2, 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 rationale for the study. Authors should convey to readers the unique aspects of their reviews which distinguish them from other available material (e.g., monographs, book chapters). The main subject should be emphasized

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

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

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

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

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

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

- Introduction (250 – 750 word): It should contain information on historical literature data on the relevant issue; the problem should be defined; and the objective of the study along with the problem solving methods should be mentioned. The Introduction, although typically is the shortest of sections, perhaps the most critical. The Introduction must effectively state the issues and formulate the rationale for those issues or questions. Its organization might differ somewhat for a clinical report, a study of new scientific data, or a description of a new method. Most studies, however, are published to: (1) report entirely novel findings (frequently case reports,

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

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

to choose a level of alpha of 0.05 and a beta of 0.80, these levels are somewhat arbitrary and not always appropriate. In the case where the implications of an error are very serious (e.g., missing the diagnosis of a cancer), different alpha and beta levels might be chosen in the study design to assess clinical or biological significance.

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

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

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

- References: Care must be exercised to include references that are available in indexes. Data based on personal communication should not be included in the reference list. References should be arranged in alphabetical order and be cited within the text; references that are not cited should not be included in the reference list. The summary of the presentations made at Symposia or Congresses should be submitted together with the manuscript. The following listing method should be used. References should derive primarily from peer-reviewed journals, standard textbooks or monographs, or well-accepted and stable electronic sources. For citations dependent on interpretation of data, authors generally should use only high quality peer-reviewed sources. Abstracts and submitted articles should not be used because many in both categories ultimately do not pass peer review. They should be listed at the end of the paper

in alphabetical order under the first author's last name and numbered accordingly. If needed, the authors may be asked to provide and send full text of any reference. If the authors refer to an unpublished data, they should state the name and institution of the study, Unpublished papers and personal communications must be cited in the text. For the abbreviations of the journal names, the authors can apply to "list of Journals" in Index Medicus or to the address "http://www.nlm.nih.gov/tsd/serials/lji.html".

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

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

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

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

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

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

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

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

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

- Figures: All figures should be numbered consecutively throughout the text. Each figure should have a label pasted on its back indicating the number of the figure, an arrow to show the top edge of the figure and the name of the first author. Black-and-white illustrations should be in the form of glossy prints (9x13 cm). The letter size on the figure should be large enough to be readable after the figure is reduced to its actual printing size. Unprofessional typewritten characters are not accepted. Legends to figures should be written on a separate sheet of paper after the references. The journal accepts color figures for publication if they enhance the article. Authors who submit color figures will receive an estimate of the cost for color reproduction. If they decide not to pay for color reproduction, they can request that the figures be converted to black and white at no charge. For studies submitted by electronic means, the figures should be in jpeg and tiff formats with a resolution greater than 300 dpi. Figures should be numbered and must be cited in the text

- Style: For manuscript style, American Medical Association Manual of Style (9th edition). Stedman's Medical Dictionary (27th edition) and Merriam Webster's Collegiate Dictionary (10th edition) should be used as standard references. The drugs and therapeutic agents must be referred by their accepted generic or chemical names,

without abbreviations. Code numbers must be used only when a generic name is not yet available. In that case, the chemical name and a figure giving the chemical structure of the drug should be given. The trade names of drugs should be capitalized and placed in parentheses after the generic names. To comply with trademark law, the name and location (city and state/country) of the manufacturer of any drug, supply, or equipment mentioned in the manuscript should be included. The metric system must be used to express the units of measure and degrees Celsius to express temperatures, and SI units rather than conventional units should be preferred. The abbreviations should be defined when they first appear in the text and in each table and figure. If a brand name is cited, the manufacturer's name and address (city and state/country) must be supplied. The address, "Council of Biology Editors Style Guide" (Council of Science Editors, 9650 Rockville Pike, Bethesda, MD 20814) can be consulted for the standard list of abbreviations.

Dear Colleagues,

We sincerely wish the happy and healthy summer to all my colleagues and their families. We are happy to accomplish the third issue of 2018.

There are 11 clinical research articles in this issue. These are two experimental studies about the epidural fibrosis. In the third study, the results of cerebral palsy scoliosis were presented. Forth study is about sagittal plane in spinal deformity. In next three article, effects of obesity on elective spinal surgery, intracranial complications of lumbar spinal surgery, and early radiological imaging following spinal fusion operations has been discussed. Seventh study is about spinal anesthesia for elective lumbar spine surgery. In eighth study, effect of radiotherapy on postlaminectomy low back syndrome is presented. Last two article are about the lumbar disc herniation. We believe that all those studies will quietly interest the readers.

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

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

Prof. Dr. İ. Teoman BENLİ
JTSS Editor

EDITORIAL

ORIGINAL ARTICLES

EXPERIMENTAL ANIMAL STUDIES

NEUROMUSCULAR SCOLIOSIS

SAGITTAL PLANE

RISC FACTORS OF SURGICAL TREATMENT

COMPLICATIONS OF SURGICAL TREATMENT

SPINAL ANESTHESIA

LOW BACK PAIN

MINIMALLY INVASIVE SURGERY FOR SPINAL STENOSIS

RECURRENT DISC HERNIATIONS

Volume: 29, Issue: 3, July 2018 pp: 133-140 ORIGINAL ARTICLE

PIRFENIDONE ATTENUE EPIDURAL FIBROSIS IN RATS BY SUPPRESSING TNF-α , IL-1, AND α-SMA

Yahya GÜVENÇ[1],
Deniz BILLUR[2],
Pınar BAYRAM[3],
Yaşar ÖZTÜRK[4],
Mesut Emre YAMAN[5],
Sevim AYDIN[2],
Erkan KAPTANOĞLU[1]

[1] *Marmara University, School of Medicine, Department of Neurosurgery, İstanbul, Turkey*

[2] *Department of Histology and Embryology, Ankara University School of Medicine, Ankara, Turkey.*

[3] *Kafkas University School of Medicine, Department of Histology and Embryology, Kars, Turkey*

[4] *Yenimahalle Training and Research Hospital, Department of Neurosurgery, Ankara, Turkey*

[5] *Gazi University, School of Medicine, Department of Neurosurgery, Ankara, Turkey*

ORCID Numbers:
Yahya GUVENC:
0000-0002-4813-0854
Deniz BILLUR:
0000-0001-8541-8251
Pınar BAYRAM:
0000-0001-9924-7051
Yaşar ÖZTÜRK:
0000-0003-0923-5941
Mesut Emre YAMAN:
0000-0003-0049-1316
Sevim AYDIN:
0000-0003-2445-2346
Erkan KAPTANOĞLU:
0000-0002-9945-8817

Address: Yahya Güvenç,
Marmara University, School of Medicine, Department of Neurosurgery, Basıbuyuk Healt Campus, Maltepe, Istanbul, Turkey.
Phone: +90 505 899 46 39
E-Mail: dr.yahyaguvenc@gmail.com
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ABSTRACT

Aim: Postlaminectomy epidural fibrosis is implicated as a main case of failed back surgery syndrome and associated with increased risk of complications during revision surgery. Various materials or drugs have been used to inhibit formation of epidural fibrosis and reduce the compressive effect on neural structures. Nevertheless, the effects are not satisfied.

Pirfenidone is a broad-spectrum anti-inflammatory and anti-fibrotic molecule that has been shown to inhibit the fibrosis progression in patients with idiopathic pulmonary fibrosis and animal models. Anti-fibrotic mechanism of pirfenidone is associated with antagonism of activities mediated by TNF-α and TGF-B. In present study, pirfenidone was studied to investigate its anti-fibrotic effects on reducing epidural fibrosis after laminectomy in a rat model.

Methods: Thirty two Wistar albino rats were divided randomly into four equal groups: control spongostan, systemic pirfenidone and local pirfenidone groups. In all groups, total L3-L5 laminectomy was performed. At 4 weeks postsurgery, the animals euthanized and their tissue samples at the laminectomy site were assessed both immunohistochemistry of anti-IL-1, anti- TNF-α and anti-α-SMA antibodies on epidural fibrosis of animal groups and histological evaluation for; dura thickness, epidural fibrosis grading, scar tissue consistency and inflammatory response grading and presence of arachnoid involvement. All data was evaluated by statistically.

Results: Our data suggests that rats treated with pirfenidone at 4 weeks post-laminectomy had less , dura thickness, epidural fibrosis, scar tissue consistency and inflammatory response and arachnoidal involvement in comparison with the control and spongostan groups. Pirfenidone treated groups show weaker labeling for anti-IL-1, anti- TNF-α and anti-α-SMA antibodies than control and spongostan groups. Moreover, the local applicaton of pirfenidone had shown better results than systemic administration for all parameters.

Conclusion: The results of our study suggested that pirfenidone has anti-fibrotic effects on epidural fibrosis, its effectiveness especially increased when it is used locally.

Keywords: Laminectomy, epidural fibrosis, pirfenidone, immunohistochemistry IL-1, TNF-α, α-SMA

Level of Evidence: Experimental animal study, Level-II

INTRODUCTION

Laminectomy for treating spinal disorders often results in formation epidural fibrosis and it can lead to failed back surgery syndrome and persistent back and leg pain [(23)]. Epidural hematoma, epidural fat accumulation and muscle invasion induce fibroblasts activity thus, formation of epidural fibrosis occur at the laminectomy site after operation[(21)]. Surgical methods and biological, non-biological materials for the prevention of epidural fibrosis have been studied however clearly results has not been obtained from this studies. Preventing EF formation is considered the best approach to manage this problem.

During the last decades, studies have been focus on inflammatory process and fibroblast apoptosis.

Pirfenidone (PFD) (5-methyl-1-phenyl-2-[1H]-pyridone) has both anti-inflammatory and antifibrotic effects, acting through the regulation of tumor necrosis factor (TNF-α) and (TNF-β) pathways [17]. Some studies have shown that pirfenidone inhibits proliferation and activation of fibroblasts so it inhibit the pathogenesis of fibrosis [9,13,22]. Pirfenidone has been used treatment of idiopathic pulmonary fibrosis in some country. It's efficacy has been showed for Crohn's disease and intestinal fibrosis on the experimental studies [12,14].

In present study, pirfenidone was studied to investigate its anti-fibrotic effects on reducing epidural fibrosis after laminectomy in a rat model.

MATERIAL AND METHODS

Animals

Adult, male, 32 Wistar Albino rats (mean weight = 280 g) were used for this study. The experimental part of the study was conducted at the Ankara Training and Research Hospital laboratory after obtaining consent from the Ankara Training and Research Hospital Animal Experiments Local Ethics Committee. All subjects were kept under stable and standard environmental conditions during the experiment and were fed on standard animal food and water.

Operative procedure

Each animal underwent an laminectomy. Surgery was conducted with the animals under general anesthesia using xylazine (10 mg/kg, Rompun, Bayer, Turkey) and ketamine hydrochloride (50 mg/kg, Ketalar, Parke Davis, Turkey) administered intraperitoneal. Rats were placed in the prone position. The lumbar area of the rat was shaved. The surgical field was then prepared in a sterile manner using povidone-iodine solution. The surgical site was then draped in a standard fashion. All of the operative procedures were performed carefully using a surgical microscope (Zeiss OPMI- Carl Zeiss Meditec Company, Oberkochen, Germany) by the same surgeon (YG) . A longitudinal mid-line skin incision was made over the L3-L5 levels and carried down to the spinous process. The L5 lamina was identified by counting up from the sacrum.

The lumbosacral fascia was then incised and the paraspinal muscles were subperiosteally detached to expose laminae. At the L3-L5 level total laminectomy was performed. The ligamentum flavum and epidural fat were removed. The dura mater was fully exposed and the hemostasis was obtained by using cotton sheet. The laminectomy site were treated with different agents. In control and systemic drug administration groups, only laminectomy was carried out. Following that, the dorsal spinous fascia was reposed using absorbable suture, whereas the wounds were closed in anatomical layers using the same suture material (prolen polypropylene sutures, Ethicon, Ethicon endo – surgery, Inc., Cincinnati, OH, USA). There were no complication, wound infections or ant adverse effect s observed relevant to pirfenidone. The animals were euthanized on the 4 weeks post operative day using a lethal dose of pentobarbital (60 mg/kg, IE. Ulagay, Istanbul, Turkey).

Experimental Groups

All rats were randomly divided into four groups. Control group (n=8): only laminectomy was performed without treatment; Spongostan group (n=8): a spongostan (Ethicon Endo-Surgery, Inc.) soaked with 2cc/kg saline solution and was left on the dura mater after laminectomy. Systemic (S) Pirfenidone group (n=8): Pirfenidone was given 25 mg/kg/d via oral gavage. Local (L) Pirfenidone group (n=8): 25 mg/kg/d pirfenidone was locally applied with a spongostan soaked with 0,5 ml of the solution and was left on the dura mater.

Tissue processing

The tissue samples at the laminectomy site were harvested after the rats were euthanized. Specimens were fixed in phosphate buffered 10% formalin for one week. Then tissue washed in tap water and decalcified in 25% formic acid for 3 days. Tissue were then washed in tap water and this was followed by dehydration; immersion in 70%, 80%, 90% and 100% ethanol. After dehydration tissues were cleared in xylene and embedded in paraffin wax.

Histological analysis

- Light Microscopic Evaluations

Sections were cut in 5 μm thickness using a microtome (Leica RM 2125RT) and stained with Masson's trichrome. Slides were examined and photographed using an Axio Scope-A1 (Carl Zeiss, Germany) microscope at x100 magnification. All sections were evaluated in a blinded manner by the same histologist, who analyzed dura thickness, epidural fibrosis, arachnoid involvement, scar tissue consistency and inflammatory response

Dura thickness were measured using the Axiovision software program at the three predetermined segments that previously described by Cemil et al [4]. Epidural fibrosis was graded according to the method of He *et al* [8] (Table-1).

The scar tissue consistency and inflammatory response were graded using the scoring system proposed by Miyamoto *et al* [15]. These researchers used a 4-point scoring system (Table -2).

Involvement of the arachnoid layer with the presence of arachnoidal adhesions to the dura mater was also noted.

Table-1. Epidural fibrosis grading table.

Grade	Explanation
0	Dura mater was free of scar tissue
1	Only thin fibrosis bands between the scar tissues and the dura mater were observed.
2	Continuous adhesion was observed but made up less than two-thirds of the laminectomy defect
3	Scar adhesion was large and involved more than two-thirds of the laminectomy defect, and/or extended to the nerve roots.

Table-2. Scar tissue consistency and inflammatory response grading table.

Grade	Explanation
0	loose connective tissue with small collagen bundles, the presence of highly vascular adipose tissue, with moderate macrophage and inflammatory cell activity
1	connective tissue density, edges of defect with evidence of new bone formation, and mild macrophage and inflammatory cell activity.
2	dense connective tissue and/or fibrocartilage, absence of adipose tissue, avascular tissue, and absence of macrophage and inflammatory cell activity
3	dense collagenous connective tissue, absence of adipose tissue, avascular tissue, and absence of macrophage and inflammatory cell activity

Immunohistochemistry

For immunohistochemistry analysis, sections were deparaffinized and rehydrated by using xylen and a graded series of ethanol, followed by 5 min washes in phosphate buffered saline (PBS). Antigen retrieval was performed in tripsin at 37°C for 30 min and washed in PBS for 3x5 min. Afterwards, the sections were incubated for 15 min in 1% H_2O_2 in methanol to block endogenous peroxidase activity, washed in PBS for 3x5 min, blocked at room temperature for 30 min by using blocking solution (Histostain Plus Kit, 85-9043, USA) and incubated in a humidified chamber 1 h at 37°C with the primary antibodies anti - α-SMA (1:200;A5228 mouse monoclonal,Sigma Aldrich), Anti-IL-1 β (1:200, SC-7884 rabbit polyclonal,Santa Cruze), anti TNF- α (1:200, SC-1350, goat polyclonal, Santa Cruz). Sections were washed in PBS (3×5 min) and incubated at room temperature for 1 h with the biotinylated secondary antibodies (for anti- α-SMA and Anti-IL-1 β; Histostain Plus Kit, 85-9043, USA, and for TNF-α; Vector Laboratories BA-5000). After a wash with PBS (3×5 min), the sections were incubated with ready-to-use streptavidin peroxidase at room temperature for 30 min and well rinsed with PBS. Colors were developed with a DAB kit. The sections were then counterstained with hematoxylin, dehydrated, and mounted. Negative controls were prepared by substituting PBS for the primary antibodies.

H-Score

The evaluation of the immunohistochemical labeling of IL-1, TNF-α and α-SMA in samples from experimental and control groups was performed using H-SCORE[2]. Briefly, sections were evaluated using an Axioscope microscope (Zeiss, Oberkochen, Germany). Three randomly selected slides, each of five different fields at 200 x magnification, were evaluated for immunohistochemical labeling of IL-1, TNF-α and α-SMA. The labeling was scored in a semi quantitative fashion that included the intensity of specific labeling in sections. The evaluations were recorded as percentages of labeled cells of all types in each of four intensity categories, denoted as 0 (no labeling), 1+ (weak labeling but detectable above control), 2+ (distinct labeling) and 3+ (intense labeling). For each tissue, an H-SCORE value was derived by summing the percentages of cells that were labeled at each intensity multiplied by the weighted intensity of the labeling: H-SCORE=∑Pi(i+1), where "i" is the intensity score and Pi is the corresponding percentage of the cells. Two observers blinded to the experimental groups performed the H-SCORE evaluations, and the average score was used.

Statistical analysis

All data were analyzed using SPSS for Windows version 11,5 (SPSS Inc.,Chicago, IL, USA) and statistically significant values were defined as $p < 0,05$. The data for dura thickness and H-score were reported as the mean±standard deviation (SD). Differences between groups were calculated by the analysis of variance (one-way ANOVA) and Bonferroni post hoc test.

A Fisher's exact test was used to determine significant difference in grades of epidural fibrosis, scar tissue consistency and inflammatory response as well as the presence of arachnoid involvement.

RESULTS

The mean thickness of the dura mater was different in four groups ($F(3,28) = 13,789$ $p<0,001$). In control group, the mean thickness of the dura mater was found to be higher than the other three goups (respectively,

p<0,001, p<0,001, p<0,05), however the difference between the spongostan and S.Pirfenidone group were not significant (p>0,05). The mean thickness of the dura mater for L.Pirfenidone was significantly lower than the other three group's (respectively, p<0.001, p<0.05 ve p<0.05).

There was a significant difference between the distribution of groups in to epidural fibrosis grade categories (p=0.028). Control group was mainly accumulated in grade 2 and 3. There was mostly grade 1 in L.Pirfenidone group. (Fig 1, Table 3).

The scar tissue consistency and inflammatory response grades in pirfenidone treatment groups were lower than control and spongostan groups. All of the rats In L. pirfenidone group were grade 1 (p<0.001) (Table-3).

Arachnoidal involvement was observed in 62.5% of the rats in the control group, 37,5% of the rats in the Spongostan group, 25% of the rats in S.Pirfenidone group and the was no arachnoidal involvement in L.pirfenidone group. The difference between the groups was slightly non-significant (p=0,064).

The mean of the H-score for IL-1 was different in four groups (F(3,28)= 25,651 p<0,001). In the control group, the mean of the H-score was statistically significantly higher than the other three groups (respectively p<0,01, p<0,001, p<0,001). There was no difference between spongostan and S.pirfenidone groups (p>0,05). However L. Pirfenidone group was significantly lower than spongostan group (p<0,01). When S.pirfenidone and L. Pirfenidone group was compared, the difference was slightly non-significant. (p=0.055) (Fig 2-3, Table 3).

The mean of the H-score for TNF-α was different in four groups (F(3,28)=9,508 p<0,001). There was no significant difference between Control, Spongostan and S.Pirfenidone groups (p>0,05 for all). The mean of the H-score for TNF-α was significantly lower in L.Pirfenidone group than the control and spongostan groups (respectively p<0,01, p<0.01). There was no significant difference between L.Pirfenidone and S.Pirfenidone groups (p>0,05) (Fig 2-3, Table-3).

The mean of the H-score for α –SMA was different in four groups (F(3,28)= 42,092 p<0,001). There was no difference between control and spongostan groups and means of both groups were significantly higher than the S.Pirfenidone and L.Pirfenidone groups (p<0,001 for all). There was no difference between S.Pirfenidone and L. Pirfenidone groups. (p>0,05) (Fig 2-3, Table-3).

