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About Us

Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spinal Surgery Society. First journal was printed on January, in 1990. It is a double-blind peer-reviewed multidisciplinary 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 publis¬hes original scientific research articles, invited reviews and case reports that are accepted by the Editorial Board, in English.

The journal is published once in every three months and a volume consists of four issues. Journal of Turkish Spinal Surgery is published four times a year: on January, April, July, and October.

Journal of Turkish Spinal Surgery is indexed in TÜBİTAK ULAKBİM TR Index, EBSCO, J-Gate, GALE, ProQuest, Türkiye Atıf Dizini, Index Copernicus and Europub.

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 - organize 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 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. Journal of Turkish 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 at least two reviewers review them. 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. Associate Editors and Editor in Chief are responsible in reviewing and approving material that is published. 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.

Journal of Turkish Spinal Surgery is available to the members of the society and subscribers free of charge. Membership fees, congresses, and the advertisements appearing in the journal meet the publication and distribution costs.

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.

Journal of Turkish 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, well-designed research plans, and more refined reporting. Scientific articles, as in other types of articles, represent not only an accomplishment, but also a creative process.

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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 Abstract, Introduction and Discussion sections, and the answers should be mentioned in Abstract, 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.

Journal of Turkish 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.

JOURNAL OF TURKISH SPINAL SURGERY

Instructions to Authors

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PEER REVIEW

Article is reviewed by secretaries of the journal after it is uploaded to the web site. Article type, presence of the all sections, suitability according to the number of words, name of the authors with their institutions, corresponding address, mail addresses, telephone numbers and ORCID numbers are all evaluated and shortcomings are reported to the editor. Editor request the all defect from the authors and send to vice editors and native English speaker editor after completion of the article. Vice editors edit the blinded article and this blinded copy is sent to two referees. After reviewing of the article by the referees in maximum one month, the review report evaluating all section and his decision is requested, and this blinded report is sent to the author. In fifteen days, revision of the article is requested from the authors with the appreciate explanation. Revised blinded copy is sent to the referees for the new evaluation. Editor if needed may sent the manuscript to a third referee. Editorial Board has the right to accept, revise or reject a manuscript.

-Following types of manuscripts related to the field of "Spinal Surgery" with English Abstract and Keywords are accepted for publication: I- Original clinical and experimental research studies; II- Case presentations; and III- Reviews.

AUTHOR'S RESPONSIBILITY

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 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.

It 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.

CONFLICTS OF INTEREST

Authors must state all possible conflicts of interest in the manuscript, including financial, institutional and other relationships that might lead to bias or a conflict of interest. If there is no conflict of interest, this should also be explicitly stated as none declared. All sources of funding should be acknowledged in the manuscript. All relevant conflicts of interest and sources of funding should be included on the title page of the manuscript with the heading "Conflicts of Interest and Source of Funding".

ARTICLE WRITING

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. 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 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 abstract 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: Original articles should contain the following sections: “Title Page”, “Abstract”, “Keywords”, “Introduction”, “Materials and Methods”, “Results”, “Discussion”, “Conclusions”, and “References”. “Keywords” sections should also be added if the original article is in English.

- Title (80 characters, including spaces): Just as the Abstract is important in capturing a reader’s attention, so is the title. Titles rising or answering questions in a few brief words will far more likely do this than titles merely pointing to the topic. Furthermore, such titles as “Bisphosponates reduce bone loss” effectively convey the main message and readers will more likely remember them. Manuscripts that do not follow the protocol described here will be returned to the corresponding author for technical revision before undergoing peer review. All manuscripts in English, 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, e) ORCID numbers of the authors. 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).

- Abstract: A150 to 250 word abstract should be included at the second page. The abstract should be written in English and for all articles. The main topics to be included in Abstract section are as follows: Background Data, Purpose, Materials- Methods, Results and Conclusion. The Abstract 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 words): 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.

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 emphasized 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 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 escribe 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 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 gro-ups 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 so-mething else (different in what way? the readermay 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 as-sumptions, 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.

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: References are numbered (Arabic numerals) consecutively in the order in which they appear in the text (note that references should not appear in the abstract) and listed double-spaced at the end of the manuscript. The preferred method for identifying citations in the text is using within parentheses. Use the form of the "Uniform Requirements for Manuscripts" (http://www.icmje.org/about-icmje/faqs/icmje-recommendations/). If number of authors exceeds seven, list first 6 authors followed by et al.

Use references found published in peer-reviewed publications that are generally accessible. Unpublished data, personal communications, statistical programs, papers presented at meetings and symposia, abstracts, letters, and manuscripts submitted for publication cannot be listed in the references. Papers accepted by peer-reviewed publications but not yet published ("in press") are not acceptable as references.

Journal titles should conform to the abbreviations used in "Cumulated Index Medicus".

Please note the following examples of journal, book and other reference styles:

Journal article:

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

Book chapter:

2. Wedge IH, Kirkaldy-Willis WH, Kinnard P. Lumbar spinal stenosis. Chapter 5. In: Helfet A, Grubel DM (Eds.). Disorders of the Lumbar Spine. JB Lippincott, Philadelphia 1978;pp:61-8.

Entire book:

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

Book with volume number:

4. Stauffer ES, Kaufer H, Kling THF. Fractures and dislocations of the spine. In: Rock-wood CA, Green DP (Eds.). Fractures in Adults. Vol. 2, JB Lippincott, Philadelphia 1984;pp:987-1092.

Journal article in press:

5. Arslantaş A, Durmaz R, Coşan E, Tel E. Aneurysmal bone cysts of the cervical spine. J Turk Spinal Surg. (In press).

Book in press:

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

Symposium:

7. Raycroft IF, Curtis BH. Spinal curvature in myelomeningocele: natural history and etiology. Proceedings of the American Academy of Orthopaedic Surgeons Symposium on Myelomeningocele, Hartford, Connecticut, 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 Neuro-logical Surgeons, Miami, Florida, April 7, 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, often 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 abbrevia-tions.

-Acknowledgments: Note any non-financial acknowledgments. Begin with, "The Authors wish to thank…" All forms of support, including pharmaceutical industry support should also be stated in Acknowledgments section.

Authors are requested to apply and load including the last version of their manuscript to the manuscript submission in the official web address (www.jtss.org). The electronic file must be in Word format (Microsoft Word or Corel Word Perfect). Authors can submit their articles for publication via internet using the guidelines in the following address: www.jtss.org.

- Practical Tips:

1. Read only the first sentence in each paragraph throughout the text to ascertain whether those statements contain all critical material and the logical flow is clear.

2. Avoid in the Abstract comments such as, "… this report describes…" Such statements convey no substantive information for the reader.

3. Avoid references and statistical values in the Abstract.

4. Avoid using the names of cited authors except to establish historical precedent. Instead, indicate the point in the manuscript by providing citation by superscripting.

5. Avoid in the final paragraph of the Introduction purposes such as, "… we report our data…" Such statements fail to focus

the reader's (and author's!) attention on the critical issues (and do not mention study variables).

6. Parenthetically refer to tables and figures and avoid statements in which a table of figure is either subject or object of a sentence. Parenthetic reference places interpretation of the information in the table or figure, and not the table or figure.

7. Regularly count words from the Introduction through Discussion.

TABLE-1. LEVELS OF EVIDENCE

LEVEL- I .

1) Randomized, double-blind, controlled trials for which tests of statistical significance have been performed

2) Prospective clinical trials comparing criteria for diagnosis, treatment and prognosis with tests of statistical significance where compliance rate to study exceeds 80%

3) Prospective clinical trials where tests of statistical ignificance for consecutive subjects are based on predefined criteria and a comparison with universal (gold standard) reference is performed

4) Systematic meta-analyses which compare two or more studies with Level I evidence using pre-defined methods and statistical comparisons.

5) Multi-center, randomized, prospective studies

LEVEL –II.

1) Randomized, prospective studies where compliance rate is less than 80%

2) All Level-I studies with no randomization

3) Randomized retrospective clinical studies

4) Meta-analysis of Level-II studies

LEVEL– III.

1) Level-II studies with no randomization (prospective clinical studies etc.)

2) Clinical studies comparing non-consecutive cases (without a consistent reference range)

3) Meta-analysis of Level III studies

LEVEL- IV.

1) Case presentations

2) Case series with weak reference range and with no statistical tests of significance

LEVEL – V.