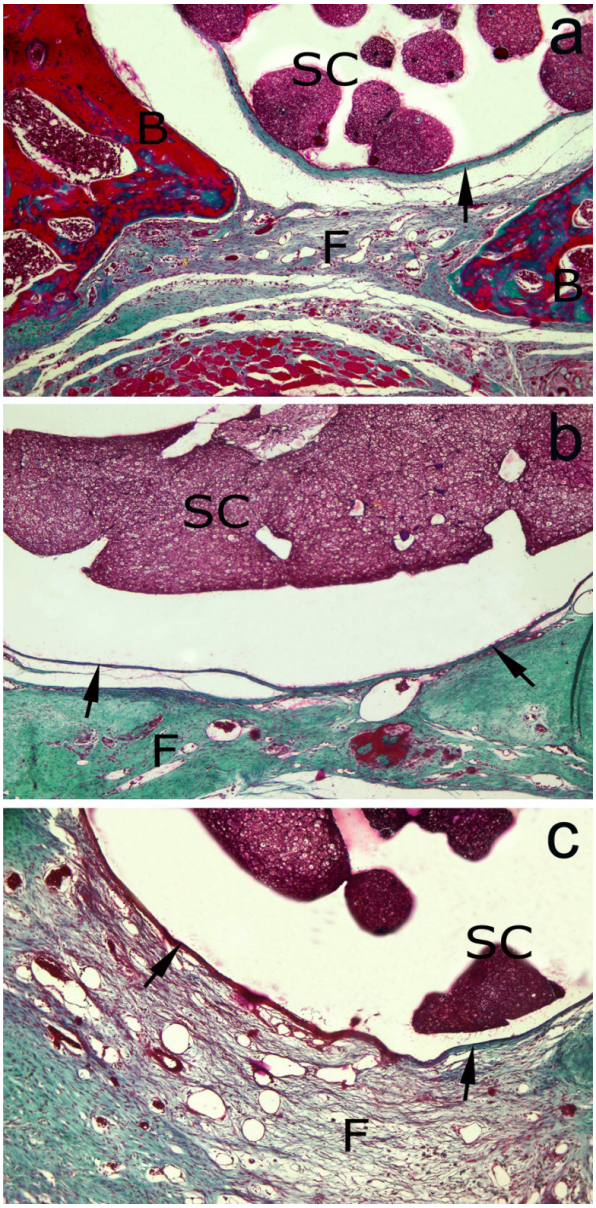

Figure-1. Representative micrograph of the rat dural tube and epidural fibrosis 4 weeks following laminectomy. **a)** Grade-1 epidural fibrosis is observed in pirfenidone treatment groups. Dura mater is free and Only thin fibrous band (arrow) is observed between the fibrosis (F) and the dura. B: new bone formation. **b)** Grade-2 epidural fibrosis in spongostan group. Fibrosis that dense connective tissue covered less than two-thirds of the laminectomy defect and adhere to the dura mater (arrow). **c)** Grade 3 epidural fibrosis is observed in control group. Epidural fibrosis (F) that highly vascular loose connective tissue covered more than two-thirds of the laminectomy defect and adhered to dura mater (arrow). SC: spinal cord. Masson's trichcrome x 100

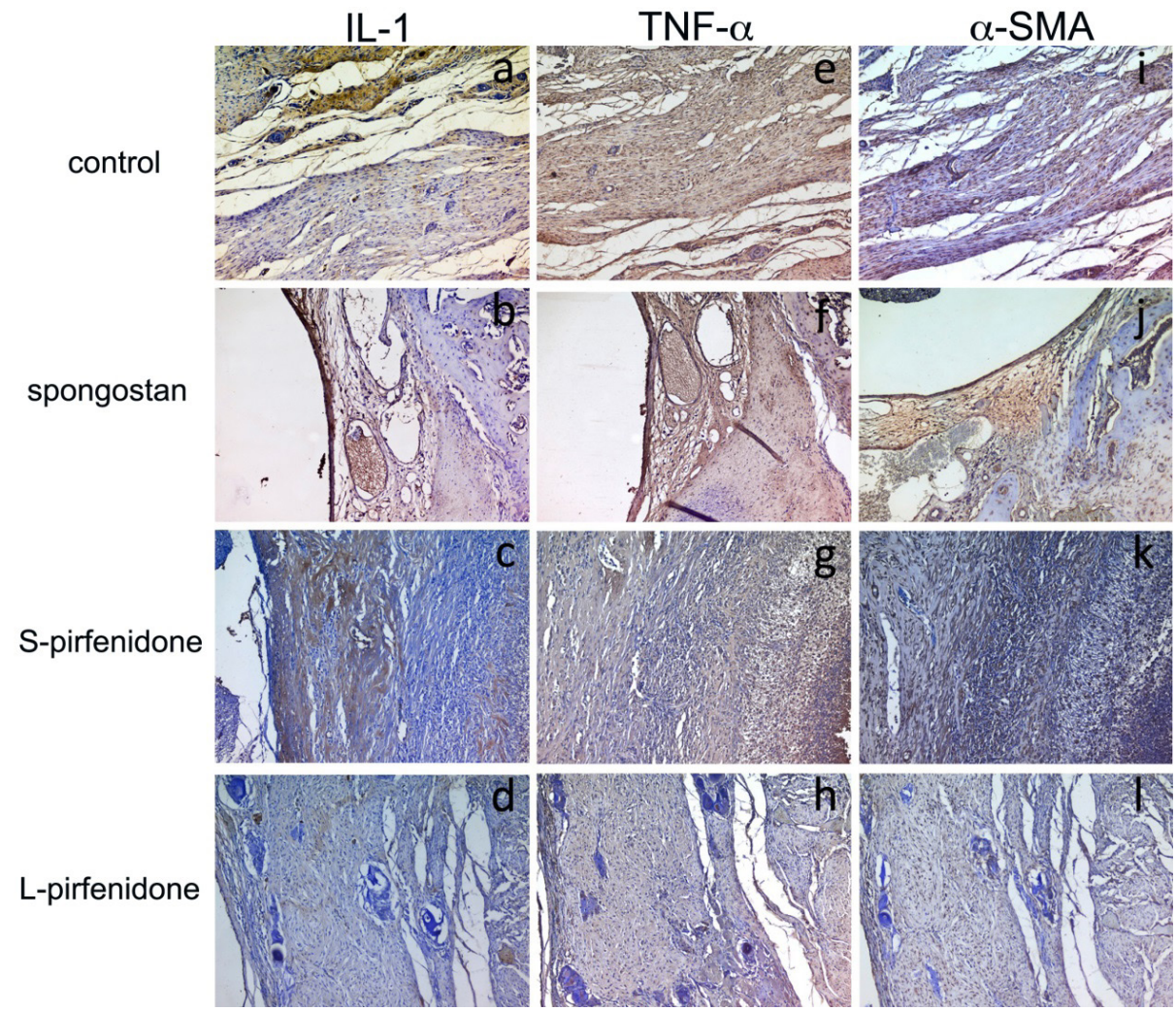

Figure-2. Immunohistochemistry of IL-1 (a, b, c, d), TNF-α (e, f, g, h) and α-SMA (i, j, k, l) on epidural fibrosis of control, spongostan, S-pirfenidone and L-pirfenidone rats. The magnification was 200x.

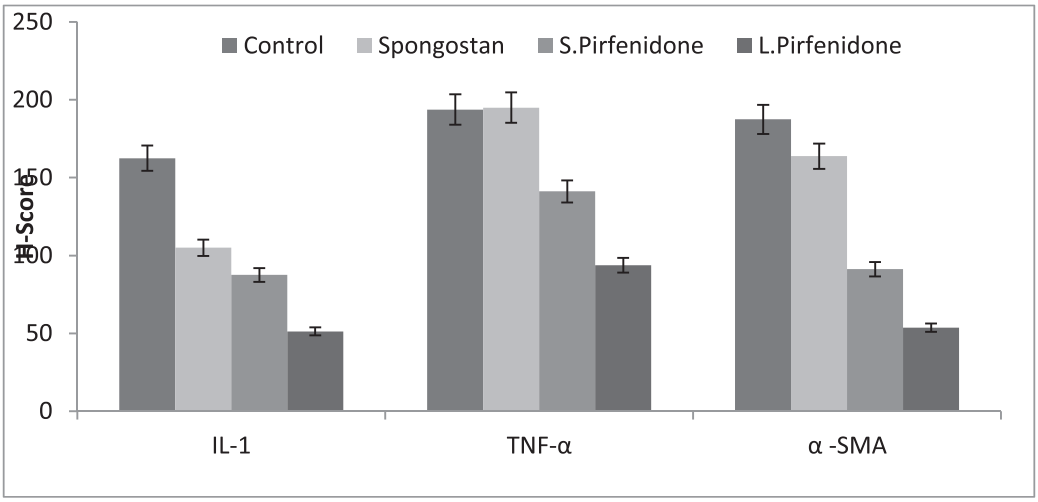

Figure-3. The distribution of immunostaining intensity (H-score) in epidural fibrosis samples with anti-IL-1 ,anti-TNF-α and anti α-SMA antibodies.

Table-3. The scar tissue consistency and inflammatory response grades in pirfenidone treatment groups were lower than control and spongostan groups. All of the rats In L. pirfenidone group were grade-1 (p<0.001).

Variables	Control	Spongostan	S.Pirfenidone	L.Pirfenidone	p
Dura mater thickness, *Mean±SD*	23.5±4.4	16.7±4.7	16.8±3.67	11.1±1.9	<0.001
H Score Results, *Mean±SD*					
IL-1	162.5±32.4	105.0±30.7	87.5±16.7	51.25±20.3	<0.001
TNF-α	193.8±59.7	195.0±62.1	141.2±45.5	93.75±33.8	0.001
α –SMA	187.5±30.6	163.8±35.8	91.2±20.3	53.75±17.7	<0.001
Epidural Fibrosis, n (%)					
Grade 1	0 (0%)	3 (37.5%)	5 (50%)	5 (62.5%)	0.028
Grade 2	2 (25%)	3 (37.5%)	1 (12.5%)	3 (37.5%)	
Grade 3	6 (75%)	2 (25%)	3 (37.5%)	0(0%)	
Scar tissue consistency and inflammatory response, n (%)					
Grade 1	0 (0%)	2 (25%)	6 (75%)	8 (100%)	<0.001
Grade 2	4 (50%)	4 (50%)	2 (25%)	0 (0%)	
Grade 3	4 (50%)	2 (25%)	0 (0%)	0(0%)	
Arachnoidal involvement, n(%)					
Yes	5 (62.5%)	3 (37.5%)	2 (25%)	0 (0%)	0.064
No	3 (37.5%)	5 (62.5%)	6 (75%)	8 (100%)	

SD, Standart Deviation

DISCUSSION

Laminectomy technics are widely used technics in spinal disorders surgery and they often results in the formation of epidural fibrosis, Epidural fibrosis is the major cause of postoperative morbidities such as persistent low back pain and disability [23]. In an effort to find a solution to this problem, numerous methods have been studied to prevent EF by surgical methods and various biological agents. Nevertheless, clinical results of these methods have been limited because the effects were not as satisfactory as expected. The new treatment methods should be developed for prevent EF.

The new-targeted therapies of EF is against to fibrosis mechanism. However, mechanism of fibrosis formation is still unclear, a study has shown that after lomber laminectomy epidural hematoma, epidural fat accumulation and muscle invasion at the laminectomy site plays important role in the formation of epidural fibrosis [21]. Some reports have shown that fibroblast proliferation was the main reasons for epidural fibrosis [3].

Additionally, the number of fibroblasts is considered as a parameter for determining the density of epidural fibrosis[3]. Another study suggested that activated fibroblasts/myofibroblasts are critical effector cells associated with the progression of fibrosis [25,27].

Pirfenidone (5-methyl-N-phenyl-2- (1H)-pyridone is a drug with anti-fibrotic and anti-inflammatory effects. Pirfenidone's antifibrotic properties have shown in various clinical and animal-based experimental studies [5]. Pirfenidone is first drug of choice for IPF. Pirfenidone has been accepted for the treatment of idiopathic pulmonary fibrosis in many countries and it is first drug of choice for IPF, now. Latest studies have shown that pirfenidone has beneficial effect for Crohn's disease and intestinal fibrosis[14]. Some animals studies have shown that pirfenidone inhibit progression of fibrosis and prevent the formation of fibrotic lesions on rat hepatic,pulmoner, bladder, renal , cardiac cells [1,6-7,9,22].

Pirfenidone has been shown to prevent the accumulation of hydroxyproline, procollagen I and III, inflammatory cells and transforming growth factor-beta TGF-β [11]. Pirfenidone exerts many effects, that is, a decrease in fibroblast proliferation, reduction of TFG-β stimulated reactions, lowered levels of a myofibroblast marker alpha smooth muscle actin (α-SMA) [16].

Proinflammatory cytokines for example tumor necrosis factor TNF-α, interleukin IL-1β and vascular endothelial growth factor (VEGF) playing important roles in inflammation process. Pirfenidone effect some pro-inflammatory cytokines, including IL-1β, IL-6, IL-12, IL17, and TNF-α. Suna at. All Show that treatment

with pirfenidone reduce the expression of IL-1β, IL-6, and IL-12 [24]. We showed that the H-score for IL-1 was significantly lower in the L-pirfenidone group when compared with spongostan group. Our study showed that pirfenidone reduce the expression of IL-1.

Myofibroblast differentiation is important event of the pathogenesis of fibrosis. α-SMA is specific marker molecule of myofibroblast differentiation. In order to evaluate the effects of pirfenidone, we evaluated the expression of α-SMA. We showed that α-SMA expression was significantly suppressed by pirfenidone.

TNF-α is potent activator of the intracellular signaling molecules, it stimulates the proliferation of fibroblasts via TGF-β1. The H-score for TNF-α was significantly lower in L.Pirfenidone group than the control and spongostan groups, in this study (respectively p<0,01, p<0.01).

The mean thickness of the dura mater for L.Pirfenidone, the scar tissue consistency and inflammatory response grades in pirfenidone treatment groups, epidural fibrosis grade in pirfenidone groups were lower than other groups.

Histological and immunohistochemistry analysis have showed that pirfenidone attenue EF in the postlaminectomy rat model.

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Volume: 29, Issue: 3, July 2018 pp: 141-146 ORIGINAL ARTICLE

THE PREVENTION EFFECT OF *N*-ACETYLCYSTEINE ON EPIDURAL FIBROSIS IN THE POST-LAMINECTOMY RAT MODEL

Yahya GÜVENÇ[1],
Mesut Emre YAMAN[2],
Yaşar ÖZTÜRK[3],
Gülüşan ERGÜL[4],
Fatma Kübra ERBAY[5],
Tolga TOLUNAY[6],
Güner MENEKŞE[7],
Abdullah ÖZCAN[8],
Erkan KAPTANOĞLU[1]

[1] *Marmara University, School of Medicine, Department of Neurosurgery, İstanbul, Turkey.*
[2] *Gazi University, School of Medicine, Department of Neurosurgery, Ankara, Turkey.*
[3] *Yenimahalle Traning and Education Hospital, Department of Neurosurgery, Ankara, Turkey.*
[4] *Yenimahalle Traning and Education Hospital, Department of Pathology, Ankara, Turkey.*
[5] *TOBB University of Economics and Technology, Department of Micro and Nanotechnology, Ankara, Turkey.*
[6] *Yenimahalle Traning and Education Hospital, Department of Orthopaedics, Ankara, Turkey.*
[7] *Ankara Traning and Education Hospital, Department of Neurosurgery, Ankara, Turkey.*
[8] *Marmara University, Neuroscience Institute, Department of Anesthesiology, İstanbul, Turkey.*

ORCID Numbers:
Yahya GUVENC: 0000-0002-4813-0854
Mesut Emre YAMAN: 0000-0003-0049-1316
Yaşar ÖZTÜRK: 0000-0003-0923-5941
Gulusan ERGUL: 0000-0002-6631-6118
Fatma Kubra ERBAY: 0000-0002-4117-1098
Tolga TOLUNAY: 0000-0003-1998-3695
Guner MENEKSE: 0000-0002-5912-6949
Abdullah OZCAN: 0000-0002-2625-6325
Erkan KAPTANOĞLU: 0000-0002-9945-8817

Address: Yahya Güvenç,
Marmara University, School of Medicine, Department of Neurosurgery, Basıbuyuk Healt Campus, Maltepe, İstanbul, Turkey.
Phone: +90 505 899 46 39
E-Mail: dr.yahyaguvenc@gmail.com
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ABSTRACT

Aim: The development of epidural fibrosis after laminectomy lead to postoperative morbidities, persistent radicular pain and failed back syndrome. Various materials or drugs have been used to inhibit formation of epidural fibrosis and reduce the compressive effect on neural structures. Nevertheless, the effects are not satisfied. NAC has mucolytic, antioxidant and anti-inflammatory effect. The aim of this study was to evaluate the effect of NAC on spinal epidural fibrosis in the post-laminectomy rat model.

Methods: Twenty-four albino rats were divided randomly into three equal groups: control, spongostan and Local NAC. Each animal underwent a laminectomy. Local NAC group (n=8): 100mg/kg was locally applied with a spongostan soaked with 0,5 ml of the solution and was left on the dura mater. At 4 weeks post surgery, the animals euthanized and their tissue samples at the laminectomy site were assessed histological evaluation for dura thickness, epidural fibrosis grading, inflammatory response grading and presence of arachnoidal involvement. All data were evaluated by statistically.

Results: Epidural fibrosis were observed significant lower in the NAC group when compared with control group (p= 0.001) . Inflamattory cell density was significant lower in the NAC group when compared with control and spongostan group(p=0.001 and p=0.015, respectively). Arachnoidal involvement was not observed in NAC group. The differences between all groups weren't statistically significant for dura thickness and fibloblastic density (p=0.162 and p=0.056, respectively, Kruskal Wallis test)

Conclusion: The results of our study suggested that NAC has anti-fibrotic effects on epidural fibrosis in the post-laminectomy rat model.

Keywords: NAC, Laminectomy, Epidural fibrosis, Histopathology

Level of Evidence: Experimental animal study, Level II

INTRODUCTION

Laminectomy is widespread treatment for spinal disorders. The development of epidural fibrosis after laminectomy lead to postoperative morbidities, persistent radicular pain and failed back syndrome [16]. Fibrosis is taking the place of epidural fat with fibrotic tissue, which binds the dura mater and the nerve roots to the anterior and posterior of vertebral structures [5]. Epidural fibrosis leads to difficulties in revision surgery because of that iatrogenic nerve root injury or dura mater tear may seen highyl in revision surgeries. Various biological or nonbiological materials were used to prevent epidural fibrosis but satisfactory results havent achivied, yet. Because of that preventing, the occurrence of Epidural fibrosis is still a great problem for surgeons and patients.

N-Acetylcysteine (NAC) is a thiol-containing radical scavenger and glutathione precursor. NAC has mucolytic, antioxidant and anti-inflammatory effect [3,14].

Some previous studies have indicated that NAC has beneficial effects in clinical conditions which free radicals

are involved, and it has been reported to attenuate pulmonary fibrosis, liver fibrosis and skin fibrosis in experimental studies [4,10,21-22].

The aim of this study was to evaluate the effect of NAC on spinal epidural fibrosis in the post-laminectomy rat model.

MATERIAL AND METHODS

Animals

Adult, male, 24 Wistar Albino rats weighing 250-350g were used for this study. The experimental part of the study was conducted at the Ankara Training and Research Hospital laboratory after obtaining consent from the Ankara Training and Research Hospital Animal Experiments Local Ethics Committee. All subjects were kept under stable and standard environmental conditions during the experiment and were fed on standard animal food and water.

Operative procedure

Each animal underwent a laminectomy. Surgery was conducted with the animals under general anesthesia using xylazine (10 mg/kg, Rompun, Bayer, and Turkey) and ketamine hydrochloride (50 mg/kg, Ketalar, Parke Davis, Turkey) administered intraperitoneally. The rats were placed in the prone position. The lumbar area of the rat was shaved then prepared in a sterile manner using povidone-iodine solution. All of the operative procedures were performed using a surgical microscope (Zeiss OPMI- Carl Zeiss Meditec Company, Oberkochen, Germany) by the same surgeon (YG). A longitudinal mid-line skin incision was made over the L1-L3 levels and carried down to the spinous process.

At the L1-L3 level total laminectmy was performed. The ligamentum flavum and epidural fat were removed. The dura mater was fully exposed and the hemostasis was obtained by using cotton sheet. After the application of the topical agents, the wounds were closed in anatomical layers using the same 4-0 Prolene polypropylene sutures (Ethicon; Ethicon Endo-Surgery, Inc., Cincinnati, OH, USA). There were no complication, wound infections or ant adverse effect s observed relevent to NAC. The animals were euthanized on the 4 weeks postoperative day using a lethal dose of pentobarbital (60 mg/kg, IE. Ulagay, Istanbul, Turkey).

Experimental Groups: All rats were randomly divided into three groups .
Control group (n=8): only laminectomy was performed without treatment;
Spongostan group (n=8): a spongostan (Ethicon Endo-Surgery, Inc.) soaked with 2cc/kg saline solution and was left on the dura mater after laminectomy.
Local Nac group *(n=8):* 100mg/kg was locally applied with a spongostan soaked with 0,5 ml of the solution and was left on the dura mater.

Histopathological Evaluation

Vertebral columns were fixed 10% buffered formalin for 1 week, and then were decalcified for 5 days in Biocal C solution. The laminectomy site was identified and four 2-mmthick sections were obtained. Sections were embedded in parafin and serial sections (5μm) were cut with microtome and stained with Hematoxylin Eosin (HE) and Massom Trichrome (MT). A pathologist under the Nikon Eclipse 80i light microscope as regards dural thickness and epidural fibrosis evaluated all laminectomized spine sections in a blinded manner. Quantitative morphometric analysis was performed on sections using the Nikon Nis Elements D 3.1 Digital Analyzing System. Epidural fibrosis was evaluated as described by He and colleagues [6] (Table-1). Fibroblast cell density was evaluated as described by Sen and colleagues [15] (Table-2).

Table-1. Epidural fibrosis grading table. (He at all.)

Grade	Explanation
0	Dura mater was free of scar tissue
1	Only thin fibrosis bands between the scar tissues and the dura mater were observed.
2	Continuous adhesion was observed but made up less than two-thirds of the laminectomy defect
3	Scar adhesion was large and involved more than two-thirds of the laminectomy defect, and/or extended to the nerve roots.

Table-2. Fibroblast cell density scoring system.

Grade	Cell density
Grade 1	<100 cells in each area at x400
Grade 2	100-150 cells in each area at x400
Grade 3	>150 cells in each area at x400

Statistical analysis

All data were analyzed using SPSS for Windows version 11.5 (SPSS, Inc., Chicago, IL, USA). The Shapiro Wilk test was used to determine if the distributions of continuous variables were normal. The nonparametric Kruskal Wallis test was used to compare differences in groups, the Mann Whitney U Test was used to determine the differences between subgroups. The presence of arachnoidal involvement was analyzed using a likelihood ratio test. A p value less than 0.05 was considered statistically significant.

RESULTS

There was not seen any rat mortality related to study. There was no case with neurologic deficits or cerebrospinal leak in any of the rats. All animals were ambulatory during the study.

The mean thickness of dura were 0.024 mm in NAC group, 0,025 mm in spongostan group and 0,028 mm in control group. The differences between all groups weren't statistically significant for dura thickness and fibloblastic density (p=0.162 and p=0.056, respectively, Kruskal Wallis test) (Figure.1-A, 1-C,Table-3).

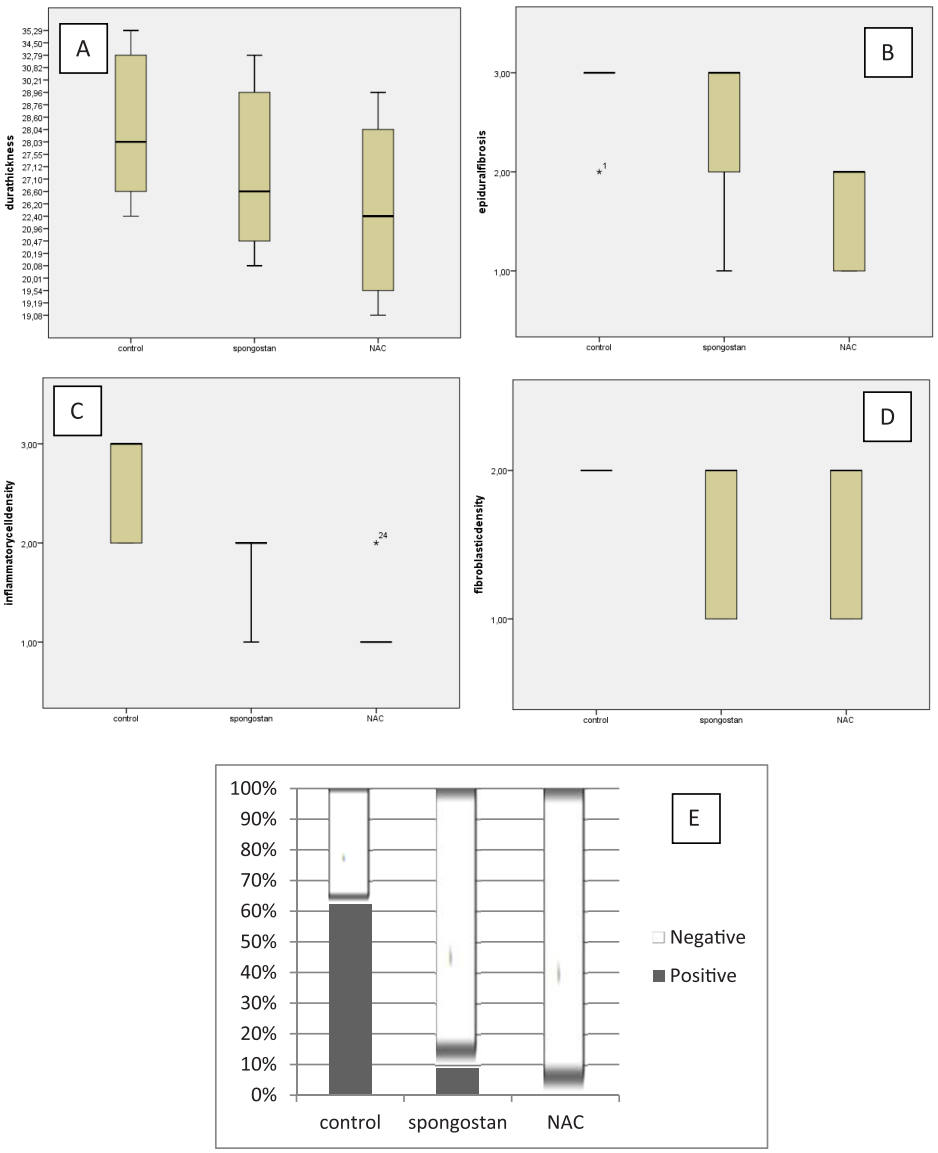


Figure-1. (A) Comparison of dural thickness among groups. The horizontal lines in the middle of each box indicate the median, whereas the top and bottom borders of the box mark the 25th and 75th percentiles, respectively. The whiskers above and below the box mark the maximum and minumum dural thickness. **(B)** Comparison of epidural fibrosis grades among groups. The horizontal lines in the middle of each box indicate the median, whereas the top and bottom borders of the box mark the 25th and 75th percentiles, respectively. The whiskers above and below the box mark the maximum and minumum epidural fibrosis grades. Asterisks represent extreme cases. **(C)** Comparison of fibroblastic density grades among groups. The horizontal lines in the middle of each box indicate the median, whereas the top and bottom borders of the box mark the 25th and 75th percentiles, respectively. The whiskers above and below the box mark the maximum and minumum fibroblastic density grades. **(D)** Comparison of inflamattory cell density grades among groups. The horizontal lines in the middle of each box indicate the median, whereas the top and bottom borders of the box mark the 25th and 75th percentiles, respectively. The whiskers above and below the box mark the maximum and minumum inflamattory cell density grades. Asterisks represent extreme cases. **(E)** Comparison of arachnoidal involvement among groups. The light bars indicate the ratio of arachnoidal involvement negative within each group, the prevalence of arachnoidal involvement positive was shown as solid bars.

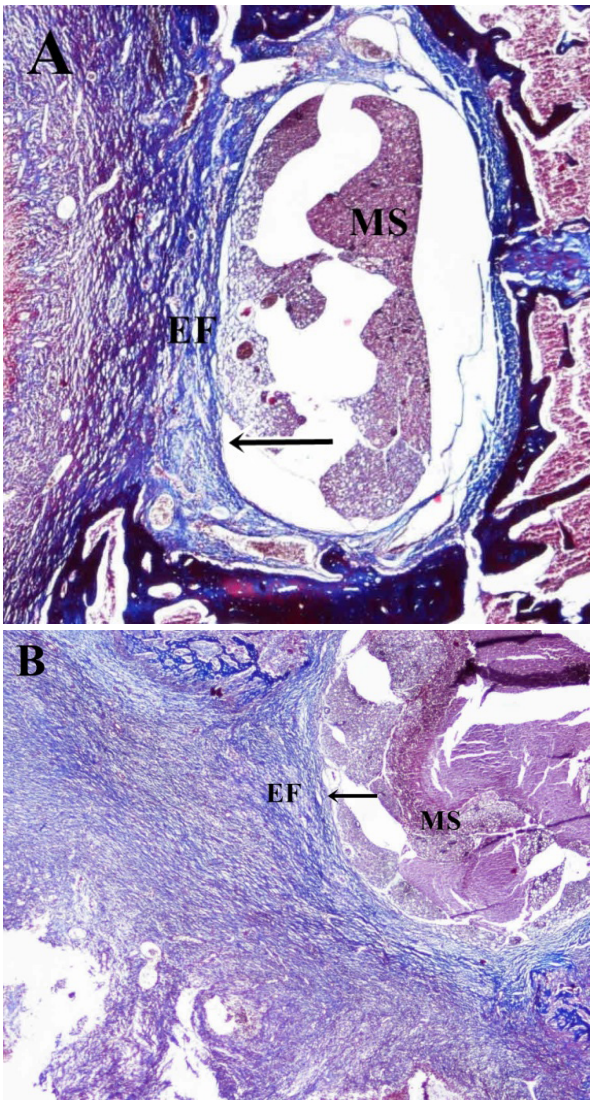
In NAC group, Grade-1 and Grade-2 epidural fibrosis were observed in in equal rate (% 50). In spongostan group, Grade-1, Grade-2 and Grade-3 epidural fibrosis were found in % 25, % 25 and % 50 of the rats, respectively. Grade-2 and Grade-3 epidural fibrosis were observed in % 12.5 and % 87.5 of the rats, respectively in the control group.

The difference between the spongostan and both the NAC and control group wasn't statistically significant (p=0.74 and p=0.095, respectively). Statistically significant difference was determined between the NAC and control group (p= 0.001) (Figure-1.B, Table-3).

In NAC group, Grade-1 and Grade-2 inflamattory cell density were observed in % 12.5 and %87.5 of the rats, respectively. Grade-1 and Grade-2 were observed in % 25 and % 75 of the rats, respectively in spongostan gorup.

In control group, Grade 2 and Grade 3 inflamattory cell density was detected in equal rate (% 50). When the grade of the control group was compared with NAC and spongostan groups, the differences were statistically significant (p=0.001 and p=0.015, respectively). The difference between the NAC and spongostan group was also statistically significant (p=0.015) (Figure-1.D, Table-3).

Arachnoidal involvement was not observed in NAC group. A few rats in the spongostan group (% 50) and control group (% 62.5) demonstrated arachnoidal involvement. The differences between the NAC and both control and spongostan group was statistically significant (p=0.009 and p=0.025). There was not statistically difference between the spongostan and the control graphy up (p=0.626) (Figure-1E, Table-3).



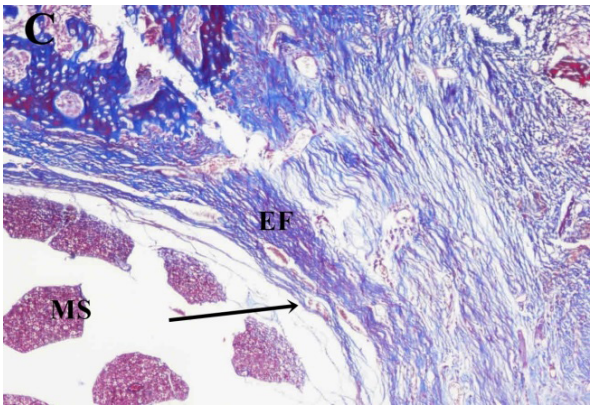


Figure-2. Photomicrographs of the study (Masson's Trichrome, x40 objective) **(A)** Grade-3 epidural fibrosis (EF) from Control group. EF covered the whole laminectomy defect and adhered to the underlying Dura mater (black arrow). Grade 3 fibrosis is observed in most of the specimens in Control group. **(B)** Grade-2 epidural fibrosis specimen from Spongostan group. Epidural fibrosis adhered the underlying Dura (black arrow) and covered less than two-thirds of the laminectomy defect. **(C)** In the NAC group Grade-1 fibrosis is adherent to the underlying Dura (black arrow) without direct contact to the medulla spinalis (MS).

Table-3. Result of Statistical analysis

Variables	Control	Spongostan	NAC	P value[1]
Dural thickness	28.03 (22.40-35.29)	26.60 (20.08-32.79)	22.40 (19.08-28.96)	0.162
Epidural fibrosis	3 (2-3)[b]	3 (1-3)	2 (1-2)[b]	0.003
Fibroblastic density	2	2 (1-2)	2 (1-2)	0.056
Inflammatory cell density	3 (2-3)[b,c]	2 (1-2)[a,c]	1 (1-2)[a,b]	0.001
Arachnoid involvement	5/3[b]	4/4[a]	0/8[a,b]	0.028

Data were represented as median (25-75 percentile).
[1] Kruskal-Wallis test
[a] NAC group versus the spongostan group ($p<0.05$)
[b] NAC group versus the control group ($p<0.01$)
[c] Spongostan group versus the control group ($p=0.015$)

DISCUSSION

Postoperative fibrosis is a expected outcome of surgical wound healing and it arise from the disrupted intervertebral disc and muscles in the surgical wound [8,20]. This fibrotic tissue may extend to epidural space when laminectomy performed. The development of epidural fibrosis after laminectomy lead to postoperative morbidities, persistent radicular pain and failed back syndrome [16]. Radicular pain is caused by leading compression or tethering the nerve roots and movement of vertebral column increased stretch so the pain is intensified [1,19]. The best solution to this problem is preventing EF formation.

Some mechanisms have been aimed to explain the presence of post-laminectomy EF. LaRocca and colleagues have suggested that fibrosis originates from the posterior invasion of fibroblasts, extending from the erector spinae muscle to the dura and then growing into the haematoma [9]. Holtz at all. have suggested that the fibrosis formation and separation of fibrin are prevented by a physical barrier and inhibition of fibroblast proliferation [7].

A lot of drugs and agents have been studied to prevent EF, but experiments showed that they still have some limitations before clinical use.

NAC has mucolytic, antioxidant and anti-inflammatory effect. NAC acts as a cysteine precursor for the synthesis of glutathione (GSH), it changes intracellular GSH levels and increasing the antioxidant protection of the cells [12]. Reactive oxygen species (ROS) include the superoxide anion (O2–), hydrogen peroxide (H2O2), and hydroxyl radicals (OH). The high ROS levels induce oxidative stress and inflict cell damage. NAC inhibit ROS production trough anjiotensin-2 blocage and increasing the antioxidant protection of the cells. It may help reduce the inflammation process. NAC ***suppresses*** the EF through antioxidant and antiinflamatuar effect [18].

We have hypothesized that NAC may have preventive effects on epidural fibrosis via anti-inflammatory and antioxidant effects. We have showed that epidural fibrosis was significantly lower in the NAC group when we compare with the Control group. Inflamattory cell density and arachnoidal involvement were lower in the NAC group when we compared with the control and Spongostan group. These are important evidence for our hypothesis.

There are some studies in the litrature which explain NAC attenue fibrosis in different experimental study. NAC decrease interstitial fibrosis, indicating that ROS elimination effectively slowed the progression of renal fibrosis in mice [18]. Administration of oral NAC increased intracellular and extracellular glutathione levels so NAC therapy may be delay idiopatic pulmoner fibrosis progression [13]. Liu at all. have showed that NAC blocked hyperglycemia promoted induced cardiac fibroblast proliferation and myofibroblast differentiation on mice. (Cong Liu) Several studies have shown that NAC could be used for the treatment of pulmonary fibrosis, liver fibrosis, and skin fibrosis [4,10,21-22] .

As a results of a macroscopic scoring system, histological evaluation showed that NAC suppressed the EF in rats. Our finding first demonstrated the beneficial effect of topical application of NAC in laminectomy models. Nevertheless, the efficacy of this agent should be further explored in additional experimental and clinical studies.

Conflict of interest

The authors have no conflicts of interest.

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Volume: 29, Issue: 3, July 2018 pp: 147-152 ORIGINAL ARTICLE

CLINICAL OUTCOMES OF THE PATIENTS WHO UNDERWENT SURGERY FOR CEREBRAL PALSY SCOLIOSIS

Ali GÜLEÇ[1],
Sadettin ÇİFTCİ[1],
Egemen ODABAŞI[1],
Ahmet YILDIRIM[1]

[1] *Department of Orthopaedics and Traumatology, Selçuk University Faculty of Medicine, 42030, Konya, Turkey.*

ORCID Numbers:
- Ali GÜLEÇ: 0000-0001-8265-825X
- Saadettin CIFTCI: 0000-0003-3249-3420
- Egemen ODABASI: 000-0003-0160-8504
- Ahmet YILDIRIM: 0000-0002-3953-091X

Address: Department of Orthopaedics and Traumatology, Selçuk University Faculty of Medicine, 42030, Konya, Turkey.
Phone: +90 530 828 07 75
E-Mail: drag42@gmail.com
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ABSTRACT

Introduction: Static encephalopathy developing linked to damage occurring in the immature brain for any reason is called cerebral palsy (CP). As CP patients have abnormal muscle tonus and linked posture disorders, scoliosis is frequently encountered. In this article, we retrospectively investigated CP scoliosis cases operated at our clinic and complications.

Material and Method: Thirteen patients with surgical treatment at our clinic from 2011-2017 for CP scoliosis were retrospectively investigated. The surgical techniques, improvement rates, perioperative complications and long-term motor function changes (GMFCS) were assessed.

Results: Nine males and 4 females were operated. Mean age was 14.3 years (range: 5-21), and mean Cobb angle was 79.3 (range: 45-135). The improvement amount in the Cobb angle was assessed as 48.2 (range: 20-70). Preoperative GMFCS score was 5 for 7 patients, 4 for 5 patients and 3 for 1 patient. One patient developed paraplegia in the 12th hour after correction (this patient was exitus in the postop 6th month due to later developing pulmonary complications). One patient developed urinary incontinence. Infection was not identified in any patient. One patient had level increased due to development of kyphosis in proximal neighboring segment.

Conclusion: We believe encouraging improvements can be obtained with posterior instrumentation and fusion surgery in CP scoliosis patients minimizing complications including coronal balance, sagittal balance and pelvic obliquity and there is no major disadvantage compared to the unit rod instrumentation system.

Key words: Cerebral palsy, pelvic obliquity, surgical treatment, instrumentation.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Development of static encephalopathy linked to damage occurring in the immature brain is called cerebral palsy [22]. The most commonly-observed form is quadriplegic spastic CP. The most common risk factor is asphyxia [14]. Due to spasticity developing linked to the disease, changes occur first in muscles and later in bone and joint structures. Scoliosis is one of the problems developing linked to cerebral palsy with the disease encountered at different rates according to form [11,18-19].

The scoliosis incidence developing in CP patients is associated with age and GM-FCS [7]. It is reported there is an inverse correlation between the 35 scoliosis problem developing in cerebral palsy and ambulation potential [11,20]. Patients with hip dislocation, early-onset scoliosis and Cobb degree of 30 before 10 years of age are high risk patients for progression [28]. Scoliosis patients with CP may have nutrition and mobilization affected linked to deformity and hygiene may be disrupted [8,13]. At the same time, deformity affects lung capacity and cardiac problems may occur. Pelvic

obliquity occurring may disrupt seated balance and make mobilization with a wheelchair impossible [8,12]. Though the use of a brace may correct this situation slightly, it will not be possible to correct the deformity or stop the progression [13]. Due to problems like the rapid progression of deformity and this situation making treatment more difficult in these patients, surgical treatment is required in the early period [22].

Surgical treatment of scoliosis occurring in CP patients ensures significant improvement in quality of life [15]. The aim of this article is to investigate all aspects of CP scoliosis cases treated in our clinic to examine treatment outcomes in light of the literature.

MATERIAL AND METHOD

Ethical permission was obtained from Selçuk University Faculty of Medicine Non Interventional Clinical Research ethics committee.

Thirteen patients operated for CP scoliosis from 2011 to 2017 were retrospectively investigated. Patients with scoliosis linked to CP and with follow-up for at least 6 months postoperative were included in the study. As all 13 patients met the inclusion criteria they were all included in the study.

Patient medical records were investigated for age, sex, ambulation potential, mental status, level according to gross motor functional classification system (GM-FCS), diseases or medical states accompanying CP (gastrointestinal pathologies or gastrotomy tube, cardiopulmonary pathologies, skeletal system pathologies requiring additional surgical intervention). GM-FCS assessment was performed as adapted and recommended by *Palisano et al.* [17].

The duration of hospitalization, necessity for intensive care, additional surgical intervention requirements, and amounts of blood product replacements were checked from the records. The complications were divided into three groups as intraoperative, early postoperative (within 3 months) and late postoperative (after 3 months) [22].

Radiography was taken while standing if possible, or sitting if necessary, with AP and lateral investigations. Cobb angle, thoracic kyphosis angle and lumbar lordosis angle were measured with the Cobb method and recorded. The study by *Shrader et al.* determined the most reliable technique in terms of intraobserver and interobserver assessment was the Maloney method for measurement of pelvic obliquity, so in our study the Maloney method was used for measurements taking Shrader et al. as reference [16, 21]. With this technique, the angle between the line determined perpendicular to the horizontal line joining the iliac crests and the line drawn between T1 and S1 is measured [21] (Figure-1).

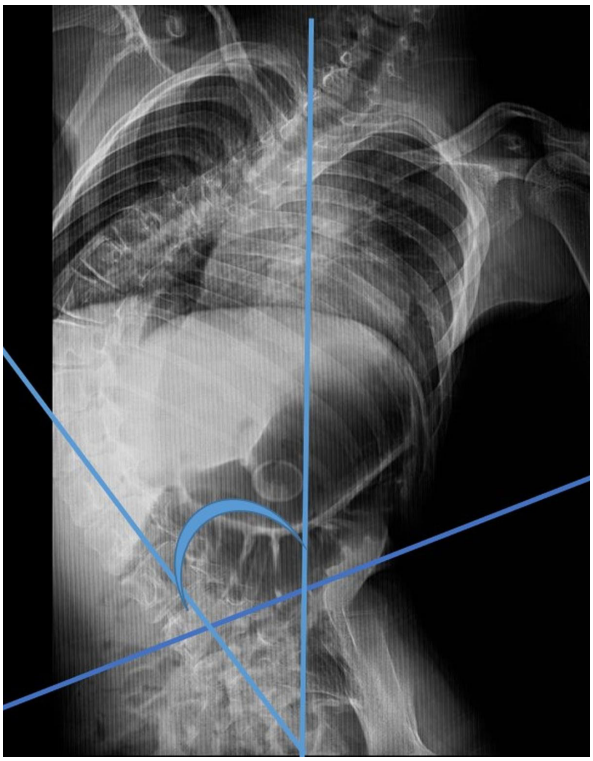

Figure-1. Measurement of pelvic obliquity by Maloney's method

Demographic Data:

Thirteen patients (9 male, 4 female) abiding by the inclusion criteria were included in the study. All patients were quadriplegic CP patients. When GMFCS is assessed, 5 patients were level-4, 7 patients were level-5 and 1 patient was level-3. Eleven children were determined to have severe mental retardation with the remaining two having moderate degree of mental retardation. Mean age was 14.3 years (range: 5-21). Mean follow-up duration was 31.8 months (range: 6-74).

Curvature and Surgical Properties:

All patients had single major curvature. Mean fusion level was 14.6 (range: 14-17). The distribution of the apex of curvature was thoracic (T) in 8 patients, thoracolumbar (TL) in 4 patients and lumbar (L) in 1 patient. Instrumentation was sufficient from L4-T5 with no pelvic fusion in 2 patients, while 5 of the remaining 11 patients had pelvis to T2, 2 patients had pelvis to T4, 1 patient had to T5, 1 patient to T8, 1 patient to T3 and 1 patient to T1. No patient required cervical instrumentation.

All patients only had posterior instrumentation applied. The erythrocyte suspension (ES) replacement amounts, hospitalization stay and blood loss amounts were investigated (Table-1).

The apex curvature was determined for thoracic, thoracolumbar and lumbar regions as described by Lenke [9]. All measurements were taken by the same person.

When determining the surgical indications for patients, solid curvature without correction or slowing possible with orthotic treatment above 40 degrees were determined. All patients had posterior instrumentation and fusion applied with pedicle screw and rod system.

Table-1. Demographic data and surgery

AGE	SEX	GMFCS	FIXATION	ILIAC FUSION
12	M	4	T1 -L5	YES
17	F	5	T2-L5	YES
14	M	5	T2-L4	YES
13	M	5	T3-L4	YES
17	F	4	T4-L5	NO
15	M	5	T2-L5	YES
5	M	4	T2-L5	YES
15	M	5	T2-L5	YES
15	M	4	T5-L5	YES
19	M	5	T8-S1	YES
12	F	3	T4-L5	YES
12	F	4	T4-L5	NO
21	M	5	T4-S1	YES

RESULTS

Preoperative mean Cobb angle was 79.3º (range: 65º (range: 20º-70º) (Figure-2).

Preoperative kyphosis angle was mean 31.9º (range: 0º-90º), while postoperative kyphosis angle was mean 38.4º (range: 15º-70º) (Table-2).

There were 6 major complications; 1 patient developed pneumothorax, 1 patient had paraplegia, 2 patients had pneumonia, 1 patient had urinary incontinence and 1 patient had junctional kyphosis in the postoperative 1st year. One patient was identified to have L5-S1 irritation on the neuromonitor intraoperatively; however no postoperative problem developed. Pneumothorax was treated with closed underwater drainage system in intensive care.

Paraplegia developed during neurological examination in intensive care in the 12th hour postoperative. Steroid treatment was begun. However, with no improvement in neurologic status and progression developing, the patient was re-operated 3 hours later with rods removed and correction canceled. There was still no improvement in neurologic deficit.

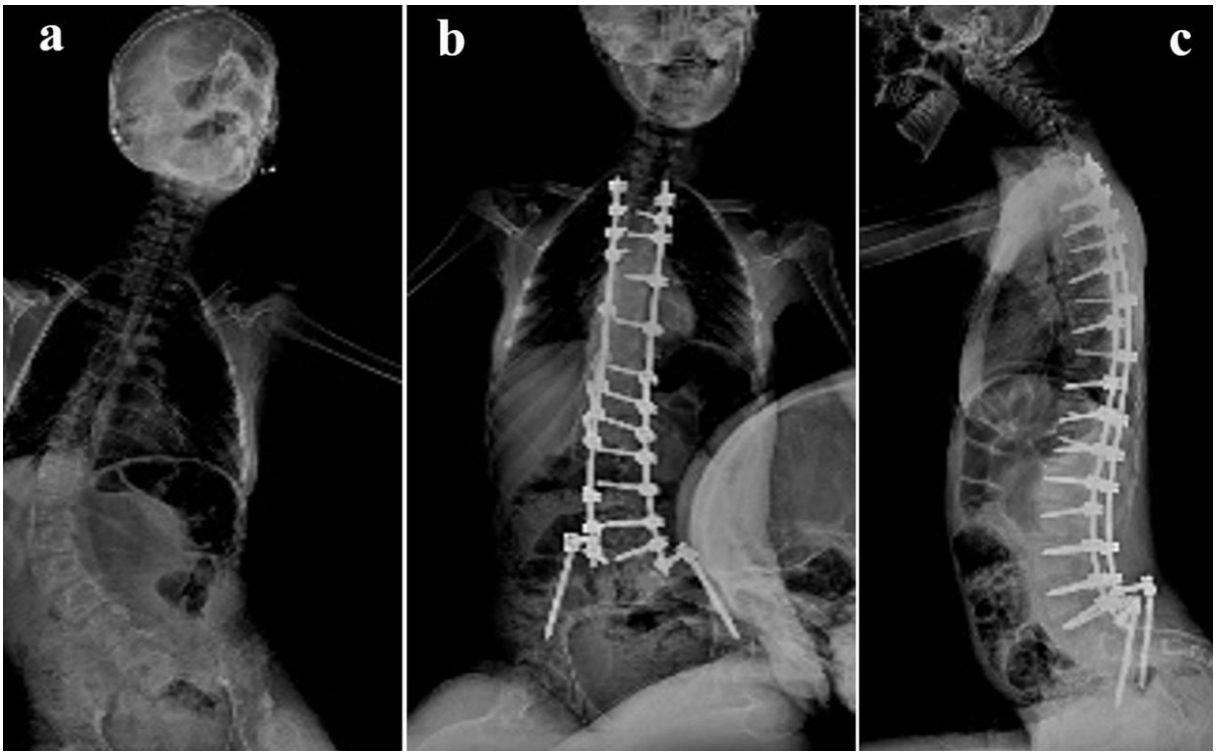

Figure-2.a, b, c. Pre- post operative X-rays.

Patients developing pneumonia were treated with antibiotherapy. The patient developing junctional kyphosis proximal to T4 had revision surgery applied and instrumentation was added to 2 levels above. Urinary incontinence had fully resolved by the 6th month postoperative. No patient developed surface or deep infection (Table-3).

The patient developing postoperative paraplegia was exitus after aspiration pneumonia developed in the 6th month postoperative. No other case developed mortality during follow-up.