1) Expert opinion and review articles

2) Anecdotal reports of personal experience regarding a study, with no scientific basis

TABLE-2. CLINICAL AREAS

Anatomy

Morphometric analysis

Anesthesiology

Animal study

Basic Science

Biology

Biochemistry

Biomaterials

Bone mechanics

Bone regeneration

Bone graft

Bone graft sustitutes

Drugs

Disc

Disc Degeneration

Herniated Disc

Disc Pathology

Disc Replacement

IDET

Disease/Disorder

Congenital

Genetics

Degenerative disease

Destructive (Spinal Tumors)

Metabolic bone disease

Rheumatologic

Biomechanics Cervical Spine

Cervical myelopathy

Cervical reconstruction

JOURNAL OF TURKISH SPINAL SURGERY

Cervical disc disease
Cervical Trauma
Degenerative disease
Complications
Early
Late
Postoperative
Deformity
Adolescent idiopathic scoliosis
Kyphosis
Congenital spine
Degenerative spine conditions
Diagnostics
Radiology
MRI
CT scan
Others
Epidemiology
Etiology
Examination
Experimental study
Fusion
Anterior
Posterior
Combined
With instrumentation
Infection of the spine
Postoperative
Rare infections
Spondylitis
Spondylodiscitis
Tuberculosis
Instrumentation
Meta-Analysis
Osteoporosis
Bone density
Fractures
Kyphoplasty
Medical Treatment
Surgical Treatment
Outcomes
Conservative care
Patient Care
Primary care
Quality of life research
Surgical
Pain
Chronic pain
Discogenic pain
Injections
Low back pain
Management of pain
Postoperative pain
Pain measurement
Physical Therapy
Motion Analysis
Manipulation
Non-Operative Treatment
Surgery
Minimal invasive
Others
Reconstructive surgery
Thoracic Spine
Thoracolumbar Spine
Lumbar Spine
Lumbosacral Spine
Psychology
Trauma

Fractures

Dislocations

Spinal cord

Spinal Cord Injury

Spinal stenosis

Cervical

Lumbar

Lumbosacral

Tumors

Metastatic tumors

Primary benign tumors

Primary malign tumors

APPLICATION LETTER EXAMPLE:

Editor-in-Chief

Journal of Turkish Spinal Surgery

Dear Editor,

We enclose the manuscript titled '....' for consideration to publish in Journal of Turkish Spinal Surgery.

The following authors have designed the study (AU: Parenthetically insert names of the appropriate authors), gathered the data (AU: Parenthetically insert names of the appropriate authors), analyzed the data (AU: Parenthetically insert names of the appropriate authors), wrote the initial drafts (AU: Parenthetically insert initials of the appropriate authors), and ensure the accuracy of the data and analysis (AU: Parenthetically insert names of the appropriate authors).

I confirm that all authors have seen and agree with the contents of the manuscript and agree that the work has not been submitted or published elsewhere in whole or in part.

As the Corresponding Author, I (and any other authors) understand that Journal of Turkish Spinal Surgery requires all authors to specify any contracts or agreements they might have signed with commercial third parties supporting any portion of the work. I further understand such information will be held in confidence while the paper is under review and will not influence the editorial decision, but that if the article is accepted for publication, a disclosure statement will appear with the article. I have selected the following statement(s) to reflect the relationships of myself and any other author with a commercial third party related to the study:

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Dear Colleagues,

Once again, I'd like to say that I feel very privileged to be the person responsible for publishing this, the 3rd issue, of our professional journal this year. I want to extend a heartfelt thanks to all the reviewers, assistant editors, secretaries and the Galenos Publishing team for the effort they all put into publishing this issue.

This issue includes seven clinical research studies and one basic research study. I hope that each of you will take the time to review this issue very carefully, and incorporate the information and insights contained herein, to your already very well informed knowledge bases.

The first study examines "What Information do Teenagers With Idiopathic Scoliosis and Their Families Need When First Diagnosed?". The second study is about "Monoaxial Pedicle Screws With Sublaminar Fixations in The Correction of Adolescent Idiopathic Scoliosis". The third, is a clinical study, a single center experience entitled "Posterior Only Surgery for Rigid Scoliotic Curves Progressed Above 80 Degrees: Does it Yield Sufficient Correction?". The fourth article is entitled, "Chest Injuries Accompanying Blunt Spinal Trauma" while the fifth study is a basic research article investigating "Biochemical Analysis for Neuroprotective Effects of Ganoderma Lucidum in Experimental Rat Spinal Cord Trauma Model". The sixth study is entitled "Adverse Events Following Lumbar Spine Fusion: The Impact of Diabetes Mellitus." In the seventh study, the authors evaluated "The fate of Abstracts Presented at Turkish Spine Congresses in 2015 and 2017". The eighth article is a retrospective study about "Prognostic Criteria for Post-operative Success in Patients Undergoing Surgery for Adult Spinal Deformities".

Once again, I'd like to recognize the efforts of everyone especially for our reviewers who worked tirelessly to get this issue out to our readers in spite of the issues posed during these very unusual and difficult times. I hope our readers appreciate the work that went into this, and that each of you take the time to read and absorb the vital information contained here. I hope in near future pandemic will be diminishing by the use of vaccinations. Our mission remains, as always, to keep you abreast of all the latest developments in our field. Once again, this issue is intended to further that goal. I wish to my readers wonderful holiday with their families.

With kindest regards,

Editor in Chief

Metin Özalay, M.D.

JOURNAL OF TURKISH SPINAL SURGERY

Contents

ORIGINAL ARTICLES

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WHAT INFORMATION DO TEENAGERS WITH IDIOPATHIC SCOLIOSIS AND THEIR FAMILIES NEED WHEN FIRST DIAGNOSED?

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ABSTRACT

Objective: The aim of this study was to determine the information needs of individuals with adolescent idiopathic scoliosis (AIS) and their families when the disease was first diagnosed.

Materials and Methods: A total of 117 patients with AIS and their parents volunteered to participate in this study. A survey developed specifically to assess the information needs of AIS patients and their families was sent by e-mail. Of the AIS patients, 59.8% were aged >16 years and completed the survey alone, and 40.2% were aged <16 years and they completed the survey together with their parents.

Results: The results of this study demonstrated that in the initial diagnosis, scoliosis could be observed even if the angle was <20°. Generally, scoliosis was first noticed by the child's mother. As expected, at the time of the initial diagnosis, the children diagnosed as having scoliosis were upset and confused and their parents also felt upset and worried. The information most needed was reported to be answers to the questions of "Will it get better, what are the causes of scoliosis?", "What is scoliosis and what are the possible treatment options?", and the least frequently asked question was "Will surgery be needed?".

Conclusion: Clear, accurate, complete, and personalized information is required by patients and their families. This information is essential in enabling patients to make major decisions and to take ownership and responsibility for the decision. Involvement in decision-making helps to improve compliance with treatment and finally also improves satisfaction with the agreed treatment method used.

Keywords: Adolescent idiopathic scoliosis, survey, information needs, family

INTRODUCTION

Scoliosis is a three-dimensional deformity of the spine, with numerous epidemiological causes (congenital, neuromuscular, etc), and adolescent idiopathic scoliosis (AIS) is the most common (80-90%) type[1-4]. Current treatment methods for idiopathic scoliosis include observation, physiotherapy, brace treatment and surgery[3-6].

The appropriate treatment method is largely determined by a scoliosis orthopaedic consultant, based on a number of progression risk factors (age, maturity, curve magnitude etc.)[1]. However, sometimes the decision or choice of treatment can be influenced by the consultant's belief in a particular treatment method. For example, scoliosis-specific exercise management techniques are recommended less by consultants not only in Turkey, but also in numerous other countries, such as the UK, Australia and the USA.

However, whether the treatment process is conservative or operative, AIS patients and their families sometimes need to make major decisions. Schwieger et al.[7] reported that patients with scoliosis who did not participate in their treatment decisions (shared-decision making), reported poorer quality of life scores than those who participated in their treatment decisions. Therefore, it is essential that AIS patients and their families are fully and properly informed in making decisions related to their treatment.

Patients generally expect to be cared for by their healthcare system and to be provided with crucial and relevant information about any proposed healthcare assessment and treatment[8]. Beall et al.[9] reported that patients with AIS and their families

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used the internet nearly twice as much as children and teenagers diagnosed with other orthopaedic conditions in order to try and understand their diagnosis.

Previous studies that have evaluated the information needs of scoliosis patients and their families have mainly focused on the experiences of patients undergoing surgical management[10-13]. Furthermore, there is a limited number of research studies that have questioned patients about what information they need with regards to scoliosis surgery[14,15]. Rullander et al.[10] questioned the experiences of patients and their families following scoliosis surgery, in respect of postoperative pain, and nausea, and general satisfaction both before and after the hospitalization.

In a recent study in the UK, Wellburn et al.[16] evaluated the information needs and satisfaction levels of AIS patients and their parents when they were first diagnosed. The study also explored their emotions together with the ease with which they were able to obtain information from the internet. The authors also evaluated the adequacy of the information obtained from the internet when the children were diagnosed.

Not only is little known about the information needs of AIS patients and their families, but in Turkey no studies to date have examined these information needs. Therefore, the aim of this study was to evaluate the information needs of individuals with AIS and their families at first diagnosis.

MATERIALS AND METHODS

The research proposal has been approved by Bandırma Onyedi Eylül University Faculty of Health Sciences, Non-Interventional Ethics Committee with the number 2020-14 and dated 06.03.2020. The study was approved by the hospital Institutional Review Board and was conducted in compliance with the Helsinki Declaration. The informed consent was signed by both the volunteers and one of their legal representatives.

Participants

A survey was sent by e-mail to 150 individuals with AIS who were admitted to İstanbul Kartal Dr. Lütfi Kırdar City Hospital, Clinic of Orthopaedics and Traumatology between March-April 2020.

The patients included in the study were those with a diagnosis of AIS, with child and parents willing to participate in the research. The study exclusion criteria were defined as follows: Non-idiopathic scoliosis, any rheumatological or orthopedic disease, any mental disorder, or a history of spinal operation.

Instrument of Data Collection

The information needs survey in AIS is divided into two sections and consists of 18 items in total. The first 8 items are about patient characteristics that are not personally identifiable, such as age, gender, curve type, and curve size. The remaining items focused on the information needs and emotional responses of each patient and their parent. Permission for use was obtained from the developers of the questionnaire. When predefined responses were given, they were supported with free text boxes for the participants to enter alternative responses, with the instruction to choose one or all responses. A summary of the questions used in the research is presented in Appendix 1[16,17].

Data Analysis

Data obtained in the study were analyzed statistically using IBM SPSS Statistics 21.0 (SPSS Inc, Chicago, IL, ABD). Descriptive statistics were reported as mean ± standard deviation, minimum-maximum values for numerical variables, and as frequency and percentage for all qualitative variables.

RESULTS

A total of 117 AIS patients (96 girls, 82.10% and 21 boys, 17.90%) volunteered to participate in this study. 59.80% (n=70) of the participants were aged >16 years and completed the questionnaire alone and it was completed together with the parents by the 40.20% (n=47) of AIS patients aged <16 years. The mean age of the patients when they first attended the hospital due to scoliosis was 13.70±3.20 years old (range:10-18 years).

Four different curve types and five curve sizes (relative to the Cobb angle) were defined as the characteristics of scoliosis curvature. The most common curve types were thoracolumbar and lumbar curves, and the most common ranges of curve size were 10°-19° and 20°-29° (Table 1).

When the patient and parents were asked who was the first person to notice a problem in the teenagers back, the first people to notice a potential back problem were stated to be mother (42.7%), doctors (22.2%), themselves (13.7%), family relatives (6%), father (5.10%), teachers (4.30%), sisters (2.6%), physiotherapists (21.7%), brother (0.9%), and school screening (0.9%). The time taken to be referred for the first admission to hospital was reported to be 0-6 months (20.5%), 1 year (14.5%), 2 years (11.1%), 3 years (9.4%) and >3 years (44.4%).

The participants were asked to select all the options that depicted different emotions from a predetermined list of seven options. Both the patients and their parents were asked to state all the emotions they had felt when their child was diagnosed

Table 1. Curve characteristics of the study participants

Classification of curves	n	%
Thoracic	11	9.4
Lumbar	37	31.6
Double-major	31	25.5
Thoracolumbar	38	32.5
Curve magnitude		
10°-19°	39	33.3
20°-29°	34	29.1
30°-39°	31	26.5
40°-49°	11	9.4
≥50°	2	1.7

with scoliosis. The pre-determined emotions and responses are shown in Table 2. Feelings of being upset and confused were the most frequently reported.

When the children and their parents were told that they had scoliosis, the participants were asked to indicate what questions they deemed to be most appropriate from the list of options regarding their specific information needs. "Will it get better? What causes scoliosis? What is scoliosis? What are the possible treatment options?" were the questions most frequently asked and the least needed information was "whether surgery would be needed". It was observed that more than half of all the scoliosis patients, whether completing the questionnaire on their own or with their parents, marked all the information needed items (Table 3).

It was stated by 95.7% of participants that they had received information about scoliosis. When asked about the source of this information it was said to have been obtained verbally (89.9%), in writing (18.8%) and electronically (36.8%). The information was evaluated as very satisfactory by 11% of the respondents, satisfactory by 43% and neither satisfactory nor satisfactory by 26%. The information was said to be sufficient by 31.6%, not satisfactory by 21.4%, confusing by 8.5% and 8.5% did not receive any information. Of those who did not receive any information, 90% stated that they would have preferred to receive information about their deformity.

When participants were asked what could be done to improve the information they had received, the following responses were given: The information provided needed to be written in language that was easier to understand, it was important to increase the communication provided by doctors and it was also important to establish forum sites or websites where they could communicate with experts and each other to conduct more research and to share the results with them, and frequent public seminars could be held.

In response to the question "was this information verbal, written, or electronic?" 81.2% of participants reported that they had searched the internet for information about their diagnosis. They had searched all kinds of websites where information could be obtained, such as Google, Youtube, Pubmed, the sites of private health organizations and articles provided by healthcare professionals that provided information about scoliosis. The participants evaluated the information obtained from the internet as useful (25%), inadequate (23%) and confusing (17%).

Finally, 17.9% of the participants stated that they had also received emotional support and 82.90% of them stated that it would be beneficial to communicate with people in the same situation. The respondents also commented on the ways that they would prefer to see the information prepared and presented (Table 4).

DISCUSSION

The results of this study demonstrated that at initial diagnosis, AIS can be observed even if the Cobb angle is <20°. The results also showed that generally scoliosis is first noticed by mothers.

Table 2. Distribution of responses to pre-determined feelings

Information need	Patient		Parent/Carer		Total	
	n	%	n	%	n	%
Upset	33	47.1	29	61.7	62	53.0
Devastated	10	14.3	7	14.9	17	14.5
Annoyed	1	1.4	4	8.5	5	4.3
Nervous	14	20.0	14	29.8	28	23.9
Anxious	5	7.1	11	23.4	16	13.7
Worried	19	27.1	24	51.1	43	36.8
Confused	28	40.0	18	38.3	46	39.3

Table 3. Distribution of information needs responses

Information need	Patient		Parent/Carer		Total	
	n	%	n	%	n	%
What is scoliosis?	50	71.4	33	70.2	83	70.9
What causes scoliosis?	53	75.7	35	74.5	88	75.2
Is it hereditary?	41	58.6	29	61.7	70	59.8
Will it get better?	58	82.9	37	78.7	95	81.2
What happens now?	40	57.1	26	55.3	66	56.4
What treatment options are there for me?	50	71.4	29	61.7	79	67.5
Will I need an operation?	41	58.6	22	46.8	63	53.8
How will it affect me in later life?	46	65.7	30	63.8	76	65.0

Table 4. Participants comments
Information that participants would prefer to have
General information about scoliosis can be presented in the form of a booklet.
The musculoskeletal system can be colored to show the muscles affected by scoliosis in a way that children can understand
More detailed information about new developments could be added.
Further suggestions, and opinions regarding the information provided
The information should be given to the child, not just the parents
Not only surgical information should be given, but what should be done and what awaits patients afterwards should be explained.
Suggesting only swimming about sports that can be done restricts children a lot. More options should be offered.
When giving information, the psychology of the family and child should be given importance and the specialist should motivate the patient.
Other comments emphasizing that it was important to raise awareness and to explain all available treatment options
It should be explained that it is a treatment that requires patience
The public needs to be made aware of scoliosis by providing regular seminars.
Children's awareness of scoliosis needs to be addressed in schools

At the initial diagnosis the patients felt upset and confused and parents reported feeling very upset and worried on learning that their child had scoliosis. The following were the most common information they wanted to know: "Will it get better?" (81.2%), "What are the causes of scoliosis?", "What is scoliosis?", and "What are the possible treatment options?". The information they least wanted to know was whether or not they would need surgery (53.8%). However, it was reported that surgeons generally mentioned this, whether surgery was needed or not.

A total of 117 AIS patients participated in the study, of which 59.8% were older than 16 years and completed the survey themselves. The average age at the time of admission to the first hospital with the diagnosis of scoliosis was 13.7 years, and most of the individuals diagnosed with AIS were female (82.1%). In a similar study in the UK, Wellburn et al.[16] reported that 58% of the patients with AIS were older than 16 years and completed the survey themselves, the mean age of the individuals was 13.3 years when first referred to the hospital and the majority were female (92%). Furthermore, the most common curve types in the Wellburn et al.[16] study were thoracic and lumbar, and the most common ranges of curve size were 40°-49° (28%) and 30°-39° (23%). In the current study, the most common type of curves were thoracolumbar and lumbar, and the most common curve size ranges were 10°-19° (33.3%) and 20°-29° (29.1%).