Table-2. Blood variations and intensive care duration

PREOP HB	POST HB	ES REP.	IC DURATION
14	9.5	3	5 DAYS
13	9.4	4	3 DAYS
13.6	9.2	4	2 DAYS
13.2	8.5	15	35 DAYS
13	9.5	6	2 DAYS
16	9.5	8	14 DAYS
11	9.5	2	NONE
14	10	5	3 DAYS
13	10	5	NONE
12	9.5	4	1 DAYS
15	9.5	2	2 DAYS
16	10	2	NONE
15	10	7	2 DAYS

Table-3. Correction rates

PREOP COBB	POSTOP COBB	PREOP KYF	POST KYF	PELV OB PRE	PELV OB PST
65	0	70	70	15	5
67	20	36	25	15	0
50	15	15	40	15	5
100	60	10	15	20	5
70	35	70	45	0	0
130	40	90	45	45	5
50	30	45	45	30	15
100	45	35	45	35	10
70	30	30	30	20	5
70	30	45	45	20	5
80	10	0	20	15	0
45	10	30	30	5	0
135	80	45	45	45	10

Table-4. Complications

GMFCS	PULMON.	INFECT	JUNC KYF	iMP FAIL
4	NONE	NONE	T4	NONE
5	NONE	NONE	NONE	NONE
5	NONE	NONE	NONE	NONE
5	NONE	Pneumonia	NONE	NONE
4	NONE	NONE	NONE	NONE
5	Pneumothorax	Pneumonia	NONE	NONE
4	NONE	NONE	NONE	NONE
5	NONE	NONE	NONE	NONE
4	NONE	NONE	NONE	NONE
5	NONE	NONE	NONE	NONE
3	NONE	NONE	NONE	NONE
4	NONE	NONE	NONE	NONE
5	NONE	NONE	NONE	NONE

DISCUSSION

Nearly all scoliosis CP patients develop deformity, with progression especially rapid during the growing period [2-3,11,13,20,22]. Additionally, the majority of CP patients have additional problems like mental retardation, gastrointestinal system problems and nutritional disorders. In the patient series of *Sitoula et al.,* 97 % had serious additional problems with 27 % having tracheostomy. In the same series, 94 % of patients were severely mentally retarded and 88 % had gastrostomy [22]. Another study reported high rates of mental retardation and rates of additional disease up to 100 % [5]. In our study, all patients had quadriplegic CP. Of patients, 84 % had advanced degree of mental retardation, while the remainder had moderate degree of mental retardation.

Posterior instrumentation and the unit-rod system are known to provide successful and permanent improvement in Cobb angle, sagittal balance and pelvic obliquity, necessary for sitting balance [4,22,25,27]. However, no matter how much improvement comes from successful interventions, it is reported pelvic obliquity may be disrupted [27]. In our cases, correction was only applied with pedicle screws and posterior instrumentation with double rods, without any additional intervention (anterior approach, etc.), and improvement rates of 40-100 % were achieved for Cobb angle.

Sitoula et al. identified nearly 75 % improvement in their series and stated there was a 3 degree improvement loss; however, they did not identify Cranchaft phenomenon [22]. Pelvic obliquity improved from 25º preoperative to 3º in the early postoperative period in the series by *Dias et al*. and 4º was determined during follow-up [4]. *Lonstein et al*. in a case series identified that the pelvic obliquity with mean 15º degrees in the preoperative period was 8º during postoperative follow-up and mean 40 % improvement was present [10].

Bekmez et al. in a group with multiple osteotomy applied to the posterior column identified mean postoperative pelvic obliquity was 12º and they reported better improvement of pelvic obliquity was obtained with pedicle subtraction osteotomy [1]. In our cases, pelvic obliquity of mean 21.5º (range: 0-45) was found to be mean 5º (range: 0º-15º) in the postoperative period.

In broad case-series studies, deep wound infection rates are reported at rates of 1.1 % to 6%. In the same series, surface wound infection rates are reported to reach 10 % [10,23-24]. None of our cases developed deep or surface wound infection. However, as our case numbers were limited in a true sense, there is a clear need for data from broader series. In CP scoliosis cases, ambulation potential and neurologic status are the two basic factors proven to be associated with mortality. This risk is greater for quadriplegic patients, with serious mortality rates of 1/4 to 1/8 of patients. However, some of these deaths occur in the perioperative period [6,25]. In our cases, mortality was developed in a patient due to complications in the 6th month postoperative. When cases are looked at from a broad angle, apart from the junctional kyphosis in a patient and mortality in a patient, all the other complications appeared to develop in the early postoperative period. The 2 major complications of mortality and junctional kyphosis occurred during follow-up in the late postoperative period. Our limited number of patients and retrospective data are the basic limitations of our study in terms of reliability.

We believe encouraging improvements can be obtained with posterior instrumentation and fusion surgery in CP scoliosis patients minimizing complications including coronal balance, sagittal balance and pelvic obliquity. When assessed together with the literature, there is a need for larger patient series but no major disadvantage of the pedicle screw and double rod instrumentation technique was found compared to the unit-rod instrumentation technique.

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Volume: 29, Issue: 3, July 2018 pp: 153-157 ORIGINAL ARTICLE

ASSESMENT OF CORRELATION BETWEEN GLOBAL SAGITTAL AXIS AND CLINICAL SCORES IN SPINAL DEFORMITY PATIENTS

Ömer BOZDUMAN[1],
Murat KÖKEN[2]

[1] *Afyonkarahisar State Hospital Department of Orthopaedics and Traumatology, Afyonkarahisar, Turkey.*
[2] *Ufuk University Faculty of Medicine Department of Orthopaedics and Traumatology, Ankara, Turkey.*

ORCID Numbers:
- Ömer BOZDUMAN: 0000-0002-3874-633X
- Murat KÖKEN: 0000-0001-9180-0625

Address: Ömer BOZDUMAN, Afyonkarahisar Devlet Hastanesi, Ortopedi ve Travmatoloji Kliniği, Afyonkarahisar Türkiye.
Mail: omerbozduman@gmail.com
Phone: +90 530 117 85 78
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ABSTRACT

Objectives: Sagittal deformity requires higher energy to maintain an erect posture. Clinically, to be able to assess the severity of sagittal deformity and efficacy of compensatory mechanisms, new parameters are required. This study investigated the correlation between clinical relevance of global sagittal axis (GSA) and the severity of sagittal deformity.

Methods: In this study, retrospective review of patients who underwent full-body radiographs and clinical scoring systems which are Oswestry Disability Index (ODI), Scoliosis Research Society–22 and the visual analog scale for back and leg pain are integrated. The GSA is the angle between a line from the center of C-7 to midpoint of the femoral condyles, and a line from the posterior superior corner of the S-1 sacral endplate to midpoint between the femoral condyles. Correlation between clinical scoring systems and GSA data were compared.

Results: Eighty-four patients (mean age 46 years) were included. The GSA correlated significantly with all ODI, Scoliosis Research Society–22 and the visual analog scale for back and leg pain scores. Statistical analysis revealed that in sagittal deformity, the GSA increased with a concurrent increase in pelvic posterior translation (+0.186) and knee flexion (+0.284) and decrease in pelvic retroversion (-0.832)

Conclusions: The GSA is a practical and reliable measure to assess the sagittal deformity.The GSA correlated highly with clinical scores.

Key Words: Global Sagittal Axis; Sagittla deformity; Sagittal Alignment

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

In spine patients, radiographic analysis of the sagittal plane is important for surgeon for determining the treatment. Jean Dubousset and his theory of the conusofeconomy is the basis of sagittal plane. According to Dubousset, the normal human posture assumes a stance limited to a narrow anterior-posterior range to minimize muscle exertion[3]. Following Dubousset's work, investigation of sagittal plane deformities in patients become more popular [1,4,6]. Studies have shown that in sagittal spinal deformity the loss of lumbar lordosis is common, and physiological and functional malalignment of spine is seen [5]. However, other compensatory mechanisms is seen beyond spinal column [2]. Mechanisms such as thoracic hypokyphosis, hip extension (pelvic retroversion around the hip joint), and increased flexion of the knee and ankle are commonly recruited [7,9]. The combination of sagittal spinal deformity and pelvic/lower limb compensation results in an alignment in which the trunk is tilted anteriorly while the pelvis translates posterior to the gravity line [10]. The aim of this compensation is to keep the center of gravity over a narrow area between the feet [3]. There are multiple parameters to assess the severity of this deformity both radiographically and clinically.

Lafage et al [7] found that if the compensatory mechanisms fail, the clinical impact of sagittal deformity worsens. They demonstrated that in patients who are failed to compensate by pelvic retroversion, patients become more disabled. Since, a full radiographic analysis is not made in those patients; other compensatory mechanisms are not clearly investigated.

In the aspect of developing radiological technologies, new parameters can be made in order to enlight the deformities. These parameters can enlight different types of compensatory mechanisms. In the daily routine, these patients can be easily screened by surgeon. This study investigated the clinical relevance of the global sagittal axis (GSA). The authors hypothesized that the GSA would significantly correlate with regional radiographic parameters along the full-body axis, as well as clinical outcome scores.

METHODS

Study Design

This retrospective review is prepared in a single center. Patients who have adult spinal deformity and who underwent full-body stereo radiography between 2012-2018 were integrated. Patients completed Oswestry Disability Index (ODI), Scoliosis Research Society–22 and the visual analog scale for back and leg pain questionnaires. Patients with fractures, infections, neuromuscular scoliosis, and malignancies were excluded.

Data collection and radiographic analysis

Patients data of age, sex, body mass index, and medical history and questionnaires: Oswestry Disability Index (ODI), Scoliosis Research Society–22 and visual analog scale (VAS) for back and leg pain.

Stereo radiographs were assessed using Clear Canvas. Radiographic parameters included, lumbar lordosis (LL), pelvic tilt (PT), pelvic incidence (PI), T-1 pelvic angle (TPA) and C7–S1 sagittal vertical axis (SVA). Lower- extremity radiographic parameters included ankle flexion angle, pelvic shift and knee flexion angle (KA). Cranio-cervical radiographic parameters included C2–7 SVA, chin-brow vertical angle (CBVA) and C2–7 cervical curvatures. GSA is the angle between a line from the center of C-7 to midpoint of the femoral condyles, and a line from the posterior superior corner of the S-1 sacral endplate to midpoint between the femoral condyles (Figure1,2).

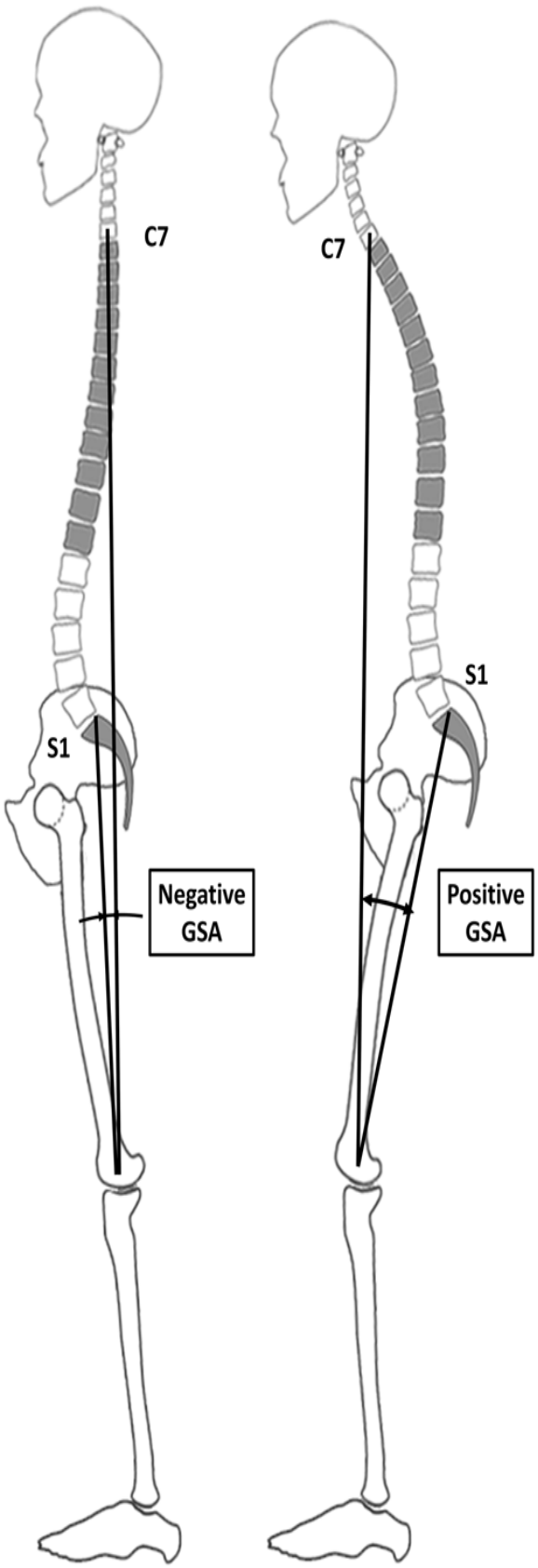

Figure-1. Showing the GSA: negative value (left) and positive value (right).

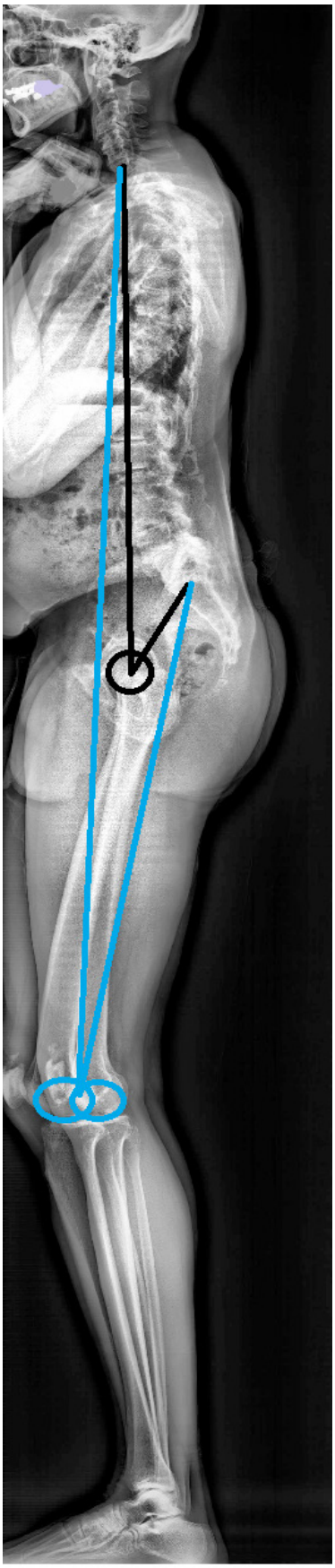

Figure-2. Example of measuring GSA on a radiograph

RESULTS

Eighty four patients met inclusion criteria, all have got degenerative lumbar scoliosis, progressive idiopathic scoliosis, orkyphoscoliosis. The mean age of the cohort was 46.1 ± 23.1years; 26.8% of patients were younger than 45 years, 31% of patients were between 45 and 65 years, and 42.2% were older than 65 years. Seventy-six percent of patients were women, and the mean body mass index was 25.2 kg/m2. Seventy-five percent of patients had no history of spine surgery. Patients had the following mean scores: ODI 24.6 ± 22, range 0–100; SRS22r 3.4 ± 0.6, range 1.7–4.7; VAS back 4.6 ± 3.2, range 0–10; and VAS leg 2.6 ± 3.4, range 0–10.

Radiographic Measurements

The mean GSA was 0.7° ± 4.8° (range -8.2 ° to 19.5 °). The cohort had a mean PI of 54.6 ° ± 12.4 ° (range 21.5° to 103.3°), a mean PI-LL of 4.6° ± 22.2° (range -63.8° to 66.5°, a mean PT of 19.4° ± 13.6° (range -34.1° to 50.0°), a mean TPA of 14.8° ± 14.6 ° (range -30.4° to 50.8°), and a mean SVA of 17 ± 56 mm (range -71.2° to 200.4°). The mean values for lower-limb measurements were as follows: KA 3.2° ± 8.8° (range -15.1° to 42.8°), ankle dorsiflexion 7° ± 4° (range -2.8° to 23.3°), and pelvic posterior shift 1.4 ± 42 mm (range -109.8° to 117.9°). The cohort had the following mean values and ranges for cervical parameters: C2–7 cervical curvature 8.4° ± 24° (range -35.7° to 146.2°), C2–7 SVA 16.8 mm ± 56.4 mm (range -90.8° to 82.4°), and CBVA 6.8° ± 13.2° (range -16.1 ° to 87.7 °).

Correlation Analysis

The GSA significantly correlated with the classic SRS-Schwab spino pelvic sagittal modifiers (PI-LL, PT, and SVA), as well as lower-limb and cranio-cervical parameters. Correlation coefficients are reported in Table-1; all correlations were significant ($p < 0.05$) (Table-1).

The GSA significantly correlated with all scores (ODI, SRS22r, VAS leg pain scores). The GSA had better correlations with ODI, SRS22r, VAS leg pain scores than with any of the other radiographic parameters. Correlation coefficients are reported in Table-2 (Table-2).

Table-1. Correlation coefficients between GSA and full-body

Sagittal Radiographic Measure	GSA
PT	0.632
PI minus LL	0.778
TPA	0.854
SVA	0.952
KA	0.794
Ankle dorsiflexion	0.572
Pelvic posterior shift	0.880
C2–7 cervical curvature	0.328
C2–7 SVA	0.226
CBVA	–0.252

Sagittal radiographic parameters*
* All correlations were significant ($p < 0.05$).

Table-2. Correlation coefficients between GSA, full-body sagittal radiographic parameters, and scores

Sagittal Radiographic Measure	ODI	SRS22r	VAS Back	VAS Leg
GSA	0.518	–0.545	0.368	0.450
PT	0.268	–0.262	—	0.208
PI minus LL	0.342	–0.346	0.258	0.342
TPA	0.394	–0.396	0.262	0.336
SVA	0.508	–0.534	0.398	0.448
KA	0.510	–0.512	0.336	0.378
Ankle dorsiflexion	0.486	–0.438	0.298	0.332
Pelvic posterior shift	0.394	–0.442	0.266	0.358

— = no-significant correlation.
* All correlations were significant ($p < 0.05$). The highest correlation coefficient
In each column is in bold face type.

DISCUSSION

This study presents sagittal spinopelvic radiographic parameters to measure GSA. Moreover, the GSA expands our understanding of the spine and pelvis to include the full-body axis. According to Diebo et al, the GSA is sensitive to spine, pelvic, and lower-extremity compensatory changes in the sagittal plane and holds one of the strongest correlations with patient-reported clinical scores reported in the literature (0.6 for EQ-5D). GSA reflects the deformity more accurately than previously defined spinopelvic parameters. GSA is important in patients whose pelvic retroversion compensatory mechanism is not enough and those who do not have the ability to compensate by pelvic retroversion.

Researchers tried to divide the sagittal plane into regions to evaluate musculoskeletal components [6,7]. Studies by both Dubousset and Duval-Beaupèreetal. Highlighted the importance of incorporating the pelvis in the assessment of spinal malalignment [3-4]. Pelvis is the access region of trunk to lower extremities through the hip joint. With the assessment of full-body radiographs, the lower extremities have just begun to get investigated. Lower-extremity compensation via increased flexion of the knees and ankles and subsequent pelvic shift plays a significant role in attempts at sagittal realignment and is therefore the direct effect of a pathological spinal deformity [2,8,9,10].

Assessing multiple radiographic analysis requires clinical and radiological experience. GSA is a simple method to investigate standing alignment and implied disability.

The simplicity of GSA offers it to be used in screening patients. Once the deformity is identified, more detailed traditional analysis would obviously be required to understand the etiology of the pathology as well as the surgical plan.

CONCLUSIONS

The GSA is a simple method for screening sagittal standing axis of the human body. The GSA is highly correlated with spinal, pelvic, and lower-extremity sagittal parameters and is compatible with clinical score to assess sagittal deformity. GSA also provides information for lower extremities and is able to enlight other pathologies rather than spine and pelvis. Moreover, the GSA is a strong indicator of patient disability and clinical scores. GSA is a simple method for communicating among physicians to address the deformity from cervical spine to ankle.

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Volume: 29, Issue: 3, July 2018 pp: 159-163 ORIGINAL ARTICLE

EFFECTS OF OBESITY ON ELECTIVE SPINAL SURGERY

H. Bahadır GOKCEN[1],
Bahattin KEMAH[2],
Engin CARKCI[3],
Erhan SUKUR[4],
Cagatay OZTURK[5]

[1] *Istinye University, Bahcelievler Medical Park Hospital, Department Orthopedics and Traumatology, Istanbul, Turkey.*

[2] *Medipol University Mega Hospital, Orthopedics and Traumatology Department, Istanbul, Turkey.*

[3] *Bahcelievler Medical Park Hospital, Orthopedics and Traumatology Department, Istanbul, Turkey.*

[4] *Sakarya University Training and Research Hospital, Orthopedics and Traumatology Department, Sakarya, Turkey*

[5] *Istinye University LIV Hospital, Orthopedics and Traumatology Department, Besiktas, Istanbul.*

ORCID Numbers:
- H. Bahadır GOKCEN: 0000-0002-5374-1166
- Bahattin KEMAH: 000-0002-4795-4309
- Engin CARKCI: 000-0002-3918-4498
- Erhan SUKUR: 000-0002-4697-7904
- Cagatay OZTURK: 0000-0003-3133-206X

Address: Istinye University, Bahcelievler Medical Park Hospital, Department of Orthopedics and Traumatology, İstanbul, Cirpici Street, Number 9, Topkapi, Zeytinburnu, Istanbul, Turkey.
E-mail: bahadrgokcen@gmail.com
Phone Number: +90 212 484 16 40
GSM: +90 533 574 21 04
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Accepted: 12th May, 2018.

ABSTRACT

Background: Obesity (Body Mass Index ≥ 30 kg/m^2) is currently a public health problem with increasing incidence. Obesity increases the challenges and complications of surgery in all surgical branches. In this study, we aimed to evaluate the intraoperative and perioperative complications of obesity encountered in spinal surgery.

Materials and Methods: All patients undergoing elective spinal surgery in one orthopedic surgery practice between 2017 and 2018 were included in this study. Patient demographics, body mass index (BMI), preoperative hemoglobin and hematocrit values, volume of blood transfused, incision lengths, number of surgical levels, operational time, and amount of bleeding were retrospectively identified. Patients were divided into two groups according to BMI levels (Group A, < 30kg/m^2; Group B ≥ 30 kg/m^2), and statistical analyses were performed using the Student's t and Mann-Whitney U tests.

Results: Seventy-seven patients with a mean age of 57.8 years (range, 19–72) were included in this study. Their mean BMI was 29.3 kg/m^2 (19.9–39 kg/m^2). The mean BMI of Group A was 25.7 kg/m^2 and that of Group B was 34.6 kg/m^2. The amount of bleeding, number of surgical levels, and skin-incision length were statistically significantly different between the two groups. The mean values of all of these parameters were higher in Group B.

Conclusion: Although numerous factors play roles in operational success, we believe that identifying obesity in a patient is important for pre- and postoperative surgical preparation by the operation team.

Keywords: Obesity, Body Mass Index; Orthopaedic Surgical Procedures; Surgical blood loss; Operative Time.

Level of Evidence: Retrospective Clinical Study, Level III

INTRODUCTION

Obesity is defined as having a body mass index (BMI) ≥ 30 kg/m^2, and its importance among public-health problems is increasing worldwide [25]. In the USA, obesity has become a health problem affecting one-thirds of the population, and it is defined as a crucial factor in development of musculoskeletal diseases. Even in Turkey, the importance of obesity and accompanying comorbidities is increasingly being recognized. Obesity is responsible for the clinical findings of hip and knee osteoarthritis [10]. In addition, it has been proven in the literature that obesity is among the factors forming a basis for degenerative spinal disease [1,21].

The number of spinal surgeries has increased in recent years. Spinal surgeries increasingly involve more complex cases, including patients with a high BMI. Obesity, which is a cause of comorbidity in spinal diseases, may also cause an increase in the rate of complications encountered following spinal surgery [4,8,9,17,23].

In the literature, obesity has been associated with prolonged operation time and higher rates of hemorrhage and revision in patients undergoing spinal surgery [13,20,24,27,30]. The objective

of this study was to retrospectively compare perioperative data of obese patients with that of non-obese patients undergoing elective surgery, and to evaluate operative complications in obese patients, who constitute an increasing proportion of the patient group undergoing spinal surgery in recent years.