Reichel and Schanz[18] stated that the initial shock of being diagnosed with scoliosis may have resulted in emotional uncertainty together with feelings of fear, depression, despair or hopelessness that needed to be overcome. In the current study, the feelings experienced by patients and/or their parents following the diagnosis of scoliosis were observed to be mostly "feelings of being upset (53%), confusion (39.9%) and worry (36.8%). In the study by Wellburn et al.[16], worry (21%), anxiety (20%) and being upset (19%) were the most frequently reported feelings.

The current study findings also concur with the results of studies by Bull and Grogan[13], van Schaik et al.[19], and Salisbury et al.[20] where patients with AIS and their parents were questioned about their feelings both before and after surgery. Confused and worried feelings, including being intensely upset were reported by the respondents. The feeling of being annoyed was the least frequent feeling and this concurred with the study of Wellburn et al.[16].

Another frequently reported feeling by the participants was the sense of feeling nervous (23.9%). In a study by Macculloch et al.[14], this feeling was reported before surgery. Wellburn et al.[16] suggested that feelings of nervousness may have been caused by an "unknown fear or lack of information" following their diagnosis. Furthermore, Brosnan[21] detailed that families with accurate and complete information reportedly had less anxiety and stress, which in turn contributed to a better overall operative experience for the patients and their parents as well as for the clinicians.

In the current study, 54% of the participants found that the information provided about scoliosis and its treatment was satisfactory but the satisfaction levels in Turkey are generally lower than those reported by Wellburn et al.[16]. As scoliosis treatment can be a long and difficult process for patients and their families, accurate knowledge with regards to any medical condition may encourage the patient to actively participate in the decision-making process and their care. Families who are informed and knowledgeable about medical conditions are then able to inform and prepare their children for the treatment processes that await them. Recent studies suggested that patients who understand their condition well are able to modify or change their decision-making behavior about treatment, and well-informed parents tend to be much more involved with their children's care and consequently were found to increase their treatment compliance[22-24].

In the current study the vast majority of respondents (81%) reported that they had searched the Internet about their newly diagnosed status. Wellburn et al.[16] reported that 77% of participants had searched the Internet for information relating

to their condition. Bull and Grogan[13] reported that searching the Internet was the main source of information for many parents of a child who had had scoliosis surgery.

In the current study, information that the participants encountered on the Internet was found to be useful (25%), inadequate (23%) and confusing (17%). Recent studies have shown that although the number of websites relating to scoliosis is high, the information on these websites is of low quality[25-27]. Regardless of health literacy, Gutierrez et al.[28] stated that patients rely primarily on healthcare providers to obtain health information.

Therefore, it is very important that all healthcare professionals take responsibility for educating their patients and referring them to appropriate valid and reliable websites. Furthermore, it is crucial that healthcare professionals are fully informed of the content of the websites that they recommend to patients[25,27]. Wellburn et al.[25] further recommended that websites should be designed to meet AIS patient needs and that the content should be clear, evidence- based and regularly updated.

In this study conducted in Turkey, the participants stated that they primarily accessed information about scoliosis on the Internet from "Google", "Youtube", "Pubmed", and the websites of medical centers together with research papers provided by healthcare professionals.

Nason et al.[26] demonstrated that the webpages provided by academics and doctors contained higher quality information than other web pages. Nason et al.[26] stated that as clinicians, it is not only necessary to direct patients to appropriate websites, but it is also important that healthcare professionals help in the development of high quality content on the Internet. Furthermore, nearly two decades ago, Beall et al.[9] reported that patients with scoliosis and their families used the internet to understand their diagnosis nearly twice as often as those diagnosed with other orthopedic conditions. As Internet usage is very common today it is very important that the content of websites is prepared by scoliosis professionals in their native language so as to correctly inform patients and provide them and their families with the knowledge and information that they need and which is applicable to them.

In the current study, the vast majority of participants stated that they had not received any emotional support, and they suggested that it would be beneficial to communicate with other young people in the same situation. Reichel and Schanz[18] emphasized that support for patients is both necessary and helpful and the provision of psychological group sessions and individual discussions is likely to prevent psychosocial disorders. This is consistent with the results of a study by Hinrichsen et al.[29], in which it was reported that most patients were very satisfied when joining a scoliosis group.

A number of valuable suggestions were made by the study participants on how they would prefer to see the information prepared and presented. These suggestions were as follows "General information about scoliosis can be presented in the form of a booklet", "The musculoskeletal system can be colored to show the muscles affected by scoliosis in a way that children can understand" and "More detailed information about new developments could be added." In a previous study, participants preferred to see "Some information may be with pictures, something a bit friendlier, sort of tailored to people our age"[16]. One of the key suggestions that the participants strongly recommended was the necessity of providing scoliosis education within schools as well as increasing public awareness through public seminars. In addition, participants stated that they wanted to talk at greater length with the healthcare professionals (physicians). The children and their parents also suggested that it would be very helpful if the language used during the medical visit included less medical jargon and more use of "easy to understand" and "user-friendly" language.

Participants stated that more detailed information was needed and for this to be provided both verbally and in writing (using pictures more in the information). They also stated that it was important that the information provided is given to the child as well as to the family. Furthermore, the participants suggested that it was very important to consider the emotional and psychological needs of the child as well as their parents, for example any issues or problems with anxiety, self-confidence and self-esteem, all of which are affected by having a spinal deformity.

In line with these recommendations, we suggest that communication and the way in which information is provided is of paramount importance to this patient group and their families, so it is important that their information needs are addressed.

In the current study, the socio-economic and socio-cultural factors related to having AIS were not addressed, and this should be a component of future studies. Furthermore, although the sample size of 117 participants may be considered small in terms of a national survey, it is a relatively large sample in terms of empirical studies within the field of scoliosis. The strengths of this study that sought to ascertain the information needs of AIS patients and their parents is the first such study conducted in Turkey. The results showed that these needs do not greatly differ from the information needs expressed by patients and their parents in the UK and elsewhere.

The results of this study can significantly inform recommendations and guidelines as well as future scoliosis policies in Turkey. It can also be considered of great importance and timely to develop international recommendations and guidelines on what the minimal standards of information provided to scoliosis patients and their parents should be. This would help patients and their parents all over the world receive the same satisfactory level of information necessary for their needs, in an attempt to try and decrease the anxiety and psychological issues experienced by patients and their parents, associated with a diagnosis of AIS.

CONCLUSION

Clear, accurate, complete and personalized information is very important to patients and their families. This information is

essential for making major decisions regarding the best and most appropriate type of treatment needed (operative or non-operative) for the patient as well as to increase patient and parent responsibility, compliance and satisfaction with their treatment.

The key issues that need to be considered in the decision to determine the most appropriate treatment for scoliosis are the risk factors associated with curve progression.

Ethics

Ethics Committee Approval: The research proposal has been approved by Bandırma Onyedi Eylül University, Faculty of Health Sciences, Non-Interventional Ethics Committee with the number 2020-14 and dated 06.03.2020.

Informed Consent: The informed consent was signed by both the volunteers and one of their legal representatives.

Authorship Contributions

Design: T.K.Ç., J.B.S., Data Collection or Processing: İ.Ç., Analysis or Interpretation: B.A., A.A., Literature Search: T.K.Ç., B.A., A.A., J.B.S., Writing: T.K.Ç., B.A., İ.Ç.

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Appendix -1

Patient Survey Questions

1. Who is completing this survey?
2. How old were you/your child when first referred to the hospital for scoliosis?
3. Is the person with scoliosis male/female?
4. Please enter the letters in the first half of your postcode.
5. Who first identified there may be a problem? (please do not enter their name)
6. How long is it since you/your child had the first referral appointment at the hospital?
7. What type of curve were you/your child diagnosed with?
8. How many degrees was the curve at the first referral?
9*. How would you describe your feelings on being told you/your child had scoliosis?
10*. Was a scoliosis specialist nurse present/available when you attended for your consultation?
11*. What were your specific information needs on being told that you/your child had scoliosis?
12. Did you receive any information about your (child's) condition?
12a. If you did, was this information verbal, written, or electronic (websites)?
12b. Would you like to have received information about your condition?
13. If you received information, how would you rate it?
14*. Could you explain more about why you gave the information you received that rating?
15*. What in your opinion could be done to improve the information that you received?
16*. Did you search the Internet for information about your (child's) condition?
17*. Did you seek emotional support?
18*. Do you have any suggestions about what would be important to include in information and leaflets to be given to scoliosis patients and their families?

*Indicates open questions with a free text box.

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MONOAXIAL PEDICLE SCREWS WITH SUBLAMINAR FIXATIONS IN THE CORRECTION OF ADOLESCENT IDIOPATHIC SCOLIOSIS

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ABSTRACT

Objective: To evaluate the radiological outcomes of posterior spinal instrumentation by using monoaxial pedicle screws with sublaminar fixations for the treatment adolescent idiopathic scoliosis (AIS).

Materials and Methods: The data of 14 patients who underwent posterior instrumentation by using monoaxial pedicle screws with sublaminar fixations for the treatment of AIS between 2010 and 2019 were retrospectively analyzed. Patients' age, gender, preoperative Risser classification, preoperative Lenke classification, and operative data were recorded through our medical records. Proximal thoracic (PT), main thoracic (MT), thoracolumbar/lumbar (TL/L) curve Cobb angles as well as thoracic kyphosis (TK) and lumbar lordosis (LL) Cobb angles were measured through preoperative and postoperative standing full spine X-rays.

Results: The mean preoperative PT curve Cobb angle was 33.7 degrees, and it was 4 degrees postoperatively (p=0.068). The mean preoperative MT curve Cobb angle was 53.3 degrees and it was 8.7 degrees postoperatively (p=0.008). The mean preoperative TL/L curve Cobb angle was 43 degrees and it was 9.2 degrees postoperatively (p=0.005). The overall mean coronal plane correction ratio was 84%. The mean preoperative TK Cobb angle was 25.2±17.8 degrees and it was 32.9±8.9 postoperatively (p=0.101).

Conclusion: According to the results acquired from this study, monoaxial pedicle screws with sublaminar fixations demonstrated an efficient correction in both PT, MT, and TL/L curves and restoration of TK in AIS surgery.

Keywords: Adolescent idiopathic scoliosis, pedicle screw, monoaxial, sublaminar fixation, correction

INTRODUCTION

Posterior spinal instrumentation is the standard method for the surgical correction of adolescent idiopathic scoliosis (AIS) [1]. From the first introduction of pedicle screws by Roy-Camille in 1979 pedicle screw design evolved over the years[2]. Recently, pedicle screw instrumentation has become the most commonly preferred method for the treatment of scoliosis[3]. However, there is still debate about the choice of fixation method regarding using either a hybrid system, which consists of laminar wires/tapes, hooks, and pedicle screws, or using only mono/polyaxial pedicle screws[4].

Monoaxial pedicle screws were the first introduced pedicle screw and reported as having the advantage of the better correction of vertebral rotation compared to polyaxial screws[3,4]. However, it can be difficult to achieve complete seating of the screw into the rod which may result in an inadequate connection between the rod and the screw and it can cause fixation failure[5]. A recent study also remarked the difficulty of surgical correction among junior surgeons and mentioned that senior surgeons used significantly more monoaxial screws and achieved better correction in the treatment of AIS[6]. In their study comparing monoaxial and polyaxial pedicle screw in the treatment of AIS, Kuklo et al.[3] also reported greater correction of rotational and thoracic torsion deformities compared to polyaxial screws; however, the authors did not find any significant difference between monoaxial and polyaxial screws in terms of fixation stability and coronal plane deformity correction.

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In the literature, many studies exist reporting the outcomes of monoaxial screws in the treatment of thoracolumbar burst fractures. There are also studies comparing the biomechanical properties of monoaxial and polyaxial pedicle screws. Previously, Kuklo et al.[3] and Lonner et al.[4] compared monoaxial and polyaxial thoracic pedicle screws in the treatment of thoracic scoliosis. However, to date, we could not find any study evaluating the outcomes of monoaxial pedicle screw fixation with sublaminar fixation in the correction of AIS. In the current study, we aimed to evaluate the radiological outcomes of posterior spinal instrumentation by using monoaxial pedicle screws with sublaminar fixations for the surgical treatment of AIS.

MATERIALS AND METHODS

We hypothesized that monoaxial pedicle screws with sublaminar fixations resulted in an efficient coronal plane deformity correction and restoration of hypokyphosis compared to the reported studies in the literature.

Study Population

This retrospective study was performed in accordance with the "Declaration of Helsinki". Ethics committee approval was received from İstanbul Atlas University Non-Interventional Scientific Research Ethics Committee (25.06.2021-4758). Informed consent was obtained for each patient. We retrospectively reviewed the prospectively collected clinical and radiological data of 14 consecutive patients who underwent posterior spinal instrumentation for the treatment of AIS between 2010 and 2019. Patients who underwent surgical correction of AIS by using monoaxial pedicle screw and sublaminar tape fixation with a minimum follow-up of 1 year were included in the study. There was no patient with incomplete follow-up and medical records. Fourteen patients (11 females, 3 males) with the mean age of 14.2±2.2 years (ranges, 12 to 18 years) participated in the study. The mean follow-up time was 17 months (ranges, 12 to 36 months).

Operative Technique

All surgeries were performed by the senior author of this study (UA) on a radiolucent table in the prone position. A standard midline approach was used for the posterior spinal instrumentation. Monoaxial pedicle screws were placed either unilaterally or bilaterally according to the fusion levels detected preoperatively. The deformity was corrected by connecting screw and pre-contoured rods gradually by clamps. Depended to the thoracic deformity, 3 or 4 sublaminar fixations were performed in all patients from the convex side of the deformity. A combination of autologous spinous processes autograft and cortico-spongious bone allografts were used for grafting. All patients received prophylactic first-generation cephalosporin 30 minutes prior to the procedure. Postoperative intravenous antibiotics were continued for 24 hours. No postoperative bracing was used in any patients and all patients were mobilized at postoperative 1st day.

Data Evaluation

Patients' age, gender, preoperative Risser classification, preoperative Lenke classification, and instrumentation levels were recorded through our medical records. Patients' preoperative and postoperative full spine posterior-anterior and lateral radiographs were assessed by the senior author (UA) (Figure 1 and 2). Coronal Cobb angles were measured for the proximal thoracic (PT), main thoracic (MT), thoracolumbar/lumbar (TL/L) curves. Sagittal Cobb angles were measured for thoracic kyphosis (TK) and lumbar lordosis (LL). The instrumentation ratio which defined the ratio of screw fixation at the fusion levels was calculated. Bilateral monoaxial screw fixation at all levels was considered as a 100% instrumentation. The correction ratio was also calculated according to the preoperative and postoperative Cobb angles.

Statistical Analysis

Statistical analysis was performed by using SPSS 25.0 (SPSS Inc., IBM, NY, USA). Continuous data were given as means and standard deviations, whereas categorical data were given as frequencies and percentages. Comparison of preoperative

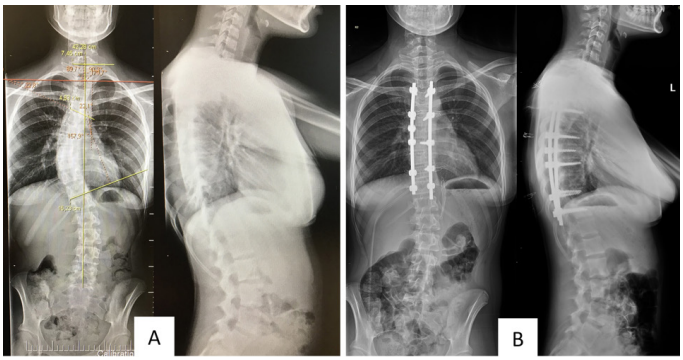

Figure 1. A) Preoperative standing posterior-anterior and lateral radiographs of a Lenke 1B patient (Patient 10) with 45 degrees MT, 40 degrees TL, and 25 degrees TK Cobb angles. B) The patient underwent posterior instrumentation between T4 and T11 levels, an 85% correction rate was achieved in the MT curve and a 63% correction rate was achieved in the TL curve

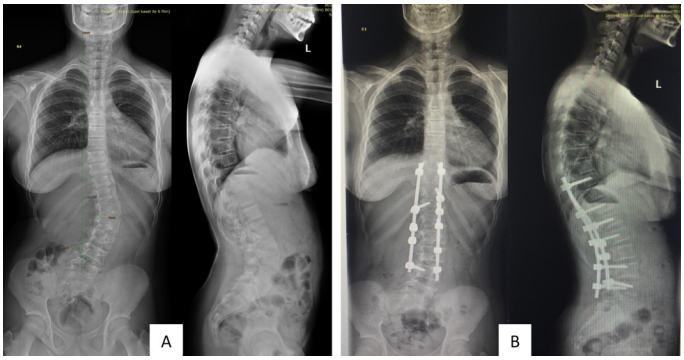

Figure 2. A) Preoperative standing posterior-anterior and lateral radiographs of a Lenke 5C patient (Patient 8) with 43 TL, and 46 degrees TK Cobb angles. B) The patient underwent posterior instrumentation between T9 and L4 levels, a 91% correction rate was achieved in the TL curve

and postoperative mean Cobb angles was performed by the Wilcoxon test. P-values lower than 0.05 were considered as statistically significant.