MATERIALS AND METHODS

Approval of the ethics committee was taken with document dated 02.04.2018 and numbered E.4899. The informed consent forms were obtained from all patients included in this study. The records of 106 patients aged over 18 years who had undergone elective spinal surgery for spinal disorders between 2017 and 2018 were retrospectively studied. Eight patients who had been operated due to infection or malignancy and 21 patients who had undergone cervical spinal surgery were excluded from the study. A total of 77 patients were included in the study.

Preoperative radiologic examinations of the patients included anteroposterior and lateral plain radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) (Fig.1a-d).

General anesthesia was performed by the same team with the same standardized protocol in each patient. Surgery was performed by a single surgeon and the same surgical team in all patients. Patients' sex, age, preoperative hemoglobin and hematocrit values, volume of blood transfused, operational time, amount of bleeding, number of surgical levels, and skin-incision lengths were extracted from the records. BMI was calculated by dividing patients' weight in kg by the square of their height in m. Patients with BMI $\geq$ 30 kg/m^2 were recorded as obese according to the WHO classification [29]. Patients were divided into two main groups: Group A having a BMI < 30 kg/m^2 and Group B with a BMI $\geq$ 30 kg/m^2. Parameters including hemoglobin and hematocrit values, volume of blood transfused, operation time, amount of bleeding, number of surgical levels, and skin-incision lengths were compared between Group A and Group B.

Statistical Analysis

Descriptive statistics (mean ± standard deviation, minimum, median, maximum) were used to define continuous variables. Comparison of two independent variables with a normal distribution was made with Student's t test. Comparison of two independent variables with non-normal distribution was made using the Mann-Whitney U test. The level of statistical significance was set at $p < 0.05$. Statistical analyses were performed using MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2013).

RESULTS

Of the 77 patients (36 male, 43 female) included in the study, 67 patients (38 Group A, 29 Group B) were diagnosed with lumbar spinal stenosis, and 10 patients (6 Group A, 4 Group B) with de novo scoliosis (Table-1).

The total number of patients was 44 in Group A and 33 in Group B. The mean age was 57.8 (range, 19 – 72) years. The mean BMI of all patients was 29.3 kg/m^2 (range, 19.9 – 39 kg/m^2). The mean BMI value was 25.7 kg/m^2 in Group A and 34.6 kg/m^2 in Group B. The mean volume of blood transfused was 2.9 IU in Group A and 3.8 IU in Group B. The mean amount of bleeding was 883.2 mL in Group A, and 1124.1 mL in Group B. This was a statistically significant difference ($p < 0.05$).

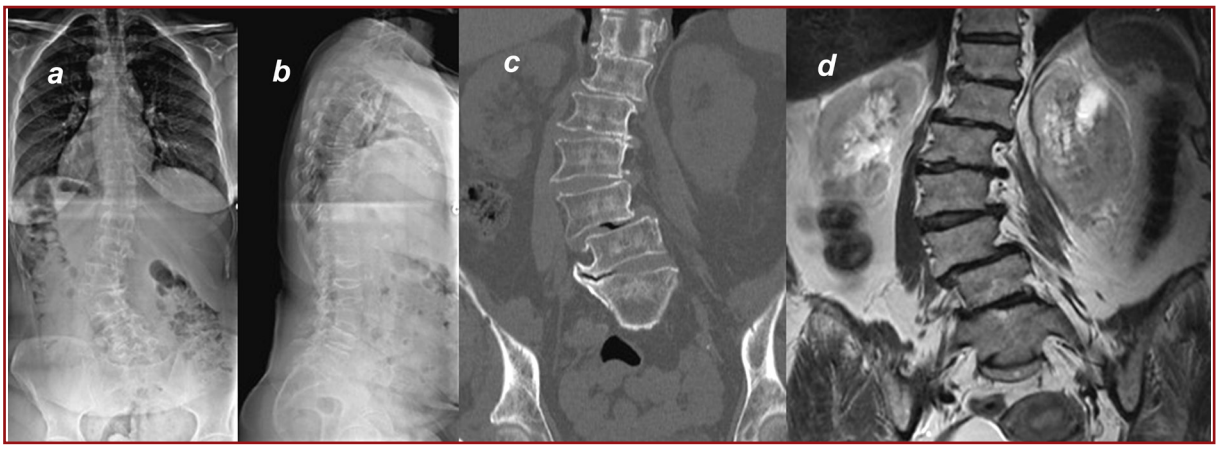

Figure-1. Preoperative radiologic examination of a patient with de novo scoliosis. **a.** Anteroposterior and **b.** Lateral plain radiograph. **c.** Coronal view of Computed tomography (CT). **d.** Coronal view of magnetic resonance imaging (MRI).

The mean preoperative Hgb value was 12.8 g/dL in Group A and 12.6 g/dl in Group B. The mean Hct value was 38.7% in Group A and 38.6% in Group B. The number of surgical levels of the patients in Group B was higher, with a mean value of 6.6, compared with 4.9 for patients in Group A. The difference was statistically significant ($p < 0.05$).

The difference in the skin-incision length was also statistically significant between groups. The mean skin incision was 13.275 cm long in Group A, and 18.225 cm in Group B ($p < 0.05$) (Table-2). No complications were encountered during any of the operations. Nine patients developed superficial wound-site infection. Two of these patients were in Group A, and seven in Group B. Superficial wound-site debridement was applied in 4 of the 9 patients, and all these patients were in Group B.

DISCUSSION

Obesity is becoming a major problem in people with orthopedic disabilities. The incidence of obese people requiring surgery is also increasing among persons with orthopedic disabilities. Spinal surgery is important among obese patient groups. In a study by As Saeed *et al.*, MRIs of 214 patients were evaluated, and degenerative disc diseases were found to be more common in obese than in non-obese patients [1]. In another study, degenerative spondylolisthesis was reported to be more common in obese patients [22]. Other studies report common facet-joint problems related to obesity [6,16]. The effect of obesity on outcomes of patients undergoing spinal surgery is still controversial [14].

Andreshak *et al.* argued that obesity has no significant effects on the rates of complications seen during surgery or on surgical outcomes, but the authors stated that obesity should not be overlooked [2]. More recent studies underline that obesity has negative effects on both intra- and post-operative surgical outcomes [7,12,18]. Obese patients are prone to medical complications due to accompanying comorbidities.

In addition, increased subcutaneous fatty tissue can make spinal surgery technically difficult. In a study by Burks et al., the risk of dura rupture was found to be higher in obese than in non-obese patients [5]. In our study, no medical complications or surgery-related complications were observed in our patients during the operations. However, we observed that increased subcutaneous fatty tissue made some interventions technically difficult in obese patients.

Table-1. Patient's diagnosis

Diagnosis N=77	Group A (BMI* < 30kg/m²) Number of Patients	Group B (BMI ≥ 30kg/m²) Number of Patients
Lumbar spinal stenosis	38	29
De novo scoliosis	6	4

**BMI: Body Mass Index*

Table-2. Comparison of parameters according to Body Mass Index

	Group A (BMI<30) (N =44) Mean ±SD	Group B (BMI≥30) (N =33) Mean ±SD	p
Blood Used	2.9±2.1	3.8±3.4	0.224[2]
Preop Hgb	12.8±1.9	12.6±1.8	0.567[1]
Preop Hct	38.7±5.1	38.6±4.5	0.952[1]
Operational Time	3.3±1.3	3.8±1.3	0.056[2]
Amount of Bleeding	883.2±632.4	1124.1±514.8	**0.007**[2,*]
Surgical Level	4.9±4,3	6.6±4,8	**0.023**[2,*]
Skin Incision Length	13.275±0.8	18.225±0.9	**<0.001**[2,*]

*BMI: Body Mass Index, SD: Standard Deviation, p[1]: Student's t, p[2]: Mann-Whitney U, *: Statistically significant*

Babu *et al.* reported that damage to the facet joint was more common in obese patients during insertion of pedicle screws [3]. In our clinic, we perform lateral dissection more often in obese patients undergoing interbody fusion to provide more opportunity for elimination of the subcutaneous fatty tissue; thus, we avoid blocking of screw medialization by thick subcutaneous fatty tissue when inserting the pedicle screw. It has been mentioned in the literature that increased subcutaneous fatty tissue also increases the rate of surgical-site infections [11,15,19]. In our study, none of our patients developed deep surgical infection. Only nine patients developed superficial infections, and the rate of superficial infection was higher in the obese than in the non-obese group (2 patients from Group A, 7 patients from Group B). In our study, longer operational time in the obese than in the non-obese group was found, consistent with the literature [13,20,28,30]. Longer operational time in obese patients may result from both the higher need for dissection of subcutaneous fatty tissue, and from the mean skin-incision length, which is about 5 cm longer in obese patients compared with that of non-obese patients. We think that the longer incision was caused by the higher number of surgical levels of our obese patients, and also by the need for more lateral dissection to eliminate the subcutaneous fatty tissue, as mentioned above. Although no difference was found between the amount of bleeding in some studies, the opinion that obesity increases bleeding is predominant in the literature [13-14,20,30].

The amount of bleeding in our study was about 350 cc more in obese than in non-obese patients. In the literature, among patients undergoing fusion surgery, the mean amount of bleeding is 180 cc in patients who underwent laminectomy and discectomy alone, about 1000 cc in patients who underwent fusion surgery, and between 430 cc and 600 cc in those undergoing minimally invasive interbody fusion procedures [2,26]. In our study, the mean amount of bleeding was about 800 cc in non-obese Group A patients and nearly 1100 cc in obese Group B patients. Given that all patients in this study underwent posterolateral or interbody fusion, the amount of bleeding in our study does not show significant difference from the amounts reported in the literature. In direct proportion to the amounts of bleeding in obese patients, the volume of blood transfused was also higher in the obese than in the non-obese group. There were no significant differences in the preoperative hemoglobin and hematocrit values between obese and non-obese patients, suggesting that the higher amount of blood used might be due to the higher amount of bleeding.

Limitations of this study include the relatively small number of patients, the retrospective nature of patient classification, and the retrospective investigation of the records. We think that evaluating a larger number of patients would enable us classify patients with a BMI $\geq$ 30 kg/m^2 according to graded obesity values, giving a more specific evaluation of the effects of varying degrees of obesity. Effects of obesity on spinal surgery can be investigated in more detail by forming more specific patient groups.

The results of this study indicate that although obesity does not appear to increase complications during operation in patients undergoing elective spinal surgery, it may lead to higher amounts of bleeding, operational time may be prolonged, and a longer surgical incision may be required with more soft-tissue dissection. Although numerous factors play roles in operational success, we believe that recognizing accompanying obesity of the patient is important for both pre- and postoperative surgical preparation by the operation team.

Conflict of interest: None

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Volume: 29, Issue: 3, July 2018 pp: 165-172 ORIGINAL ARTICLE

INTRACRANIAL COMPLICATIONS OF LUMBAR SPINAL SURGERY

Baran YILMAZ[1],
Zafer Orkun TOKTAŞ[1],
Deniz KONYA[1]
Teyyub HASANOV[2]

[1] *Bahçeşehir University Medical School, Department of Neurosurgery, İstanbul, Turkey.*

[2] *Medikal Park Pendik Hospital, istanbul, Turkey.*

ORCID Numbers:
- Baran YILMAZ: 0000-0001-6296-8381
- Teyyub HASANOV: 0000-0002-6198-7742
- Zafer Orkun TOKTAŞ: 0000-0002-5842-5891
- Deniz KONYA: 0000-0002-4263-6096

Address: Baran Yılmaz, Bahçeşehir University Medical School, Department of Neurosurgery, İstanbul, Turkey.
Phone: +90 535 316 26 93
E-mail: baranylmz@gmail.com
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ABSTRACT

In this study, we present the largest series composed of 10 patients, with different kinds of remote intracranial complications after lumbar spinal surgery. Remote intracranial events happened after lumbar spine surgery that were performed from 2002 to 2017 in senior author's practice were reviewed and ten patients were retrieved from the database with relevant clinical and radiological information. We have 10 patients (8 women and 2 men; mean age: 56±18.5 years; age range: 12–81 years) with remote intracranial events happened after lumbar spine surgery. Although the presenting symptoms may be mostly nonspecific, remote intracranial event should be suspected in any patient with intractable headach e, focal neurological deficits or unexplained deterioration of consciousness following spine surgery.

Key words: Spinal surgery, comlication, intracranial complications.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Lumbar spine surgery is related with various complications. Remote intracranial events after lumbar spine surgeries are relatively rare. These events usually happen due to intracranial pressure alterations caused by cerebrospinal fluid (CSF) loss following dural tear [1,18] or by peroperative systemic blood pressure changes [29,33]. These remote events may be classified into 6 groups: intracerebral hematoma (ICH), subdural/epidural hematoma (SDH/EDH), intraventricular/subarachnoid hemorrhage (IVH/SAH), cerebellar hemorrhage (CBH), cerebral venous sinus thrombosis (CVT) and others.

Etiology of these various remote complications remains unclear, yet evidence suggests that they are caused by excessive intra-opereative CSF loss and excessive post-operative suction by drains, which results in cerebral dehydration. Excessive cerebral dehydration may cause tearing of the bridging and pial veins [17,30,32]. Furthermore, CVT and hemorrhagic venous infarction may also occur in patients with pro-thrombotic states as CSF leakage indirectly contributes to volume loss in the cerebral sinuses [18,24]. Beside these, Liu et al. described pituitary apoplexy in a patient operated for lumbar fusion with anterior laparoscopic approach [23] and Choi et al. reported seizure subsequent to percutaneous endoscopic lumbar discectomy under local anesthesia [6].

In this study, we present one of the largest series composed of 10 patients, with different kinds of remote intracranial complications happened after lumbar spinal surgery. We also discuss presumed pathophysiology, differential diagnosis, and avoidance of remote intracranial complications after lumbar spinal surgery.

PATIENTS AND METHODS

Chart-review was conducted using protocols approved by the Committee for the Ethical Issues of Bahçeşehir

University, and affiliated hospitals. Remote intracranial events happened after lumbar spine surgery that were performed from 2002 to 2018 in senior author's practice were reviewed and ten of more than six thousand patients were retrived from the database with relevant clinical and radiological information.

Data regarding the following variables were looked for: demographics, clinical presentation, index spinal procedure, postoperative complications, presence/absence of drain placement, location of intracranial events, radiologic findings, treatment strategies, and outcome (Table-1).

RESULTS

There were 10 patients (8 women and 2 men; mean age: 56 ± 18.5 years; age range: 12–81 years) with remote intracranial events happened after lumbar spine surgery. All patients were symptomatic postoperatively. Onset of symptoms ranged from immediately after surgery to postoperative Day 5. Symptoms included headache (n=8), aphasia (n=2), seizure (n=3), visual problem (n=2) and altered mental status (n=3). Perioperative hemodynamic instability had not been documented for any patient. All patients underwent head CT, which revealed ICH (n=3):, SDH (n=2), IVH (n=1), SAH (n=2), CBH (n=3), CVT (n=1), intracranial tumor (n=1) and pituitary apoplexy (n=1). Five patients had more than one pathology. Seven patients were treated conservatively, while 3 patients required cranial neurosurgical intervention. Craniotomy was performed for the patient presenting with seizure who had been revealed to have concomitant intracranial tumor (n=1), microsurgical decompressive surgery was done via transphenoidal route for the patient with apoplexy (n=1) and ventriculostomy was placed temporarily to one of the patients with ICH to relieve hydrocephalus (n=1). Ultimately, 8 patients achieved a full recovery with minimal or no residual neurological deficit. Two patients with ICH died in the following weeks postoperatively one of whom had been declared as beeing brain dead on the 20th postoperative day, and the other patient had been discharged to a rehabilitation facility with some cognitive impairment and died due to pulmonary complications. Patients with ICH had the worst prognosis.

The first case who presented with low-back and bilateral lower extremity pain was a 51-year-old woman. She had neurological claudication. There was hypoesthesia on bilateral L3-L5 dermatomes. Lumbar MRI scans demonstrated spinal stenosis at multiple levels and minimal degenerative scoliosis. She underwent posterior laminectomies from L2 to L5 with L5-S1 discectomy, L5-S1 TLIF cage placement, posterior spinal fusion from T10 to S1 with instrumentation. A dural tear was identified at L4 level during the procedure. Primary closure was performed with 5-O silk, and dura sealant (Adherus®, HyperBranch Medical Technology, Inc, North Carolina). A hemovac drain was placed into the epidural space. Post-operative period was uneventful. On the fifth day, the patient readmitted to our clinic with severe back and leg pain. On physical examination, subcutaneous and paravertebral fluid collection were noted. CSF collection at the surgical site was observed on MRI, therefore re-operation was planned. At midnight, she complained of severe headache all around the head, nausea and and vomiting, which were not alleviated in the recumbent position. CT head scan depicted cerebral infarction with accompanying minimal ICH and IVH. In a few hours, she developed altered consciousness, increased vomiting and left hemiparesia despite conservative approach. On repeat head CT scan, increase in edema areas around infraction zones were observed. On MR angiography there was sinus thrombosis. Low molecular weighted heparin anticoagulation was initiated, however heparin related thrombocytopenia occured and heparin was replaced with rivaroxaban substitute. Her status got better day-by-day. After 38 days of second admission, the MRI depicted clot resolution. She had minimal residual neurologic deficits. Six-month of oral rivaroxaban regimen was scheduled.

The second patient, A-58 year-old man, admitted to our clinic due to long lasting low-back and bilateral leg pain. There were hypoesthesia on L5 and S1 dermatomal zones and 1/5 motor weakness of right foot plantar flexion. Lumbar MRI scans revealed lumbar spinal stenosis at L4 and L5 levelswith protruding additional intervertebral disc herniation. He underwent posterior laminectomy for L4, laminotomy for L5, L5-S1 microdiscectomy, and bilateral L3 to L5 transpedicular fixation with arthrodesis. The surgery was uneventful. The patient awoke from surgery neurologically intact. On the post-operative 6th hour, he became lethargic with sudden onset headache and bilateral blurred vision. An emergency head CT displayed an intrasellar lesion with varying densities, extending upward to the optic chiasm. The lesion had mass effect over optic chiasm and cavernous segments of bilateral internal carotid arteries. Corticosteroid replacement therapy was started. Other possible etiologies were searched thoroughly, nothing except the pituitary apoplexy was found. There was no electrolyte imbalance and the hormone profile was normal. A microsurgical decompressive surgery via transphenoidal route was performed on post-operative day 1. The lesion was hemorrhagic and necrotic. Histopathological analysis was compatible with PA within a chromophobe adenoma. Post-operative MRI showed the decompression of the optic chiasm. Post-operative hormone profile and electrolyte levels were in normal range. He was discharged with ongoing steroid replacement regimen. He was in awell condition 4 months after the surgery.

Tablo-1. Data regarding the following variables were looked for: demographics, clinical presentation, index spinal procedure, postoperative complications, presence/absence of drain placement, location of intracranial events, radiologic findings, treatment strategies, and outcome

Remote complication	Age (years)/ Sex	Presentation	Diagnosis	Index Spinal Procedure	Durotomy	Drain	Complaint, Symptom, Onset	Radiologic Findings	Treatment Strategies	Outcome
ICH	67 / F	back pain and severely impaired functional mobility	arachnoid cyst, spinal stenosis.	T9-11 laminectomies, arachnoid cyst fenestration, T8-12 posterior bilateral transpedicular screw fixation	deliberate	+	HA, somnolent, within 24 hours postoperatively	right frontal intracerebral hemorrhage accompanying with subarachnoid hemorrhage and bilateral cerebellar hemorrhages	Conservative	no further neurological deficits, died 3 months later after discharge
	75 / F	back pain and neurogenic claudication	lumbar spinal stenosis	L1-L5 laminectomies, , T10-S1 posterior bilateral transpedicular screw fixation	incidental		HA, somnolent, left hemiparesia, after 4 days postoperatively	right basal ganglia hemorrhage accompanying with subarachnoid hemorrhage/ intraventricular hemorrhage	Ventriculostomy	brain dead on the 20th postop day
	44 / F	back pain and postural instability	Severe Thoraco-lumbar kypho-scoliosis	L1-L4 laminectomies, , T10-L5 posterior bilateral transpedicular screw fixation	incidental		HA, after 3 days postoperatively	right frontal intracerebral hemorrhage	Conservative	Complete recovery
CBH	53 / F	Low- back and bilateral legpain	L4-5 lumbar spinal stenosis + intervertebral disc + grade II spondylolist	L4 laminectomy, L4–L5 microdiscectomy, L3-5 bilateral transpedicular screw fixation + L4-5TLIF	incidental	+	HA, dysarthria, N/V, 2 days postop	small site of hemorrhage in right cerebellar hemisphere	Conservative	Complete recovery
	48 / F	Low- back and bilateral legpain	Lumbar spinal stenosis	L4 laminectomies, L4–L5 microdiscectomy, L4-5 bilateral transpedicular screw fixation+ L4-5TLIF	incidental	+	HA, dysarthria, N/V, progressive ataxia, After 24 hours postoperatively	small sites of hemorrhage in both cerebellar hemispheres	Conservative	Complete recovery

Remote complication	Age (years)/ Sex	Presentation	Diagnosis	Index Spinal Procedure	Durotomy	Drain	Complaint, Symptom, Onset	Radiologic Findings	Treatment Strategies	Outcome
SDH	81 / M	Low-back pain, neurogenic claudication	Lumbar spinal stenosis	L4 laminectomy	incidental	+	HA, severe back / bilateral leg pain, 3 weeks postoperatively	bilateral frontal, temporal, and parietal subacute subdural hematomas	Surgical evacuation and lumbar CSF fistula repair	Complete recovery
		12 / F	Spastic tetra-paraparesia	Dorsal selective rhizotomy	deliberate		HA	Right fronto-temporal subacute subdural hematoma	Conservative	Complete recovery
CVT	51 / F	low-back and bilateral lower extremity pain	spinal stenosis, degenerative scoliosis	L2-5 posterior laminectomies, L5-S1 microdiscectomy+ TLIF cage placement, T10-S1 posterior spinal fusion + instrumentation	incidental	+	HA, N/V 5 days	venous infarction in bilateral thalamus + basal ganglia, hemorrhagia in right caudate nucleus +lateral ventricules, thrombosis in right sigmoid sinus + transverse sinus + sinus rectus	Conservative	Minimal residual deficits
Pit. Apo.	58 / M	low-back and bilateral leg pain	L4-5 lumbar spinal stenosis + intervertebral disc	L4 posterior laminectomy, L5 laminotomy, L5-S1 microdiscectomy, bilateral L3-5 transpedicularscrew fixation + arthrodesis	none	-	HA, lethargy, bilateral temporal hemianopsia 6 hours	intrasellar lesion extending upward to the optic chiasm + cavernous segments of bilateral internal carotid arteries	Decompression via transphenoidal route	No visual field defect
Seizure	66 / F	bilateral lower extremity pain and neurogenic claudication	L4-S1 spinal stenosis, grade II spondylo listhesis	L4-S1 posterior laminectomies, bilateral L4- S1 transpedicular screw fixation	none	-	Anisocoria, right sided hemiparesia, seizure 20 minutes	Intracranial right frontal, contrast-enhanced lesion with peripheral edema and midline shift	Craniotomy and tumor excision	Complete recovery

The patient who had immediate postoperative seizure was a-66-year-old woman. She presented with bilateral lower-extremity pain and neurological claudication at 100 meters. Her neurological examination and the pre-operative laboratory values were normal. Lumbar MRI scans revealed L4 to S1 spinal stenosis and grade II spondylolisthesis. She underwent posterior laminectomies for L4 to S1 with bilateral L4 to S1 transpedicular screw fixation. The procedure ended with no intraoperative complications. However, 20 minutes after turning off the anesthetics, her spontaneous respiration was still irregular, and in neurological examination there was no verbal response, anisocoria and right sided hemiparesia was observed with concomitant seizure. The patient re-intubated and an emergent head CT was performed that revealed a right frontal, intracranial contrast-enhanced lesion with peripheral edema and midline shift. Twenty-four hours after the initial surgery the patient underwent craniotomy and tumor excision, with complete neurological recovery.