RESULTS

The preoperative clinical data of the patients were demonstrated in Table 1. The mean preoperative PT curve Cobb angle was 33.7±2.5 degrees, and it was 4±5.3 degrees postoperatively (p=0.068). The mean preoperative MT curve Cobb angle was 53.3±7.5 degrees and it was 8.7±4.4 degrees postoperatively (p=0.008). The mean preoperative TL/L curve Cobb angle was 43±9.8 degrees and it was 9.2±7.7 degrees postoperatively (p=0.005).

The postoperative data were summarized in Table 2. The mean preoperative TK Cobb angle was 25.2±17.8 degrees and it was 32.9±8.9 postoperatively (p=0.101). The mean LL angle was 47.9±13.9 degrees and it was 46.8±10.5 postoperatively (p=0.850).

The overall mean curve correction ratio was 84%±14% and the mean monoaxial screw instrumentation ratio through all fusion levels was 72%±10%. No complication occurred during the follow-up time.

DISCUSSION

The most important finding of this was that we achieved a mean 88% correction ratio in the PT curve, a mean 84% correction ratio in the MT curve, and a mean 79% correction ration in the TL/L curve. Our correction ratio can easily be accepted as a higher ratio in comparison to the reported studies in the literature about the treatment of AIS by monoaxial screws[3,4,7].

In their study comparing monoaxial and polyaxial screws in the treatment of Lenke type 1 AIS, Kuklo et al.[3] achieved a mean 41% PT correction, 65% MT correction, and 55% TL/L correction with monoaxial screws. Lonner et al.[4] reported a better MT correction by monoaxial screws (69%) in their study comparing monoaxial, polyaxial, and hybrid constructs. Blondel et al.[7] mentioned that the decrease in the thoracic Cobb angle was 72% in their monoaxial screw hybrid group.

Our results also demonstrated an increase in thoracic hypokyphosis and restoration of TK. We detected a relative hypokyphosis in our patients preoperatively (25.2 degrees) and it was corrected to normal values postoperatively (32.9 degrees). Kuklo et al.[3] reported a mean 28.2 TK preoperatively and it was decreased to the mean 24.5 degrees postoperatively in their monoaxial screw fixation group. In their monoaxial screw group, Lonner et al.[4] reported a preoperative mean 32 degrees TK and it was decreased to the mean 30 degrees postoperatively. Blondel et al.[7] achieved a better TK restoration in their hybrid polyaxial screw group compared to their hybrid monoaxial screw group. Acaroglu et al.[8] also remarked the difficulty of 3D deformity in AIS correction surgery and mentioned that TK is decreased as the lengthening of the spinal column while correcting the coronal plane deformity. The authors reported an overall 0.5-degree increase in thoracic hypokyphosis, in their study evaluating 53 articles about the treatment of AIS by various instruments. In our study, we achieved a mean 7.5 degrees correction in thoracic hypokyphosis. This finding can be explained by the augmentation of monoaxial screw fixation with sublaminar fixation. Acaroglu et al.[8] also mentioned that increase in TK angle was highest in hybrid constructs. We also achieved a better increase in the TK angle by our monoaxial

Table 1. Preoperative data of the patients

Patient	Age	Gender	Risser grade	Lenke curve type	Preop PT curve	Preop MT curve	Preop TL/L curve	Preop thoracic kyphosis	Preop lumbar lordosis
1	15	Female	4	5 C	*	*	46	23	44
2	16	Female	4	5 C	*	*	42	53	64
3	16	Male	4	2 A	33	56	35	27	38
4	14	Female	4	1 B	36	48	*	32	52
5	17	Female	5	1 C	*	*	43	20	57
6	16	Female	5	5 C	*	*	41	5	24
7	12	Female	3	1 B	*	46	32	11	36
8	12	Female	0	5 C	*	*	43	46	60
9	18	Male	5	2 A	36	49	*	32	48
10	13	Female	4	1 B	*	45	40	25	60
11	12	Female	3	1 A	*	53	*	20	46
12	14	Female	3	6 C	30	70	70	59	76
13	13	Female	4	1 B	*	53	*	6	32
14	18	Male	5	1 B	*	60	38	-6	34

*Cobb angles <25 degree were not taken into consideration
PT: Proximal thoracic, MT: Main thoracic, TL/L: Thoraco lumbar/lumbar, Preop: Preoperative

Table 2. Postoperative data of the patients.

Patient	Fusion levels	Instrument ratio**	Neutral vertebrae	Stable vertebrae	Postop PT curve	Postop MT curve	Postop TL/L curve	Postop thoracic kyphosis	Postop lumbar lordosis	Correction ratio***
1	T8-L4	77%	L5	L4	*	*	24	49	66	48%
2	T10-L4	71%	L5	L5	*	*	2	28	48	95%
3	T2-L1	58%	L1	L1	0	3	0	30	20	95%
4	T2-T11	70%	T11	T10	0	3	*	24	46	94%
5	T11-L3	91%	L5	L4	*	*	11	35	44	75%
6	T6-L4	77%	L4	L4	*	*	6	42	42	85%
7	T2-T11	65%	T10-L5	T11-L4	*	11	12	27	43	76-62%
8	T9-L4	68%	L5	L5	*	*	4	40	56	91%
9	T2-L1	62%	L1	L1	13	15	*	32	44	64-69%
10	T4-T11	68%	T11-L4	T11-L4	*	7	15	26	54	85-63%
11	T4-L2	63%	L3	L3	*	12	*	30	38	77%
12	T2-L4	66%	L5	L5	3	10	0	50	60	90-86%
13	T5-T12	87%	T12	L1	*	4	*	18	49	92%
14	T4-T11	87%	T11-L4	T11-L3	*	14	18	30	45	77-52%

*Cobb angles <25 degree were not taken into consideration
**Bilateral screw placement in all fusion levels considered as 100% instrumentation
***Correction ratio=[(Preop-Postop Cobb angle/Preop Cobb angle)x100]. 100% correction was not taken into consideration
PT: Proximal thoracic, MT: Main thoracic, TL/L: Thoraco-lumbar/lumbar

screw and sublaminar fixation constructs. This issue should be investigated by further studies.

The choice of proper implant is still on debate. Some authors favor the use of hybrid constructs, which consists of hooks and wires, in thoracic curves in addition to pedicle screws; whereas, some authors recommended the use of all pedicle screw constructs[9-12]. Aubin et al.[13] evaluated the implant selection of spine surgeons in the treatment of AIS through a spine surgery simulator, and they remarked the large variability between six surgeons in terms of implant selection, implant numbers, fusion levels, and rod rotation maneuvers. The authors concluded that this variability may be dependent on the surgeon's experiences[13]. This difference also exists between senior and junior spine surgeons. Qiao et al.[6] remarked that senior surgeons used more monoaxial screws and achieved better thoracic correction compared to junior counterparts in the treatment of AIS. With monoaxial screws, it can be difficult to achieve a perpendicular axis between the screw and rod, which may cause a gap between the rod and screw interference during tightening by a nut[14]. This situation can be challenging for the surgeons and provoke them to use polyaxial screws due to the freedom of the screw head in all axis. Wang et al.[15] also mentioned that extra forces to ensure proper rod setting is more needed with screws that have less freedom. Many biomechanical studies compared different designs of pedicle screws to evaluate the stability of fixation as well as the efficacy of correction. Liu et al.[14] performed a biomechanical investigation of direct vertebral derotation comparing monoaxial, uniplanar, and polyaxial pedicle screws. The authors achieved superior direct vertebral derotation by monoaxial screws compared to polyaxial and uniplanar screws[14]. In another study, Schroerlucke et al.[16] showed that monoaxial and uniplanar screws resisted higher loads than polyaxial screws. Authors reported that polyaxial screws failed mostly by screw-head slippage while monoaxial and uniplanar screws mostly failed by breakage from screw or rod[16]. On the other hand, some authors recommended the use of polyaxial screws at the distal ends of long spinal fusion constructs in order to increase screw-rod interface strength[17,18].

Low-density versus high-density instrumentation in the correction of AIS is another controversial issue in the literature. Some surgeons prefer to use fewer pedicle screws in order to decrease cost and implant-related complications while other surgeons favor using more pedicle screws to achieve a stronger construct[19]. A pedicle density ratio of 100% means that the pedicle screw is used bilaterally in all levels of fusion. In their study that evaluated high versus low pedicle screw density in Lenke 5 AIS, Sariyilmaz et al.[19] mentioned that high pedicle screw density (96.6%) and low pedicle screw density (75.4%) did not significantly differ in terms of curve correction in early postoperative and mean 40 months follow-up. de Kleuver et al.[20] reported that <80% pedicle screw density can be recommended in deformities up to 70 degrees according to a survey gathered from experienced spine surgeons. Our mean pedicle screw density was 72% which can be considered as low-density, and we achieved a mean 84% correction despite

low-density. The relationship between low-density pedicle screws and types of screws should also be investigated by further studies.