One of the three patients who had remote cerebellar hemorrhage was a 48-year-old woman. She presented with pain in her lower back and both legs. The neurologic examination showed bilateral hypoesthesia on L3-L5 dermatomes. MRI scans revealed lumbar spinal stenosis, a herniated disc at L4–L5 level, and grade II spondylolisthesis at L4–L5 level. She underwent posterior laminectomies from L3 to L5, L4–L5 microdiscectomy with L3-5 bilateral transpedicular fixation. A dural tear was identified intraoperatively and primary watertight closure was performed with 4-O silk, however approximately 100 ml of CSF escaped before the closure. When this accident occurred, an immediate drop in blood pressure was observed which was attributed to the CSF leakage. After the routine treatment for hypotension (10 mg intravenous ephedrine sulfate), the blood pressure returned to normal range within approximately 10 min. Prior to closure, a hemovac drain was placed into the epidural space. The patient awoke from surgery neurologically intact. Her blood pressure was normal in the postoperative period. At 12 hours after surgery, the patient complained of severe headache and over the next 12 hours developed some dysarthria, followed by vomitting. Over the course of the next 24 hours the patient was conscious. In the first 24 hours after surgery, 500 ml of fluid were removed via the hemovac drain. Emergent head CT demonstrated small sites of hemorrhage in right cerebellar hemisphere. The results of laboratory investigations, including platelet count and a clotting screen, were all in the normal range. The patient was managed conservatively with anti-edema treatment (4 mg intravenous dexamethasone every 6 h), analgesics, and immobilisation. Her neurological status did not deteriorate any further after the detection of hemorrhage. Control head CT at 48 hours showed no enlargement of the hemorrhage sites and there was no hydrocephalus. Nine days after the operation, the patient was discharged in good condition with no neurologic deficits and she was full mobile.

One of the three patients who had ICH was a-67-year-old woman with a history of diabetes mellitus and Parkinson's disease. She presented with intractable back pain and severely impaired functional mobility. Paraparesia of 3/5 motor weakness and hypoesthesia on bilateral T8 to S1 dermatomes were significant findings. Lumbar MRI scans demonstrated arachnoid cyst and thoracolumbar spinal stenosis at multiple levels with kyphoscoliosis. She underwent posterior laminectomies from T9 to T12 and T8 to T11posterior spinal fusion with bilateral transpedicular instrumentation. Preoperative blood pressure was 110/75 mmHg, after general anesthesia administration blood pressure dropped to 102/74 mmHg and remained within this value throughout the surgery. Total per-operative blood loss was 200 cc. The dura was opened for arachnoid cyst fenestration. Primary watertight closure was performed with 4-O silk, and dura sealant (Adherus®, HyperBranch Medical Technology, Inc, and North Carolina) was used to cover the repair site. A hemovac drain was placed into the epidural space. Post-operative laboratory values were within normal limits. Motor function was similar with preoperative state upon awakening. However, within 24 hours, the patient had severe onset headache, became somnolent and left hemiparesia became more prominent. Hence, an emergent head CT was held and revealed a right frontal intracerebral hemorrhage accompanying with subarachnoid hemorrhage, bilateral symmetrical cerebellar hemorrhages and intraventricular hemorrhage. MR-Venography of the patient was in normal limits, which excluded hemorrhagic venous infarction. In the first 24 hours postoperatively, 600 ml of serosanguineous fluid were removed via the hemovac drain and then it was removed. The patient was admitted to ICU and managed conservatively with both anti-edema treatment (4 mg intravenous dexamethasone every 6 h) and anti-epileptic treatment (500 mg intravenous Levetiracetam every 12 h). Her neurological examination status improved to baseline.

The patient was discharged to a rehabilitation facility 6 weeks after surgery with no further complications or neurological deficits. However, cognitive defects, residual dysphagia and neurogenic bladder was still present. She died 3 months later of aspiration pneumonia.

One of the two patients who had SDH was a-81-year-old man with a history of hypertension, diabetes mellitus. He presented with lower back pain, minimal lumbar scoliosis and severe neurogenic claudication at 10 meters. He was intact on neurological examination. Lumbar MRI scans demonstrated spinal stenosis at multiple levels. All laboratory data including coagulation status were within

normal limits. He underwent posterior laminectomies for L4 to L5 with L4-L5. A dural tear was identified intraoperatively which was closed with a running 4-0 silk suture and was tested under direct visualization with an applied Valsalva breath at 40 mm Hg. No residual leak was observed at that time. A hemovac drain was placed into the epidural space. Post-operative neurological examination and laboratory values were normal. However the patient noticed a slight diffuse headache while standing up and over the next 3 weeks, the headache increased dramatically and analgesics were ineffective. The pain consistently relieved in the recumbent position, therefore he remained confined to bed most of the time. Additional symptoms included severe back and bilateral leg pain. Upon admission to hospital, on physical examination, subcutaneous and paravertebral fluid collection were noted. His Glasgow Coma Scale score was 15/15 with no focal motor deficit. CSF collection at the surgical site was observed on lumbar MRI, therefore re-operation was planned. After MRI scans of the brain, which revealed bilateral subacute subdural hematomas extending along the frontal, temporal, and parietal regions, more prominent on the right side, the surgical plan was changed and it was decided to drain the hematoma from bilateral burr-holes together with repairing the CSF fistula. After draining the hematoma, the lumbar spinal exposure was held. We observed a dural tear, sutured primarily and applied dura sealant (Adherus®, HyperBranch Medical Technology, Inc, North Carolina) over the repaired dural defect. No per-operative complication occurred. The patient's complaints improved dramatically after the surgery. She was discharged from the hospital the third day after the operation with resolution of her symptoms.

DISCUSSION

Despite the large patient series have been reported about lumbar spinal surgery, literature on the prevalence of postoperative remote intracranial complications is sparse. Most of the reported cases are about ICH and CBH with or without IVH/SAH after lumbar spinal surgery [11,18,20,22,32]. SDH (less than 10 cases) [1,7,16,18,28], seizure (5 cases) [6,12], EDH (1 case) [18], pituitary apoplexy (1 case) [23] and CVT (1 case) [24] are other various remote complications.

The highest incidence of remote intracranial complication after lumbar spinal surgery is attributed to postoperative ICH and CBH [4,17]. Although more common etiologies for spontaneous cerebral hemorrhage are hypertension, coagulopathy and anti-coagulant treatment, it is rarely present in previously published reports for remote ICH or CBH after spine surgery. Instead, the most consistent contributing factor is a dural tear [18], one of the most common complications of spine surgery with a prevalence of 1 to 17 % [8,10,15,17,19]. The causes of peroperative dural tear include either eroded or thin dura, dura adhesion, and redundant dura in patients diagnosed with a tight spinal stenosis in primary spine surgery or patients who have epidural fibrosis and scar tissue adherent to the dura during revision of spine surgery [25,34]. The pathophysiological mechanism of ICH/CBH after CSF loss is unclear, yet the evidence suggests that the hemorrhages has been postulated to happen after excessive intra-operative CSF loss and excessive post-operative suction by drains, which results in cerebral dehydration, resulting in stretching and therefore tearing of the cerebral and cerebellar veins [4,17,20,22].

In our clinical practice, presentation of the patients ranges from transient cerebellar findings to large lobar hematoma causing hydrocephalus, which can be accurately diagnosed by computed tomography (CT) and magnetic resonance imaging (MRI). Kaloostian et al reported that 33% of patients with ICH were symptomatic within the first 10 hours postoperatively (17). Similarly, in our series, symptoms of 3 patients with ICH begun after 12 hours. ICHs/CBHs are usually located subcortically [17,21-22]. CBH usually has a streaking pattern of subarachnoid blood along the superior aspect of the cerebellar folia, so-called "zebra sign", which is related to a prior or ongoing loss of CSF [4,13,34].

Treating the complication of ICH varies depending on location and extent of hemorrhage and clinical examination status of the patient. Patients who have a small hemorrhage without significant mass effect and whose neurological status is appropriate may be managed conservatively with immediate removal of subfascial drain and complete bed rest, but in some cases surgical removal of hematoma, re-exploration of the surgical site or external ventricular drainage for hydrocephalus may be needed [5,11,17-18,26-27]. Mortality rates reported for remote ICH and CBH after spinal surgery reveals a mortality rate of 14% and 10 to25%, respectively [21,32]. Kaloostian et al reported that in their series of 8 patients with remote ICH, 2 were declared brain dead during their postoperative hospital stay, and 1 expired of aspiration pneumonia [17]. In our experience, 2 of 3 patients with ICH, died due to complicating systemic problems. However, all of the patients with CBH were managed conservatively, recovered well and discharged neurologically intact.

Up to date, there have been reported only seven cases of intracranial SDH after spinal surgery [1,9,13,18,30]. Similar mechanisms for remote CBH/ICH are thought to be responsible for subdural hematoma formation after CSF leakage with ensuing intracranial hypotension [2,4,17,18,20,22,25]. However, the exact pathophysiological mechanism is not known. In the present study, none of the 2 patients had a history of head injury or received anticoagulants and the postoperative coagulation status

was within normal limits. The patient with SDH after selective dorsal rhizotomy was treated conservatively with bed rest, hydration and analgesic, but the treatment of second case with huge lumbar CSF fistula necessitated bilateral hematoma evacuation with spinal dural defect repair.

Seizure and delayed emergence from anesthesia after spine surgery has been reported [2,6,12,31]. Here, we describe seizure after elective lumbar spine surgery as a first clinical manifestation in a patient with undiagnosed brain tumor. Seizure after accompanied by neurological findings may be the first sign of intracranial tumor. Several factors likely contributed to the exacerbation of mass effect and neurological sequelae after the laminectomy, including prone position, intraoperative fluid administration, surgical stress, and residual anesthesia.

A meticulous review of the literature showed that other sparse remote intracranial complications after lumbar spine surgery have been described [3,6,9,12,23-24]. In our study, we included the patients with cerebral venous thrombosis (CVT), pituitary apoplexy and seizure; respectively (described in case series). CVT is a extremely rare complication after spine surgeries, which may occur in patients with pro-thrombotic states as CSF leakage indirectly contributes to volume loss in the cerebral sinuses [18,24,27]. To the best of our knowledge, this is the second report of intracranial CVT after lumbar spine surgery complicated by dural tearing which has high mortality and morbidity rates if no intervention is done in time. High clinical suspicion in patients with severe headaches worsening in erect positions, focal neurological deficits, seizure and depressed consciousness with necessitate radiological tools and genetic analysis for thrombophilia.

Here, we also describe seizure after elective lumbar spine surgery as a first clinical manifestation in a patient with undiagnosed brain tumor. Seizure accompanied by neurological findings may be the first sign of intracranial tumor. Several factors likely contributed to the exacerbation of mass effect and neurological sequelae after lumbar spine surgery; including prone position, intraoperative fluid administration, surgical stress, and residual anesthesia.

Beside these, Liu et al described pituitary apoplexy in a patient operated for lumbar fusion, with anterior laparoscopic approach [23]. Pituitary apoplexy should be kept in mind for differential diagnosis in cases of headache, nausea, vomiting, ophthalmoplegia, visual loss and electrolyte imbalance occurring after spinal surgeries, which we encountered as the second case in the literature.

Although the presenting symptoms may be mostly nonspecific, remote intracranial event should be suspected in any patient with intractable headache, focal neurological deficits or unexplained deterioration of consciousness following spine surgery; especially complicated by known dural tear and CSF leak. These symptoms will necessitate radiological studies for diagnosis; and appropriate treatment method will be initiated spesific for each patient will save their life with good clinical outcomes.

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Volume: 29, Issue: 3, July 2018 pp: 173-176 ORIGINAL ARTICLE

IS EARLY RADIOLOGICAL IMAGING REQUIRED FOLLOWING SPINAL FUSION OPERATIONS?

Okan TÜRK[1],
İbrahim Burak ATÇI[1]

[1] *İstanbul Training and Research Hospital, Department of Neurosurgery, İstanbul*

ORCID Numbers:
- Okan TURK:
0000-0002-0074-2835
- İbrahim Burak ATCI:
000-0002-0317-4159

Address: : Okan TÜRK,
İstanbul Training and Research Hospital, Fatih, İstanbul, Turkey.
E-mail: drokanturk@gmail.com
Phone: +90 506 763 71 73
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ABSTRACT

Objective: This study aims to determine the effect of lumbar computed tomography of the cases subjected to early postoperative lumbar fusion surgery on the re-operation rate and to establish the rate of early malposition.

Material and methods: Sixty-five cases, which underwent posterior stabilization according to indications with the operations carried out in our department between 2014 and 2017, and 476 transpedicular screws files with 238 levels were evaluated retrospectively.

Results: It was found out that, 37 cases were operated under anterior- and posterior-controlled fluoroscopy (A-P) and that only 28 cases underwent operation with laterally controlled fluoroscopy. Lumbar thin-slice bone tomography was produced for all the cases as postoperative control. It was found out that single level transpedicular screw moved from safe range to medial in seven cases, and four of these patients were taken to revision surgery due to postoperative leg pain. Two cases were determined to have single transpedicular screws moved to lateral, and revision surgery was not deemed necessary for no clinical finding was present. It was determined that nine instruments with screw malposition developed only in laterally controlled fluoroscopy cases. The length of hospital stay was calculated to be 3.1 ± 0.7 days. The screw malposition rate was 0.1 %.

Conclusion: Indication-free postoperative lumbar CT imaging for patients without any clinical finding will decrease in case A-P and lateral fluoroscopy utilization and, in particular, the interpretation of images are taught to other surgeons by spinal surgeons in clinics.

Key Words: Spinal fusion, diagnosis, radiologic imaging.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

In the last two decades, the frequency of spinal stabilization and fusion surgeries against degenerative diseases and trauma has increased and established the substantial number of brain surgeries today. Such operations are conducted in order to correct spinal deformity, increase the success of fusion, support the decompression of neural elements after stabilization and facilitate postoperative rehabilitation process.

There are more than 40.000 fusion surgeries on average carried out in the USA annually for thoracolumbar vertebra. This number is responsible for approximately 20 % of all the surgical interventions implemented on lumbar region. A majority of the fusion procedures avails of spinal instrument [(4)].

Such surgical interventions frequently carried out in conjunction with lateral and anterior-posterior imaging techniques according to the convenience of operation table in C-arm fluoroscopy control. As regards to further spinal centers, pedicle screws can be placed impeccably in company with O-arm fluoroscopy and neuronavigation. Pedicle is adjacent to neural foramen and central

canal. There may be instrumental positions in surgeries without laminectomy due to puncture place or angular errors. The screw may contact neural foramen, lateral or central canal or, passing through corpus anterior, vascular structures. Though fluoroscopy frequently ensures control during surgery in most clinics, spinal surgeons and clinics generally control the instruments with a lumbar CT they create before the patient is discharged. Many surgeons traditionalized such ritual as a standard procedure for their clinics.

This study aims to determine the effect of lumbar CT of the cases subjected to early postoperative lumbar fusion surgery on the re-operation rate and to establish the rate of early malposition.

MATERIAL AND METHOD

Sixty-five cases, which underwent posterior stabilization according to indications with the operations carried out in Neurosurgery Department between 2014 and 2017, and 476 transpedicular screws files with 238 levels were evaluated retrospectively.

The cases were registered upon the evaluation of their age, sex, operational cause, operational level, transpedicular screw number, pre- and post-operative topographies, re-operational cause, operational notes and fluoroscopy controls during operation.

RESULTS

This study covers 65 patients who were subjected to posterior segmental instrumentation. The population consisted of 52 female and 13 male patients. The youngest operated case was 21 while the oldest was 77. Average age of the population of this study is 57,218 ± 14,312. The number of patients who underwent operation for T-12 fracture, L-1 fracture, recurrent lumbar disk hernia, listhesis and lumbar spinal stenosis and spondylosis was 5, 2, 10 (3 patients underwent 3 surgeries while 7 patients underwent 2 operations), 7 (5 cases had grade-1 listhesis while 2 had grade-2 listhesis) and 41, respectively. In consideration of the operational levels, the number of the patients who were evaluated as T10-L2, L1-L3, L2-L4, L2-L5, L1-L5, L3-S1, L3-L4, L5-S1, L4-L5 and L3-L5 level was 7, 1, 4, 4, 4, 5, 6, 6, 10 and 26, respectively. The total number of transpedicular screws availed of for 238 corpuses was 476.

In consequence of the evaluations, it was found out that, 37 cases were operated under anterior- and posterior-controlled fluoroscopy (A-P) and that only 28 cases underwent operation with laterally controlled fluoroscopy. Lumbar thin-slice bone tomography was produced for all the cases as postoperative control. It was found out that single level transpedicular screw moved from safe range to medial in seven cases, and four of these patients were taken to revision surgery due to postoperative leg pain. Two cases were determined to have single transpedicular screws moved to lateral, and revision surgery was not deemed necessary for no clinical finding was present. It was determined that nine instruments with screw malposition developed only in laterally controlled fluoroscopy cases. The length of hospital stay was calculated to be 3.1 ± 0.7 days. The screw malposition rate was 0.1 %.

The evaluation of postoperative complications demonstrated that bilateral drop foot developed in one case even though the screws did not violated the pedicular region. However, the case showed full recovery in terms of muscle strength in the follow-up of the following days. Five cases developed postoperative deep wound site infection. These cases started intravenous antibiotherapy upon consultation with Infectious Diseases. The cases were hospitalized and daily infection indicators were followed. Two cases that developed infection in wound site were re-operated and were treated with wound site revision, debridement and irrigation by use of two thick drainages. One case developed closed cerebrospinal fluid (CSF) fistula but was discharged without a complaint after no deficit was found in the follow-ups

DISCUSSION

The most significant point in the surgical treatment of degenerative diseases such as vertebral deformity, vertebral tumors, spondylolisthesis and lumbar spondylosis is the re-establishment of pathological vertebral segment decompression and stabilization. In the literature, King was the first person to apply screws for facet joint stabilization in vertebra in 1944. Boucher followed him and realized the first transpedicular screw use in 1959 [9,12]. Recently, posterior transpedicular screw fixations become the standard method for spinal instrumentation.

Though it has many positive effects, spinal instrumentation may also bring along various problems based on performed surgeries and the devices used. Various complications may emerge in the early intraoperative and postoperative periods such as screw breaking, screw malposition, spinal cord injury, retroperitoneal organ injury and screw elusion [1,3].

The literature contains a wide range of articles concerning screw malposition. As regards to transpedicular screw applications, the right-place screw rate is 69-94 % in techniques that are not fluoroscopy-controlled while it is 81-92 % in fluoroscopy-controlled techniques [10-11]. Screw malposition rate was reported to be 1.1-28.2 % in radiological imagines [2].

Neurological deficits due to screw malposition are rare. A study, which evaluated 3204 screws, reported no vascular, neurological or visceral damage due to any of the screws

[5]. However, another study reported neurological deficit rate to be 0.8 % [13].

The recent studies evaluated 10.350 cases which underwent spinal instrument surgery, and reported operational indication rate due to screw malposition to be 1.12 % among 116 cases.

Revision surgery may not be necessary for each screw malposition determined in neuroimaging. However, surgery may be necessary in case medial clinical cases which contact with root and canal are determined (postoperative neural deficit increase, pain, urinary and excremental incontinence) [7].

Defensive medical applications became prevalent among physicians due to recently increasing malpractice cases, and Lumbar tomographies are produced and started to be applied as a standard procedure in many clinics even though patients has no complaint in early postoperative neurological evaluations. Martin et al. compared the cases for which cervical radiography was produced and for which no radiography was taken in the 1st day among the cases which underwent fusion surgery and anterior servikal discectomy. It was found out that neuro-imagines without clinical findings increase exposure to radiation extend the length of hospital stay and has no positive contribution to the final condition [6].

In a study, Molinari et al. retrospectively assessed the patients who they evaluated with neuroimaging during hospitalization among the cases that underwent single level spinal fusion surgery. The study concluded that neuro-imagines for cases, which do not have any postoperative complaint and neuro-deficit condition, have no positive contribution to results [8].

Our study evaluated 65 cases and 450 pedicular screws. Standard lumbar CT imaging was applied to the cases in the postoperative day (between postop 1st and 12th hours). It was found out that 12 patients had screw malposition while 1 had neurodeficit. Four cases underwent re-operation in the early postoperative hours.

In this study, all the cases were operated with preoperative fluoroscopy control. It was determined that lateral imaging alone was applied to the patients with screw malposition. The reasons why A-P imaging was applied were determined to be the tables taken to the main hall, which are not compatible with A-P imaging and the surgeons who did not prefer A-P imaging.

CONCLUSION

The routine spinal imaging required in the early postoperative period was found out to be a process that does not contribute to the final condition in cases with intact neurological examination and no complaint and that increases the exposition to radiation and the length of hospital stay to a certain extent. However, it was revealed that fluoroscopy-controlled lateral and A-P imaging during lumbar stabilization surgery could decrease the rate of screw malposition. We believe that indication-free postoperative lumbar CT imaging for patients without any clinical finding will decrease in case A-P and lateral fluoroscopy utilization and, in particular, the interpretation of images are taught to other surgeons by spinal surgeons in clinics.

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Volume: 29, Issue: 3, July 2018 pp: 177-181 ORIGINAL ARTICLE

SPINAL ANESTHESIA FOR ELECTIVE LUMBAR SPINE SURGERY: IS IT EFFECTIVE?

Cumhur Kaan YALTIRIK[1]

[1] *Department of Neurosurgery, Yeditepe University School of Medicine, Istanbul, Turkey.*

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ORCID Number:
-Cumhur Kaan YALTIRIK:
000-0002-4312-5685

Address: Cumhur Kaan YALTIRIK, Department of Neurosurgery, Yeditepe University Faculty of Medicine, Istanbul, Turkey.
Phone: +90 533 3331800
Fax: +90 216 5784965
Email: dr_cky@yahoo.com
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ABSTRACT

Background: Lower back pain is a common problem in society leading to a decrease in work forces. Clinical studies indicate that the source of back pain is intervertebral disc and lumbar stenosis. Surgery for lumbar disc and lumbar stenosis can be performed under general or local anesthesia. In this study, we aimed retrospectively examination lumbar disc and lumbar stenosis patients, operated under SA, and evaluate advantages and disadvantages of this technique.

Methods: Two hundred twenty two patients who were operated for lumbar disc herniation (LDH) and lumbar stenosis (LS) under SA between March 2012 and September 2013 were included in this study. Clinical data, neurological examination, additional diseases, VAS scores, operation duration, intraoperative complication, first ambulation time, postoperative headache and hospital stay durations were collected for statistical analysis.

Results: Ninety-four (42.3 %) patients were male, and 128 (57.7 %) were female. Mean age of the males and females were 47.6 and 48 years, respectively (p=0.74). Most frequent operation technique was hemipartial laminectomy and microdiscectomy (73.9 %), followed by HPL and foraminotomy (25.2 %). Comparisons between males and females revealed operation type (p=0.39), diagnosis (p=0.17), and localization (p=0.25) not to be statistically significant between genders. There was statistically significant decrease in the VAS scores immediately after surgery (p<0.001). 7 (3%) patients needed additional intraoperative anesthetic. 8 (3.6 %) patients experienced hypotension and nausea during surgery. 153 (68.9 %) patient did not suffer from postoperative headache, while 11 (4.9 %) patient had severe headache.

Conclusion: Our study also supports spinal anesthesia in elective lumbar surgeries to decrease the surgical procedure time, loss of blood, earlier postoperative mobilization and oral feeding. However, disadvantages include post-op headache and the hypotension due to spinal anesthesia level getting higher, nausea and vomiting. In well-selected cases, the effectiveness of spinal anesthesia is proven high.

Key Words: Elective lumbar surgery, spinal anesthesia, general anesthesia.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Lower back pain is a common problem in society leading to a decrease in work forces. The lifetime prevalence reaches 80 % and annual hospital admission rates of the adult population are 15 %. Clinical studies indicate that the source of back pain are intervertebral disc pathologies in up to 39 % [(2)]. Open discectomy is the most commonly used surgical technique for lumbar disc herniation cases. Surgery can be performed under general or local anesthesia. Patient satisfaction and the ability to carry out prolonged operations in prone position without airway compromise are of advantages of using GA.

Regional anesthesia can be used for lower thoracic or lumbar spinal procedures [(1-2)]. Alternatively, the most important advantages of regional

anesthesia are the decrease of intraoperative blood loss and consequently improving operating conditions, the decrease in perioperative cardiac ischemic incidents, postoperative hypoxic episodes, arterial and venous thrombosis, and to provide proper postoperative pain control [1,10].

Additionally, in order to prevent brachial plexus injury and facial pressure necrosis, it is better to allow patients to position themselves while they are awake.

For regional anesthesia, spinal or epidural anesthesia can be selected [1,12,15]. With SA, the nerves carrying pain to the lower body and to the muscles of the lower extremities are paralyzed for a short amount of time. SA does not affect the function of the brain, respiratory system and intestines, which is caused conventional anesthesia. Therefore, patients undergoing surgery with SA will be able to be fed orally and mobilized earlier post-operatively. SA and epidural anesthesia are very similar techniques but the effect of narcotic medication administered during epidural anesthesia is shorter, hence requiring the needle to be fixated at site. Thus, as the effect of anesthesia passes, the drug can be re-administered. Compared to epidural blockade, SA provides a more rapid onset, a more predictable level of analgesia, and a more profound degree of surgical anesthesia. On the other hand, SA is associated with a greater degree of hypotension compared to epidural anesthesia [4]. However, SA may cause cardiologic and neurologic difficulties.

In this study, we aimed retrospectively examination of lumbar disc and lumbar stenosis patients, operated under SA, and evaluate advantages and disadvantages of this technique.

MATERIALS AND METHODS

Patients

Two hundred twenty two patients who were operated for lumbar disc herniation (LDH) and lumbar stenosis (LS) under SA between March 2012 and September 2013 were included in this study. Patients with uncontrolled diabetes, malignant hypertension, contra-indication for regional anesthesia, hemorrhagic diathesis, the use of anticoagulants, infection on operation site, neurological problems other than those caused by the lumbar disc, Kobner positive (psoriasis, pemphigus vulgaris), allergies of local anesthetics allergic, patients with cooperation problems and who did not accept epidural anesthesia were excluded from the study. Patients included in the study were seen on the ward in their rooms and their pre-anesthesia examinations were performed one day prior to the operation. They were informed about both regional and GA and their informed consent was obtained.

Clinical data, neurological examination, additional diseases, VAS scores, operation duration, intraoperative complication, first ambulation time, postoperative headache and hospital stay durations were collected for statistical analysis.

Spinal Anesthesia Technique

Premedication was administered for all patients before transferred to the OR. Generally, preoperative opioid is helpful in relieving the pain associated with needle insertion. The patient must be monitored during the induction of spinal anesthetic with a pulse oxymeter, blood pressure cuff and ECG. Noninvasive blood pressure should be measured at 1-minute intervals initially as hypertension may occur suddenly.

After positioning of the patient (usually sitting position), the incision site is cleaned with preparation solution and area should be covered with sterile cover. A small wheal of local anesthetic is injected into the planned operation site. Spinal needle is inserted into subarachnoid space. After confirming placement by the outflow of spinal fluid, Bupivacaine and Fentanyl are administered into the intrathecal space and patients were placed in supine position. It takes around five to ten minutes to establish spinal block (which usually occurred between T-6 and T-10). After 15 minutes, the patient is placed in an appropriate prone position for lumbar disc surgery. Oxygen at 2L/min via nasal cannula was administered afterwards.

In condition of nausea, head elevation maneuver and antiemetic drugs were effective. If surgery takes longer than planned and the patient starts experiencing pain, additional intraoperative intrathecal anesthetics are applied.

Statistical Analyses

Descriptive data were presented as mean and standard deviations, and median and min-max for numerical variables, and frequencies and percent for categorical variables. Independent group comparisons were analyzed with Chi-square and Mann-Whitney U tests between genders. Multiple group comparisons were analyzed with Friedman non-parametric test of variances, and visualized using line graphs. A Type I error level of 5% was considered as statistical significance in analyses. SPSS 18 (IBM Inc., Armonk, USA) was used for the statistical assessments.

RESULTS

Two hundred twenty two patients were included in the study. Ninety-four (42.3 %) patients were male, and 128 (57.7 %) were female. Mean age of the males and females were 47.6 and 48 years, respectively (p=0.74).

Most frequent operation technique was hemipartial laminectomy and microdiscectomy (73.9 %), followed by HPL and foraminotomy (25.2 %). Patients were mostly diagnosed with LDH (73.9 %) and LS (24.8 %). Most frequently, the pathology was localized to the left (50%), and bilateral disease was present only in 14 % of the cases. Comparisons between males and females revealed operation type (p=0.39), diagnosis (p=0.17), and localization (p=0.25) not to be statistically significant between genders (Table-1).

The changes in the VAS score before and after surgery is presented in Table-2. As expected there was a sharp and statistically significant decrease in the VAS scores immediately after surgery (p<0.001) (Table-2). This decrease was also consistent among all subgroups (Figure-1).

Seven (3 %) patients needed additional intraoperative anesthetic. 8 (3.6 %) patients experienced hypotension and nausea during surgery. 153 (68.9 %) patient did not suffer from postoperative headache, while 11 (4.9 %) patient had severe headache. Mean duration of surgery was 65 minutes and the mean hospital stay was 1.1 days.

Table-1. General demographic characteristics of patients

	All patients	Males (n=94)	Females (n=128)	p
	Mean±SD	Mean±SD	Mean±SD	
Age (years)	47.8±12.83	47.6±13.7	48.0±12.2	0.74
	n (%)	n (%)	n (%)	p
Operation type				0.39
HPL-Microdiscectomy	164 (73.9)	74 (78.7)	90 (70.3)	
HPL, foraminotomy	56 (25.2)	20 (21.3)	36 (28.1)	
HPL-pedicule screw	1 (0.5)	-	1 (0.8)	
Total laminectomy, pedicule screw	1 (0.5)	-	1 (0.8)	
Diagnosis				0.17
LDH	164 (73.9)	74 (78.7)	90 (70.3)	
LS	55 (24.8)	20 (21.3)	35 (27.3)	
Instability + LS	3 (1.4)	-	3 (2.3)	
Localization				0.25
Bilateral	31 (14)	9 (9.6)	22 (17.2)	
Right	80 (36)	37 (39.4)	43 (33.6)	
Left	111 (50)	48 (51.1)	63 (49.2)	

Table-2. Changes in the VAS scores before and after surgery

	Preoperative	Postoperative 1st day	Postoperative 7th day	Postoperative 1st month	p
	Median [min-max]	Median [min-max]	Median [min-max]	Median [min-max]	
Gender					<0.001
Male	8 [6-10]	2 [1-4]	2 [1-3]	1 [0-2]	
Female	7 [6-10]	2 [1-5]	2 [1-3]	1 [0-3]	
Operation type					<0.001
HPL-Microdiscectomy	8 [6-10]	2 [1-4]	2 [1-3]	1 [0-2]	
HPL, foraminotomy	6 [6-8]	2 [1-4]	1 [1-3]	1 [0-2]	
HPL-pedicule screw	8 [8-8]	4 [4-4]	3 [3-3]	1 [1-1]	
Total laminectomy, pedicule screw	8 [8-8]	5 [5-5]	3 [3-3]	3 [3-3]	
Diagnosis					<0.001
LDH	8 [6-10]	2 [1-4]	2 [1-3]	1 [0-2]	
LRS	6 [6-10]	2 [1-3]	1 [1-3]	1 [0-2]	
Instability + LRS	8 [8-8]	4 [4-5]	3 [3-3]	1 [1-3]	
Localization					<0.001
Bilateral	7 [6-10]	2 [1-5]	1 [1-3]	0 [0-3]	
Right	7 [6-10]	2 [1-3]	2 [1-3]	1 [0-2]	
Left	8 [6-10]	2 [1-4]	2 [1-3]	1 [0-2]	

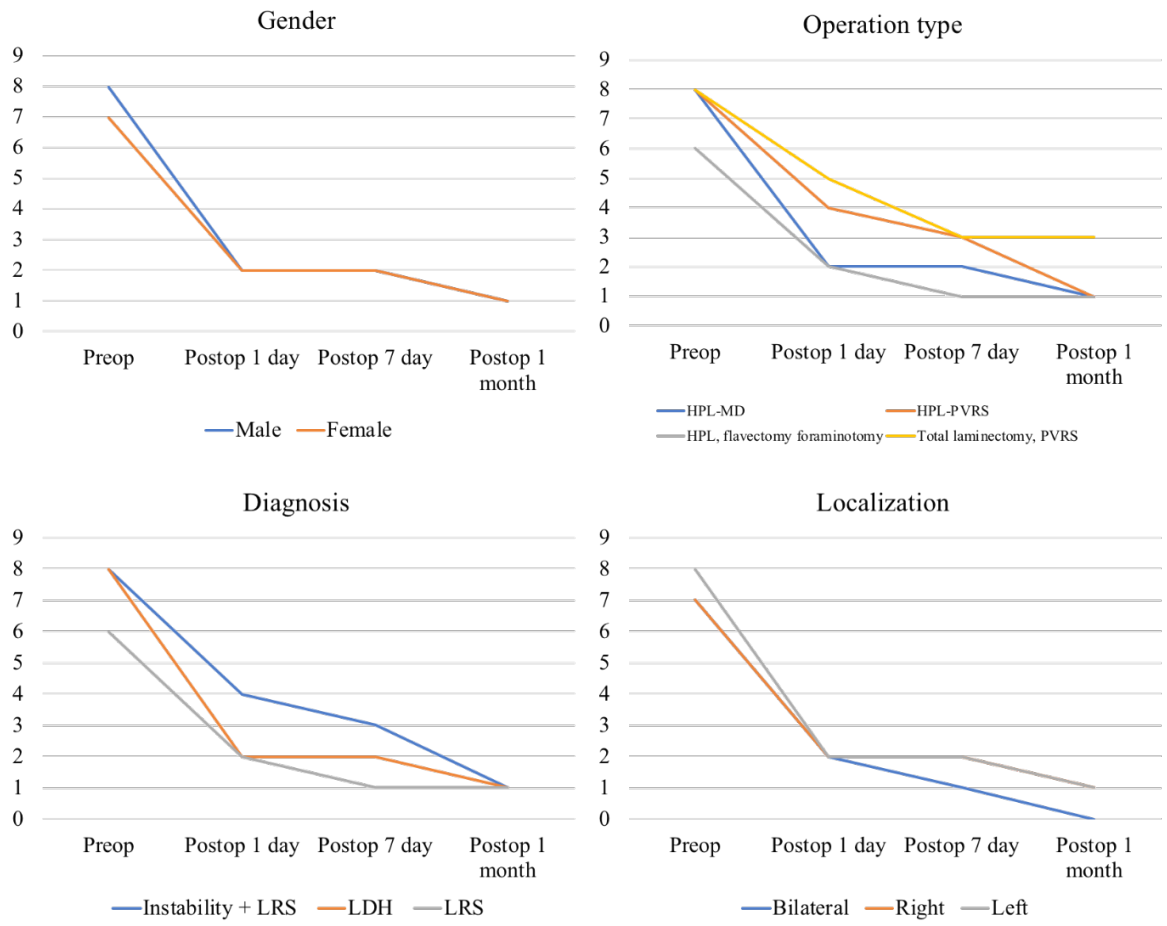

Figure-1. Changes in the VAS scores before and after surgery

DISCUSSION

Spinal, epidural or GA have been performed for lower spine surgery [1-6,8-14]. Greenbarg et al showed, SA reduced blood loss for lower limb orthopedic and vascular surgeries compared to GA [6]. Covino et al also repoted blood loss and thromboembolic complications to be reduced when SA is used [4]. In retrospective chart review, Tetzlaff et al [13] investigated the outcomes of a large series of elective lumbar spine surgical procedures performed under SA or GA. They concluded SA to be considered as an effective alternative to GA for lumbar spine surgery as it presented lower incidence of minor complications [15]. In another study of Tetzlaff et al preservation of BP on assumption of the prone position in patients during low SA suggested better preservation of autonomic nervous system compensatory mechanisms during low SA than with GA. Hassi et al reported 85.6% excellent results with SA [7]. Jellish et al compared GA and SA. They reported similar results between two groups when comparing intraoperative hemodynamics except that the incidence of increased blood pressure was more frequent with GA (26.2 % vs 3.3 %). Blood loss was less during SA (133 ± 18 mL vs 221 ± 32 mL). Postanesthesia care unit heart rates and mean arterial pressures were higher in the GA group.

McLain et al in a case-controlled study in 400 patients underwent either SA or GA for performing lumbar decompression, showed that SA was as effective as GA. They concluded that SA caused shorter anesthesia duration, decreased incidence of nausea and analgesic needs, and accompanied with fewer adverse effects [10].

Attari et al reported that SA may be better compared to GA. SA diminished blood loss, maximum blood pressure and heart rate changes, and postoperative analgesic use. In addition, surgeon and patients satisfaction was significantly more in SA [3].

Our study also supports spinal anesthesia in elective lumbar surgeries to decrease the surgical procedure time, loss of blood, earlier postoperative mobilization and oral feeding. However, disadvantages include post-op headache and the hypotension due to spinal anesthesia level getting higher, nausea and vomiting. In well-selected cases, the effectiveness of spinal anesthesia is proven high.

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Volume: 29, Issue: 3, July 2018 pp: 183-187 ORIGINAL ARTICLE

CAN RADIOTHERAPY BE A NEW TREATMENT FOR POST-LAMINECTOMY LOW BACK SYNDROME?

Mehmet Hakan SEYITHANOĞLU[1], Serkan KITIŞ[1], Tolga Turan DÜNDAR[1], Meliha Papaker GÜNDAĞ[1], Huriye Senay KIZILTAN[2], Ali Hikmet ERIŞ[2].

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

[2] *Department of Radiation Oncology, Bezmialem Vakif University Medical Faculty, Istanbul, Turkey.*

ORCID Numbers:
- Mehmet Hakan SEYITHANOGLU: 000-0002-6072-0347
- Serkan KITIS: 0000-0002-9119-5899
- Tolga Turan DUNDAR: 000-0003-0030-2618
- Meliha PAPAKER GUNDAG: 000-0003-1271-9023
- Huriye Senay KIZILTAN: 0000-0002-9930-7197
-Ali Hikmet ERIS: 0000-0001-7118-2348

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Address: Dr. Serkan Kitiş, Department of Neurosurgery, Hospital of Bezmialem Vakif University, Vatan Street, 34093 Fatih, Istanbul, Turkey
E-mail: serkankiti@yahoo.com
Phone: +90 505 374 31 50
Fax: +90 212 453 18 70
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ABSTRACT

Introduction: Post-laminectomy peridural fibrosis and arachnoid adhesions related to lower back pain are common problems after laminectomy operations. Previous studies have shown that radiotherapy might prevent low back syndrome after laminectomy.

Methods: In this study, 23 male Wistar albino rats were used. Group I included nine rats that underwent laminectomy (L group), group II included nine rats treated with laminectomy and perioperative radiotherapy (L + R group). Group III included five rats and was used as a control group that did not undergo treatment. Laminectomy was performed in the L3 and L4 lumbar vertebral regions of group I and II rats. Rats in-group II also received perioperative radiotherapy in the laminectomy area. Radiotherapy was perioperative provided with electron radiation to a total dose of 700 cGy as a single fraction.

Results: Histopathological grade 0 epidural fibrosis and grade 1 fibroblast cell density ratios were 44.44% and 88.88% in the L + R group, 0% and 33.33% in the L group, respectively. Arachnoid adhesions were present in 88.8% of the L group, but only 44.4% of the L + R group. Grade 3 epidural fibrosis was shown in four rats (44.44%) in the L group and one rats (11.11%) in the L + R group.

Conclusion: Results indicate that perioperatively provided radiotherapy is significantly advantageous in preventing post-laminectomy adhesions and is not toxic.

Keywords: fibrosis, low-dose radiotherapy, failed back surgery syndrome, post-laminectomy

Level of Evidence: Level II, experimental study.

INTRODUCTION

Laminectomy is indicated for the surgical treatment of radicular nerve pain, spinal obstruction, pressure-related paresis, and plegia. Previous research indicates that lower back and radicular pain recurs in as many as 24% failed back surgery syndrome (FBSS) cases after laminectomy, which is a significant proportion [7,16].

Epidural scar tissue, also known as the post-laminectomy membrane, is the primary cause for these complications. Peridural fibrosis is a common cause of pain in patients after spinal surgery. Gabriel et al. indicate that a common cause of fibrosis is tissue regeneration due to the destruction of epidural fat, intraspinal hematoma, and replacement of the erector muscles of the spine into the spinal canal at the operation site [7,16].

Fibrosis may lead to pain and neurolysis because it exerts pressure [4,10], and postoperative scar formation usually inhibits the regeneration of peripheral nerves (8,9). Salvage surgery has a high complication rate because of further scarring [5,10,13]. Many different methods have been developed and various materials have been implanted on the dura for preventing or reducing scar formation. Although the results have shown only moderate efficacy in the inhibition of epidural fibrosis, numerous materials

and methods, including stimulation implants for the spinal cord, autogenous adipose grafting, mitomisin, Gelfoam, Oxiplex, non-steroidal anti-inflammatory drugs, Gore-Tex, carboxymethyl cellulose, Adcon-L, and radiotherapy, have been applied to prevent scar formation [2,4,9,11,14-15,23].

Evaluation of the literature showed that low-dose perioperative radiotherapy can inhibit peridural fibrosis in FBSS cases [2-3,8-9,22,24]. Perioperative low-dose external-beam irradiation can improve pain and clinical symptoms, and external radiotherapy or brachytherapy can enhance the outcome of laminectomy operations [24].

MATERIALS AND METHODS

This exploratory study was performed at the Animal Research Center, Faculty of Medicine, in our University, in 2014. Twenty-three 4-month-old male Wistar albino rats were used. Their weights ranged from 250 to 300 g; they were housed under standard laboratory conditions (12 h light/dark cycle) at a constant temperature (25˚C) and humidity (50 %–60 %). They were allowed free access to food and water. The rats were divided into three groups. Group I included nine rats on which laminectomy was perfomed. Group II also included nine rats on which laminectomy and perioperative radiotherapy was performed. Finally, group III included five rats that did not undergo treatment and were used as a control group. Laminectomy was performed in the L3 and L4 lumbar vertebral region; in addition, the rats in group II received perioperative radiotherapy at the laminectomy area.

Surgery

All surgical interventions were performed under sterile conditions. General anesthesia was applied using 5 mg/kg xylazine (Rompun, Bayer, Istanbul, Turkey) and 60–100 mg/kg ketamine hydrochloride (Ketalar, Eczacıbası, Istanbul, Turkey). The depth of anesthesia was assessed by administering a painful stimulus to the tail vein of the rats at 15-min intervals. Following immobilization of the subjects on the operation table, they were first numbered on the inner surface of their ears. The lumbar region was then shaved. The operation area was sterilized with a 10% polyvinylpyrrolidone–iodine mixture. The lumbar fascia was opened after making an approximately 3-cm-long midline skin incision over the spinous processes. The paravertebral muscles were subperiosteally dissected from the spinous processes and laminas. The operation was performed under a microscope, and the operation site was exposed by a small automated retractor.

L3–L4 total laminectomy was performed using a small rongeur and a high-speed drill (Aesculap Microtron GD 412, Tuttlingen, Germany). The ligamentum flavum and epidural fat tissue were excised, and the dura mater and nerve roots were exposed. After washing the site with saline, the fascia was sutured with 5/0 vicryl, and the skin was sutured with 4/0 silk. The operation site was cleaned again with 10 % polyvinylpyyrolidone–iodine mixture. The animals were kept in a room at 28˚C for approximately 30 min while recovering from anesthesia. Loss of strength in the lower extremities was not detected in postoperative early neurological examinations of the animals.

The rats were sacrificed after 6 weeks by an intraperitoneal injection of a lethal dose of sodium pentothal. The vertebral column was transversely cut approximately 0.5 cm above and below the laminectomy site with a number 20 scalpel while preserving the lumbosacral fascia. The vertebral column was then removed as a block and placed in a 10 % formalin solution.

Radiotherapy

Treatment planning was performed using a computed tomographic simulation to define the anatomy and target volume. External radiation was administered with a 6-MeV electron beam using a Varian Linear Accelerator (MNT Health Care and Trade Corporation, Turkey, Bozlu Holding). The L3-4 posterior epidural space was used as the target volume. The size of the radiation field was set at 1.5 × 2 cm, which adequately included the target volume.

Radiotherapy was applied using a total dose of 700 cGy in only a single perioperative fraction. The 85 % isodose curve was covered at a depth of 2.5 cm. The 95 % isodose curve encompassed the radiation field at a depth of 1.2 cm.

Pathology

The lumbar spines of sacrificed rats were excised en bloc, fixed in 10 % buffered formalin, and subsequently placed in decalcifying solution. The specimens were dehydrated with alcohol after decalcification and embedded in paraffin. Axial sections were obtained and stained using hematoxylin and eosin and Masson's trichrome. Each specimen was evaluated and scored for determining the rate of epidural fibrosis, cell density, and arachnoidal adhesions. Fibrosis along the dura was determined and graded according to the scale used by He et al. [11]:

Grade-0: The dura mater was free of scar tissue,

Grade-1: Only thin fibrous band(s) were observed between the scar tissue and the dura mater,

Grade-2: Continuous adherence was observed, but it affected less than two-thirds of the laminectomy defect,

Grade-3: Scar tissue adherence was large, affecting more than two-thirds of the laminectomy defect or the adherence extended to the nerve roots.

The extent of fibrosis was scored for each slice, and the distribution of grades was determined for each experimental group.

Ethical approval

This study was approved by the local Animal Ethics Committee (2014/39). The study was carried out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986, and associated guidelines.

RESULTS

Pathological review

Grade 0 epidural fibrosis and grade 1 fibroblast cell density rates were 44.44% and 88.88% in the L + R group, and 0% and 33.33% in the L group, respectively. Arachnoid adhesion was present in 88.8% cases in the L group, but was observed in only 44.4% cases in the L + R group (Table 1). Grade 3 epidural fibrosis was shown in four rats (44.44 %) in the L group, and in one rat in in L + R group (11.11 %) (Figure-1, 2 and 3) (Table-1).

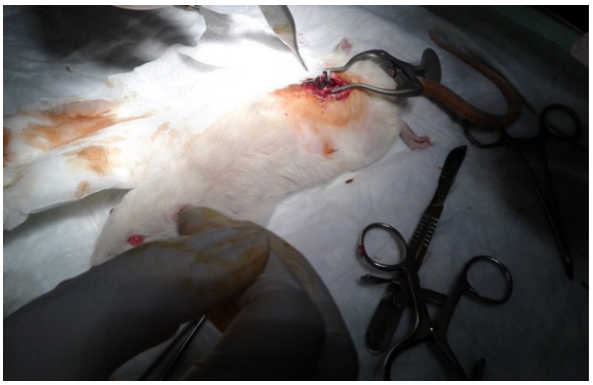

Figure-1. Laminectomy operation under a microscope.