Study Limitations

The main limitation of this study is its retrospective design. However, we evaluated a prospectively collected patient population. Besides, the retrospective design of the study prevented potential patient selection bias. The other important limitation of our study is its small and heterogeneous patient population. Nevertheless, our cohort is relatively similar to previous studies in the literature comparing the radiographic outcomes of different constructs in the treatment of AIS. The main strength of our study is being the first study in the literature individually evaluating the radiographic outcomes of posterior instrumentation by using only monoaxial pedicle screws in the treatment of AIS performed by the same surgeon.

CONCLUSION

According to the results acquired from this study, monoaxial pedicle screws with sublaminar fixations demonstrated an efficient correction in both PT, MT, and TL/L curves and restoration of TK in AIS surgery.

Ethics

Ethics Committee Approval: Ethics committee approval was received from İstanbul Atlas University Non-Interventional Scientific Research Ethics Committee (25.06.2021-4758).
Informed Consent: Informed consent was obtained from each participant.
Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: K.T., U.A., Design: K.T., U.A., Data Collection or Processing: G.K.K., Y.O.K., Y.U., Analysis or Interpretation: G.K.K., Y.O.K., Literature Search: Y.Ç., Y.U., Writing: K.T., Y.Ç.
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Conflict of Interest: The authors have no conflicts of interest to declare.

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POSTERIOR ONLY SURGERY FOR RIGID SCOLIOTIC CURVES PROGRESSED ABOVE 80 DEGREES: DOES IT YIELD SUFFICIENT CORRECTION?

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ABSTRACT

Objective: The aim of this study was to present the long-term results of posterior spinal fusion (PSF) with pedicle screws only for rigid large thoracic curves by questioning, whether this approach could yield sufficient radiographic correction together with good clinical outcomes.

Materials and Methods: Patients, who had rigid large thoracic curves and underwent PSF with pedicle screws only between 1993 and 2016 in a single center were retrospectively reviewed. Patients were radiographically evaluated by using standard posteroanterior whole body standing X-rays and side bending X-rays. Functional evaluation was performed by using SRS-22 scores.

Results: Fifty-eight patients with an average age of 16.7 and an average follow-up duration of 131.6 months were included. Rigid scoliotic curves of the study population were further subcategorized as: idiopathic (n=50), congenital (n=6), and neuromuscular (n=2) with an average flexibility of 21.7%. Average number of fused segments was 14.2. Patients had an average pre-operative major curve magnitude of 96° (range; 82°-122°) which was improved to 28° (range; 16°-52°) (p<0.001) at the last follow-up visit. An average pre-operative shoulder asymmetry of 3.2 cm in 23 patients was improved to 0.7 cm (p<0.001). An average pre-operative pelvic asymmetry of 3.6 cm in 16 patients was improved to 1.0 cm (p<0.001). Total SRS scores and the scores of all of SRS domains were noted to be improved significantly at the last follow-up.

Conclusion: Rigid thoracic scoliotic curves could be corrected with PSF with pedicle screws only, with high success and low rates of complications. By utilizing PSF to rigid thoracic curves, the possible complications of anterior surgery could be avoided, while highly successful clinical and functional outcomes could be obtained in the long-term.

Keywords: Rigid thoracic curves, posterior spinal fusion, pedicle screws, thoracic spine, curve magnitudes, functional scores

INTRODUCTION

A large and rigid scoliotic curve was defined as a curve with a magnitude of 70 degrees or above and a curve flexibility of 30% or below[1,2]. While the current gold standard treatment modality for idiopathic curves progressed beyond 45° is the posterior spinal fusion (PSF) with segmental instrumentation by using pedicle screws, the optimal treatment modality for a rigid large curve is still a controversy[3-5].

Traditionally for rigid large thoracic scoliotic curves, anterior release combined with PSF has been accepted as the standard surgical option[6-8]. However, high general complication rate of the combined surgery, in addition to its negative impact on pulmonary functions as a result of chest wall violation has also been underlined by many studies[9-11].

The concept of thoracic pedicle screws (TPS), that was introduced by Suk et al.[12], confirmed by many other studies to provide improved segmental fixation, better immediate correction of both sagittal and coronal planes, allowing shorter segments of fusion and possesing lower risks for any neurological damage as applied to Lenke type 1 and 2 thoracic curves below 70°[13-15].

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For rigid large thoracic curves, recent studies underlined the safety and correctional efficacy of posterior only approaches utilizing pedicle screws as compared to combined surgeries while questioning the rationale behind conducting the anterior procedure with potential complications together with the surgical burden and concluding that only posterior surgery could be enough for the sufficient correction of the rigid large thoracic curves[6-8,16].

The aim of this study was to present the long-term results of PSF with pedicle screws only for rigid large thoracic curves by questioning, whether this approach could yield sufficient radiographic correction together with good clinical outcomes.

MATERIALS AND METHODS

After obtaining institutional review board approval (İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedic Surgery and Traumatology, approval number: 2021/191), a retrospective analysis was undertaken to detect a consecutive group of patients with scoliosis and rigid thoracic curves, that were operated in a single institution between 1993-2016. One hundred-two consecutive patients were detected to be operated (anterior only, anterior-posterior combined, posterior only) in the aforementioned time interval in a single institution for the management of rigid thoracic curves.

Patients were enrolled in the present study on the basis of the following inclusion criteria: (1) Having been operated posteriorly with pedicle screws only; (2) having a large-rigid thoracic curve as the major curve with a magnitude of >80° (measured in standing PA X-rays) and flexibility of <30% (measured in side-bending) X-rays; (3) being a primary case (not a revision), (4) having an apical vertebra above T12, (5) having a minimum follow-up duration of 5 years (Table 1).

Exclusion criteria comprised: (1) Having been operated anteriorly/with combined procedures/posteriorly by hybrid systems (hooks, wires, etc.); (2) having a large-flexible thoracic curve as the major curve with a magnitude of >80° (measured in standing PA X-rays) and flexibility of >30% (measured in side-bending X-rays) or vice versa; (3) being a revision case, (4) having an apical vertebra below T12, (5) having a minimum follow-up duration of less than 5 years. As a result of the exclusion criteria 44 patients (2: Anterior surgery, 5: Combined anterior-posterior surgery, 23: Posterior hybrid surgery with hooks and wires, 4: Age >17.3: Rigid thoracic curve <80°, 2: Large thoracic curves with a flexibility >30%, 3: Revision cases operated elsewhere, 1: Apical vertebra above T12, 1: Unwilling to participate) were excluded from the study. The remaining 58 patients were included in the study (Table 2).

Radiographic Outcome Parameters (ROP)

Preoperative and postoperative radiographic measurements were undertaken on standing whole spine X-rays, while the flexibilities of the curves were calculated on both side bending X-rays. ROP were composed of the rigid major thoracic curve magnitude in the coronal plane, thoracic kyphosis (T5-12), shoulder asymmetry and pelvic asymmetry.

The radiographic measurements were undertaken by one independent senior spine surgeon with Surgimap software (Nemaris Inc., New York, NY, USA) to prevent any bias of multiple observes. The radiographs were obtained as standing whole spine X-rays in PA and Lateral standard position. X-rays were taken preoperatively, immediate postoperatively, at the 1st (first outpatient visit), 3rd and 6th month, annually and at the latest FU appointment.

Clinical Outcome Parameters (COP)

As patient reported outcome questionnaires SRS-22 scores were applied to evaluate the clinical and functional outcome.