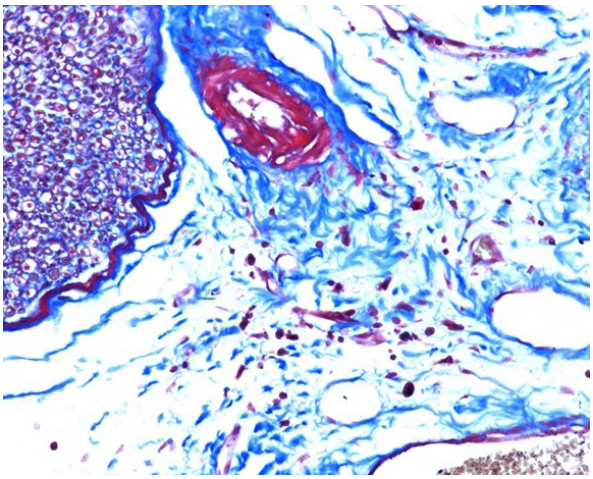

Figure-2. Grade-1 epidural fibrosis and arachnoid adhesion in a rat that received perioperative radiotherapy (Masson's trichrome staining; original magnification, 200×).

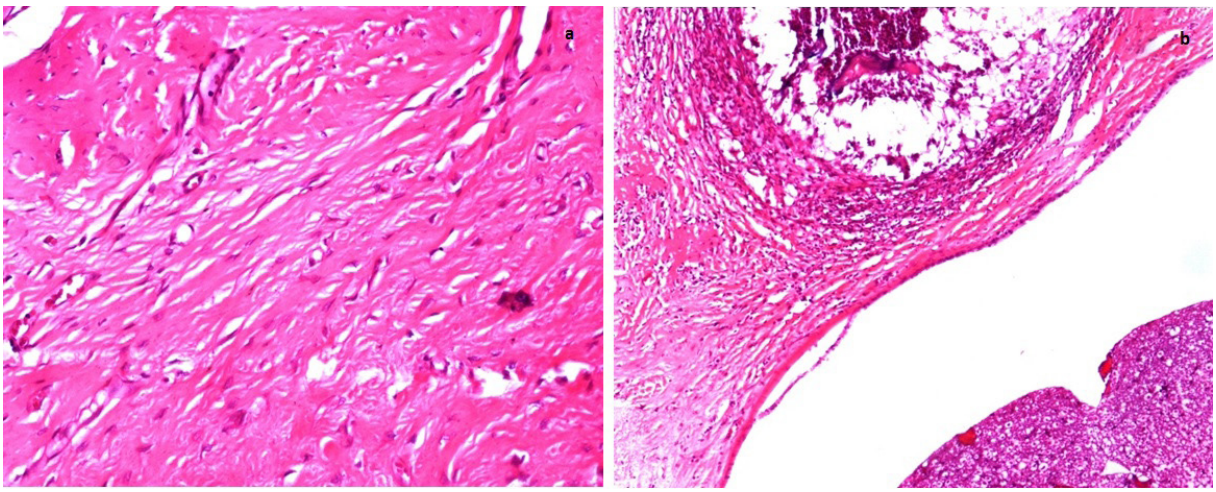

Figure-3. Grade-3 fibroblast density within the epidural fibrotic tissue in a rabbit from the laminectomy group (hematoxylin and eosin staining; original magnification, 200×).

Table 1. Rat groups and pathological results for epidural fibrosis, fibroblast cell density, and arachnoid adhesion in rats that did or did not undergo perioperative radiotherapy

Pathological evidence	L	L + R	%
Epidural fibrosis			
Grade 0	0	4	44.44
Grade 1	2	4	44.44
Grade 2	3	0	0
Grade 3	4	1	11.11
Fibroblast cell density			
Grade 1	3	8	88.88
Grade 2	3	0	0
Grade 3	3	1	11.11
Arachnoid adhesion			
Present	8	4	44.44
Absent	1	5	55.55

L: Laminectomy group; L + R: laminectomy and radiotherapy group.

DISCUSSION

Laminectomy-related salvage operations are reported to induce neurological symptoms in 8.2 % – 60 % patients because of scar-related root compression [19,21]. Therefore, many different methods are developed and various materials have been used on the dura for preventing or reducing scar formation [2,9,11,14-15]. A significant reduction in the degree of peridural fibrosis was observed in animals treated with Oxiplex or Gore-Tex. Oxiplex and Gore-Tex can prevent peridural fibrosis in the post-laminectomy areas [15].

Low-dose irradiation significantly decreases the degree of arachnoidal and peridural fibrosis and post-laminectomy syndrome; in addition, it was reported to cause no adverse neuropathic complications [6,8-9,12,24-25]. External radiation can inhibit postsurgical epidural fibrosis as effectively as the spinal membrane method [2]. In some studies, 700–900 cGy external irradiation and a 6–9-MeV electron beam energy were used and radiation was completed within 24 h postoperatively. Surgery was usually performed in the L3–L5 vertebral regions as hemi- or total laminectomy. Gross dissection and histologic sections were used for evaluating the degree of perineural fibrosis in these studies [2,24-25]. No statistically significant differences were observed in complete success rates, which ranged from 82 % to 90 % when doses were ≥900 cGy (8,9).

Therefore, we used a radiation dose of 700 cGy in this study. This study showed significant differences in rates of epidural fibrosis, fibroblast cell density, and arachnoid adhesion between rats in the L and L + R groups. Grade 3 epidural fibrosis was observed to a significantly less extent in the L + R group than in the L group according to the pathological reviews. Grade 0 epidural fibrosis and grade 1 fibroblast cell density rates were higher in the L + R group than in the L group. Arachnoid adhesion, one of the important pathological indications for a laminectomy operation, was present at a higher rate in the L group than in the L + R group. These results are consistent with those of other studies on perioperative radiotherapy for patients who have undergone laminectomy [2,8-9,21,24].

Some authors claim that low-dose radiotherapy may be carcinogenetic [1,6,12,17-19,25]. However, many authors have concluded that low-dose radiation therapy's risk of carcinogenesis is very low [20]. Further studies should be performed for evaluating brachytherapy and the use of different dose radiation schedules for preventing low back syndrome.

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Volume: 29, Issue: 3, July 2018 pp: 189-192 ORIGINAL ARTICLE

MINIMALLY INVASIVE SURGERY FOR ONE LEVEL SPINAL STENOSIS: UNILATERAL APPROACH BILATERAL MICRODECOMPRESSION

Şahin YÜCELİ [1]

[1] *Neon Hospital, Neurosurgery Clinic, Erzincan, Turkey.*

ORCID Numbers:
- Sahin YUCELI:
0000-0002-9471-3575

Address: Şahin Yüceli,
Neon Hastanesi, Beyin Cerrahisi Kliniği, Erzincan, Turkey.
E-mail: sahinyuceli24@gmail.com
Phone: +90 506 763 71 73
Recived: 12th March, 2018.
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ABSTRACT

Objective: The aim of our study is to investigate the effectiveness rate of minimal invasive surgery approach in one level lumbar spinal stenosis.

Materials and Method: Thirty-six patients were observed retrospectively. All patients have back and/or leg pain with neurogenic claudication. The patients were scored by visual analog scale with zero to ten; that zero is no pain and ten is the worst. Unilateral approach with bilateral microdecompression was used as the minimally invasive surgery technique for all patients with one level spinal stenosis.

Results: Pain scores were evaluated before surgery and at postoperative 1 month follow up. The pain release rate was 88 %.

Conclusions: Unilateral approach with bilateral microdecompression for treating one level lumbar spinal stenosis could be an alternative treatment for instrumentation at selected patients.

Key Words: Spinal stenosis, minimally invasive surgery, unilateral approach, bilateral microdecompression.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Degenerative lumbar spinal stenosis is currently the most common indication for spinal surgery in patients older than 65 years, and several studies have shown better surgical results over more conservative therapies [1,5-6]. The prevalence of lumbar spinal stenosis increases with age. At ages below 40 years, only 4 % of the population has radiological criteria of spinal canal narrowing. At over 60 years, this figure ranges above 19 % [10]. Other factors that influence lumbar spinal stenosis are sex, hereditary disposition, anatomical variations, osteoporosis and molecular degenerative processes [18,22].

The first laminectomy, which was performed by Sir Victor Alexander Horsley in 1887, marked the beginning of a surgical evolution for the management of lumbar stenosis [14]. Briggs and Krause introduced open laminotomy and foraminotomy to improve the clinical results [2]. However, the open techniques were later criticized because of high failure rates secondary to increased postoperative instability and the need for subsequent fusion [11]. The techniques were improved over time and the concept of preservation of facets, and pars interarticularis gained impetus [8]. Microscopic laminotomy and foraminotomy became the gold standard decompression technique, with reported success rates as high as 90 % [12].

The aim of our study is to evaluate the results of minimally invasive surgery technique unilateral laminotomy bilateral microdecompression for one level degenerative lumbar stenosis patients.

MATERIALS AND METHOD

We observed 36 patients retrospectively. All patients have back and/or leg pain

with neurogenic claudication. The patients were scored by visual analog scale with zero to ten that zero is no pain and ten is the worst. Patients diagnosed with magnetic resonance imaging and they do not have disc herniation, vertebral fractures or listhesis.

Unilateral approach with bilateral microdecompression was used as the minimally invasive surgery technique for all patients with one level spinal stenosis. With a month of follow up the patients were scored again. The difference between the scores were calculated for pain release.

Statistical Analyses

Descriptive data of VAS scores were presented as mean, standard deviation. The categorical variable gender was presented as frequency and percent. The comparisons between independent two groups were conducted by Mann-Whitney U test. The changes during the follow-ups were compared by using Friedman test, and when a statistically significant difference was observed, post-hoc analyses were performed by Wilcoxon test with Bonferroni correction. SPSS software version 21 (IBM Inc., USA) was used for the statistical analyses. Statistical significance level was considered as 0.05 in the analyses of this study.

RESULTS

This study included 36 patient with a mean age of 65.4 ± 7.6 years. There were 18 patients from each gender. Mean ages of the females was 69 ± 7.9 years, and males was 61.8 ± 9.7 years. There were no significant differences between the ages of the patients (p=0.534).

The mean preoperative and postoperative 1st month VAS values were 8.4 ± 0.4 and 1.8 ± 0.4 respectively. The comparison of these were presented in Table-1. The comparisons between genders revealed that there were no significant differences between males and females (p>0.05 for all) (Table-1).

The VAS scores measured during the study were presented in Table-2. The overall comparisons showed that VAS scores changed during the study course (p<0.001) (Table-2).

The post-hoc comparisons revealed that changes in postoperative 1st month scores were significant when compared with preoperative baseline values (p=0.001 for all) (Table-3).

Table-1. Pain scores according to gender.

	Female	Male	p
Preoperative	8.8±0.7	7.9±0.1	0.746
Postoperative 1st month	1.9±0.6	1.8±0.3	0.313

Table-2. Pain scores through the follow-up.

	Preoperative	Postoperative 1st month	p
VAS	8.4±0.4	1.8±0.4	<0.001

Table-3. Post-hoc comparisons of pain scores

	p
Preoperative - Postoperative 1st month	0.001

DISCUSSION

Minimally invasive approaches to spinal surgery have been described variously utilizing chemical, mechanical, laser and endoscopic techniques [4,7,9,20]. The goal of any surgical treatment of spinal stenosis is to decrease pain and increase the functional capacity of the patient while limiting surgery-related morbidity and mortality [17]. Surgical decompression without instrumentation can be classified into three methods; first laminectomy, secondly bilateral laminotomy and lastly the least invasive option, unilateral laminotomy to obtain bilateral decompression in undercutting technique [21]. Outcome after spinal decompression surgery is a function of patient selection, correct correlation of imaging with clinical symptoms and surgical technique [19].

Choi et al found that in patients with a specific type of spinal canal shape, unilateral laminotomy bilateral decompression yielded inferior improvement rates [3]. Therefore, they concluded that the surgical strategy should be tailored to the structural anatomy of the patient´s spinal canal [3]. Schatlo et al suggest that the configuration of the spinal canal, particularly the nomenclature of oval, round and trefoil is an anatomical function varying in frequency with lumbar segment and their results do not support the notion that the classification should influence surgical decision making [19].

den Boogert et al found that there were no differences in postoperative functional disability and pain between the surgical techniques of bilateral and unilateral approaches for microdecompression [6]. The significant differences in patient satisfaction and reduction in leg symptoms were unrelated to surgical technique and the overall treatment results were satisfactory. They concluded with that both techniques are safe and effective options for treating patients with single-level degenerative lumbar spinal stenosis [6].

Papavero et al evaluated 165 patients and they reported that microsurgical bilateral decompression using unilateral laminotomy is an effective surgical option for

lumbar spinal stenosis, even in high risk patients with multilevel stenosis [16].

Phan et al investigated that satisfaction rates were significantly higher in the minimally invasive group (84 % vs. 75.4 %; P = 0.03) than open laminectomy, whereas back pain Visual Analog Scale scores were lower (P<0.00001). Minimally invasive laminectomy operative duration was 11 minutes longer than the open approach (P = 0.001), however this may not have clinical significance [17]. However, there was less blood loss (P<0.00001) and shorter hospital stay (2.1 days; P<0.0001).

Palmer et al evaluated fifty-four consecutive patients underwent bilateral decompressions from a unilateral approach for spinal stenosis [15]. They concluded with that minimally invasive bilateral decompression of acquired spinal stenosis from a unilateral approach can be successfully accomplished with reasonable operative times, minimal blood loss, and acceptable morbidity [15].

Spetzger et al. has successfully used unilateral laminotomy and bilateral spinal canal decompression approach in the operative treatment of 29 patients with symptomatic mono or multisegmental lumbar stenosis [21]. Postoperatively, 25 of the 27 patients with neurogenic claudication (93 %) demonstrated a marked improvement of the walking distance. The follow-up of 25 patients for 18 months demonstrated an excellent result without pain in 7 patients (28 %); a good outcome with mild residual pain, but a normal working capacity in 15 patients (60 %); and a fair outcome with unchanged postoperative low back pain but markedly improved working capacity and walking distance in 3 patients (12 %).

Kim et al reported 26 patients that operated with percutaneous endoscopic contralateral interlaminar lumbar foraminotomy for lumbar degenerative spinal stenosis is an established procedure [13]. They suggested finally that facet-preserving contralateral foraminotomy and lateral recess decompression with percutaneous endoscopic contralateral interlaminar lumbar foraminotomy is effective for treatment of lateral recess and foraminal stenosis [13].

CONCLUSION

Standart techniques of spinal canal decompression currently remain the gold standard for treatment whereas problems with paraspinal musculature denervation and resultant lumbar instability have focused attention on less invasive techniques. Minimally invasive surgery is crucial not only not only for reducing tissue trauma and patient morbidity but also for improving pain and reducing postoperative stress responses and delayed complications after otherwise uneventful procedures. Unilateral approach with bilateral microdecompression for treating one level lumbar spinal stenosis could be an alternative treatment for instrumentation at selected patients.

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Volume: 29, Issue: 3, July 2018 pp: 193-196 ORIGINAL ARTICLE

THE RATIO OF RECURRENT DISC HERNIATIONS IN POSTERIOR THORACIC AND LUMBAR FUSION SURGERIES

Veysel ANTAR[1]

[1] *İstanbul Training and Research Hospital, Department of Neurosurgery, İstanbul*

ORCID Number:
- Veysel ANTAR:
0000-0003-2144-6442

Address: Veysel Antar,
İstanbul Eğitim ve Araştırma Hastanesi, Fatih, İstanbul, Turkey
E-mail: veyselantar@gmail.com
Phone: +90 506 763 71 73
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ABSTRACT

Objective: The aim of our study is to evaluate the ratio of recurrent disc herniation in posterior thoracic-lumbar fusion surgeries.

Materials and Method: We evaluate the ratio of recurrent disc herniation in posterior thoracic-lumbar fusion surgeries. The patient files and radio-diagnostic images were inspected retrospectively. Simple microdiscectomies lateral and anterior thoracic-lumbar stabilization surgeries were excluded.

Results: One hundred ninety one patients were included in the study. Mean age of the study group was 56.3 ± 14.2 years. M/F was 48.2 / 51.8. Mean age was 53.6 years for males, and 58.8 years for women (p=0.06). Most frequent diagnosis was stenosis (n=117, 61.3 %), and recurrence was present in 14.7 % of the cases (n=28). Revision operation was performed in 6.8 % of patients. The comparisons between genders revealed that stenosis rates were higher in females, and fracture rates were higher in males (p=0.003). However, rates of revision operations were similar between males and females (p=0.445). Most frequent level of recurrent disc herniation were L4-L5 (78.57 %).

Conclusions: It is spectacular that the ratio of recurrent disc herniation is more than listhesis and fracture surgeries in posterior thoracic-lumbar instrumentation surgeries.

Key Words: Recurrent disc herniation, posterior instrumentation, stabilization surgery.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

The definition of recurrent lumbar disc herniation is an ipsilateral or contralateral disc herniation at the same level as the primary herniation typically after a 6-month pain-free interval from the main surgery [5-6]. Many reasons are discussed for the degenerative process of lumbar disc degeneration and recurrence in the literature [13]. The ratio of re-herniation of operated lumbar disc herniation is 25 % whereas only of 11 % of those cases requiring revision [1,7].

The most common treatment modality could be either a repeat discectomy or a discectomy supplemented with arthrodesis [10]. Systematic reviews in the literature have investigated to understand whether undergoing a fusion procedure offers significant advantage over repeat discectomy and found no evidence to support such a recommendation [3-4,15].

In our study, we try to evaluate the ratio of recurrent disc herniation in posterior instrumentation surgeries.

MATERIALS AND METHOD

We evaluate the ratio of recurrent disc herniation in posterior thoracic-lumbar fusion surgeries. The patient files and radio-diagnostic images were inspected retrospectively. Only surgeries with posterior thoracic-lumbar instrumentation included for the study. Simple microdiscectomies

lateral and anterior thoracic-lumbar stabilization surgeries were excluded. One hundred ninety one patients were collected for the study.

Statistical Analyses

Descriptive data were presented as mean and standard deviations for numerical variables, and frequencies and percent for categorical variables. Independent group comparisons were analyzed with Chi-square and Mann-Whitney U tests between genders. A Type I error level of 5% was considered as statistical significance in analyses. SPSS 18 (IBM Inc., Armonk, USA) was used for the statistical assessments.

RESULTS

One hundred ninety one patients were included in the study. Mean age of the study group was 56.3 ± 14.2 years. M/F was 48.2 / 51.8. Mean age was 53.6 years for males, and 58.8 years for women (p=0.06) (Table-1).

Table-1. General demographics of the patients

	Mean	**SD**
Age (years)	56.3	14.2
	N	**%**
Sex		
Male	92	48.2
Female	99	51.8

The clinical characteristics of patients were presented in Table 2. Most frequent diagnosis was stenosis (n=117, 61.3 %), and recurrence was present in 14.7 % of the cases (n=28). Revision operation was performed in 6.8% of patients. Distribution of the operation sites were presented in the table. The comparisons between genders revealed that stenosis rates were higher in females, and fracture rates were higher in males (p=0.003) (Table-2).

But, rates of revision operations were similar between males and females (p=0.445). Most frequent level of recurrent disc herniations were L4-L5 (78.57%). Remaining sites of recurrence were presented in Table-3.

Table-2. Clinical characteristics of patients

	Total	**Male**	**Female**	**p**
	n (%)	**n (%)**	**n (%)**	
Diagnosis				0.003
Stenosis	117 (61.3)	48 (52.2)	69 (69.7)	
Recurrent Disc	28 (14.7)	15 (16.3)	13 (13.1)	
Listesis	24 (12.6)	11 (12)	13 (13.1)	
Fracture	19 (9.9)	16 (17.4)	3 (3)	
Infection	2 (1)	2 (2.2)	-	
Tumor	1 (0.5)	-	1 (1)	
Revision operation	13 (6.8)	7 (7.6)	6 (6.1)	0.445
Operation site				
Iliac wing	3 (1.6)	2 (2.2)	1 (1)	
T3	3 (1.6)	2 (2.2)	1 (1)	
T4	3 (1.6)	2 (2.2)	1 (1)	
T5	3 (1.6)	2 (2.2)	1 (1)	
T6	1 (0.5)	1 (1.1)	-	
T9	1 (0.5)	1 (1.1)	-	
T10	3 (1.6)	2 (2.2)	1 (1)	
T11	3 (1.6)	2 (2.2)	1 (1)	
T12	10 (5.2)	7 (7.6)	3 (3)	
L1	14 (7.3)	9 (9.8)	5 (5.1)	
L2	34 (17.8)	21 (22.8)	13 (13.1)	
L3	77 (40.3)	33 (35.9)	44 (44.4)	
L4	145 (75.9)	68 (73.9)	77 (77.8)	
L5	158 (82.7)	74 (80.4)	84 (84.8)	
S1	57 (29.8)	30 (32.6)	27 (27.3)	

Table-3. Most frequent level of recurrence disc herniation

	n	%
Diagnosis of recurrence	28	100
level of recurrence		
L5-S1	4	14.29
L4-L5	22	78.57
L3-L4	2	7.14

DISCUSSION

The choice of treatment modality between repeat discectomy and discectomy with fusion for recurrent lumbar disc herniation is an area of debate among spinal surgeons; also there are no clear guidelines established to assist surgeons in determining which approach is most appropriate to treat with [2,12,14]. In the literature, some authors suggest discectomy for patients with recurrent lumbar disc herniation and radiculopathy, whereas fusion has been recommended in cases of lumbar instability, radiographic degenerative changes and/or chronic axial lower back pain [8].

Kerezoudis et al evaluated 1405 patients from 15 studies undergoing surgery for recurrent lumbar disc herniation. and both procedures were found to cause significant improvement in symptoms and disability following revision surgery [10]. Furthermore, they concluded with that fusions were associated with longer operative times and hospital stays as well as higher intraoperative blood loss and no significant differences were found with regards to functional outcomes, reoperation rates and dural tears between the two cohorts.

Guan et al used the National Neurosurgery Quality and Outcomes Database (N2QOD) to assess outcomes of patients who underwent repeat discectomy versus instrumented fusion at a single institution from 2012 to 2015 and they found that repeat discectomy and instrumented fusion result in similar clinical outcomes at short-term follow-up; patients undergoing repeat discectomy had significantly shorter operative times and length of stay, and they incurred dramatically lower hospital charges [9].

Mroz et al made a survey of clinical and radiographic case scenarios that included a one- and twotime lumbar disc herniation was electronically delivered to 2,560 orthopedic and neurologic surgeons in the United States and the surgical treatment options were revision microdiscectomy, revision microdiscectomy with in situ fusion, revision microdiscectomy with posterolateral fusion using pedicle screws, revision microdiscectomy with posterior lumbar interbody fusion/transforaminal lumbar interbody fusion (PLIF/TLIF), anterior lumbar interbody fusion (ALIF) with percutaneous screws, ALIF with open posterior instrumentation, or none of these [11]. Surgeons in practice for more than 15 years were more likely to select revision microdiscectomy compared with surgeons with fewer years in practice who were more likely to select revision microdiscectomy with PLIF/TLIF. Similarly, those surgeons performing more than 200 surgeries per year were more likely to select revision microdiscectomy with PLIF/TLIF than those performing fewer surgeries [11].

CONCLUSION

In our study, the ratio of recurrent disc herniation operated with fusion surgery is 14.7 % and fusion surgery is a common chosen treatment modality for this disease. **:** It is spectacular that the ratio of recurrent disc herniation is more than listhesis and fracture surgeries in posterior thoracic-lumbar fusion surgeries.

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