Surgical Technique

Patients were placed in prone position. A midline skin incision followed by subperiosteal dissection of paraspinal muscles were undertaken. Pedicle screws were inserted by utilizing

Table 2. Flowchart of the study population

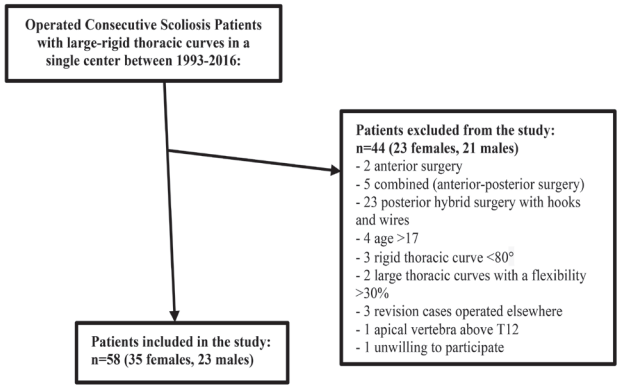

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Operated posteriorly with pedicle screws only	Operated anteriorly/with hybrid systems/posteriorly by hybrid systems (hooks, wires, etc.)
Having a large-rigid thoracic curve as the major curve with a magnitude of >80° (measured in standing PA) and flexibility of <30% (measured in side bending)	Having a large-flexible thoracic curve as the major curve with a magnitude of >80° (measured in standing PA) and flexibility of >30% (measured in side bending) or vice versa
Being a primary case (not a revision)	Being a revision case
An apical vertebra above T12	An apical vertebra below T12
A minimum follow-up duration of 5 years	A minimum follow-up duration of less than 5 years

free hand technique as Kim et al.[13] described, followed by the development of the pedicle trajectory and confirmation of the intraosseous borders. A 1.0-mm smaller diameter tapping than the diameter of the intended screw was performed to enhance the fixational stability[17]. After the placement of pedicle screws, the intraosseous screw trajectories were checked and confirmed by using fluoroscopy in both planes. Likewise, after the placement of rods, application of the correctional maneuvers and placement of set screws, the corrections and coronal-sagittal alignments were checked and confirmed by using fluoroscopy in both planes, as well. Inferior articular facets were removed by using an osteotome or rongeur to provide fusion, which was augmented by using local bone grafts harvested from facet joints and spinous processes. None of the patients required allografts or any bone substitute. Additionally apical Smith-Petersen osteotomies were performed for curves above 110° on the standing whole spine posteroanterior X-rays or for residual curves >90° on side bending X-rays.

Postoperative Rehabilitation Protocol

Patients were mobilized immediately after surgery and were allowed to return to daily activities after discharge, while return to sportive activities (including non-contact sports, swimming and light gym) were allowed after 6th post-operative month.

Information of Informed Consent

All patients were taken informed consents, so that their pre, intra- and postoperative data including the X-rays could be used for publication by hiding their identity.

Statistical Analysis

For the statistical analysis, SPSS software (Version 22.0; SPSS Inc, Chicago, IL, USA) was used. Data are expressed as mean ± standard deviation. The chi-square test and Fisher's Exact test were used for the analysis of categorical variables and to compare different time points where appropriate. One-Way ANOVA test was used to determine a significant difference at various time points. A p-value less than 0.05 was considered as statistically significant.

RESULTS

Fifty-eight patients (35 females, 23 males) with an average age of 16.7 (range 12-42) and an average follow-up duration of 131.6 months (range 60-174) were included. Scoliotic curves of the study population were further subcategorized as: Fifty idiopathic (2 infantile, 8 juvenile, 26 adolescent, 14 adult), 6 congenital, 2 neuromuscular and also associated increased thoracic kyphosis in 21 patients. These curves had an average flexibility of 21.7% (range 11.4-26.8). They all had an apex of deformity above T12. Average number of fused segments was 14.2 (range 11-16). A thoracoplasty was undertaken in 19 patients. Patients had an average duration of operations of 317.4 min (range 184-360) and an average post-operative hospital stay of 3.6 days (range 3-7) (Table 3).

Patients had an average pre-operative major curve magnitude of 96° (range; 82°-122°) was improved with high statistical significance to 28° (range; 16°-52°) ($p<0.001$) at the last follow-up visit. The rate of correction was calculated as 70.8%. Twenty-three patients' average preoperative shoulder asymmetry of 3.2 cm was improved to 0.7 cm in 11 patients ($p<0.001$) with high statistical significance, while the other 12 patients were not detected to have shoulder asymmetry. Similarly, an average preoperative pelvic asymmetry of 3.6 cm in 16 patients was improved to 1.0 cm in 10 patients ($p<0.001$) with high statistical significance, while the other 5 patients were not detected to have pelvic asymmetry. Patients had an average pre-operative thoracic kyphosis (T5-T12) of 49° (range; 7°-74°), while it was improved post-operatively to 33° (range; 23°-48°) ($p=0.024$) (Table 4, Figure 1,2).

After the availability of the Turkish validated version of SRS-22 score questionnaire, it was applied to 26 patients pre-operatively and at the last follow-up appointment. They had an average preoperative total SRS score of 3.2 (Function: 3.2, pain: 3.6, self image: 2.8, mental health: 3.7, satisfaction: 2.9), which improved to 4.5 (Function: 4.4, pain: 4.2, self image: 4.8, mental health: 4.8, satisfaction: 4.1) ($p<0.001$ for total, $p<0.001$ for each domain) with high statistical significance (Table 4).

Table 3. Data regarding the patients' demographics, curves and levels of instrumentation

Number of patients	58 (35 females, 23 males)
Average age of patients	16.7 (range 12-42)
Average duration of follow-up	131.6 (range 60-174)
Types of scoliotic curves	50 idiopathic (2 infantile, 8 juvenile, 26 adolescent, 14 adult) 6 congenital 2 neuromuscular Associated increased thoracic kyphosis in 21 patients
Average curve flexibility	21.7 (11.4-26.8)
Average number of instrumented levels	14.2 (11-16)
Most proximally instrumented level	T1
Most distally instrumented level	L4
Average duration of operations	317.4 (range 184-360)
Average postoperative hospital stay	3.6 days (range 3-7)

Table 4. Radiographic, clinical and functional outcomes

	Preoperative	At the last follow-up	p-value
Average major curve magnitude	96° (82°-122°)	28° (range 16°-52°)	<0.001
Average thoracic kyphosis (T5-T12)	49° (range 7°-74°)	33° (range 23°-48°)	0.024
Average shoulder asymmetry	3.2 cm (23 patients)	0.7 cm (11 patients)	<0.001
Average pelvic asymmetry	3.6 cm (16 patients)	1.0 cm (10 patients)	<0.001
Average total SRS scores (Average domain scores) for 26 patients	Total: 3.2 Function: 3.2 Pain: 3.6 Self image: 2.8 Mental health: 3.7 Satisfaction: 2.9	Total: 4.5 Function: 4.4 Pain: 4.2 Self image: 4.8 Mental health: 4.8 Satisfaction: 4.1	<0.001 <0.001 for every domain

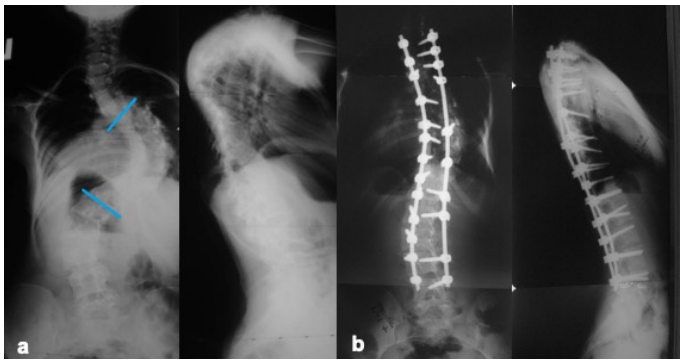

Figure 1. A 15 years old female with a ridig throracic curve of 95° reduced to 19°. A: Standing preoperative whole spine posteroanterior and lateral X-rays. B: Standing whole spine posteroanterior and lateral X-rays at the last follow-up

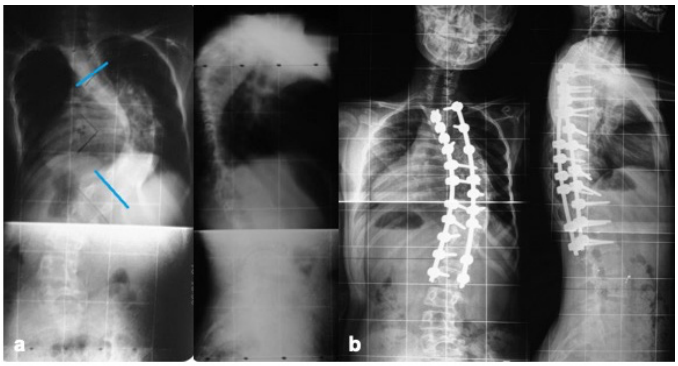

Figure 2. A 14 years old female with a rigid thoracic curve of 101° reduced to 26°. A: Standing pre-operative whole spine posteroanterior and lateral X-rays. B: Standing whole spine posteroanterior and lateral X-rays at the last follow-up

No infectious, neurologic or implant related complication was noted. Two patients were noted to have superficial wound side infections resolved with medical treatment. Two other patients were detected to have fever due to atelectasis immediate postoperatively and were treated with medication and respiratoy physiotherapy post operatively. A complication rate of 6.8% was acquired. No other major complications were noted. No revision surgery was performed to any patient in this particular cohort during the entire follow-up period.

DISCUSSION

The criterion to define a severe rigid scoliosis in addition to a diminished curve flexibility (<30%) was a Cobb angle >80° in by many studies[18-20], and >90° by other studies[21,22], and even >100° by another study[2]. Our criterion to define a large-rigid curve was also in conjunction with the studies, that accepted a Cobb angle as >80° and a curve flexibility <30%.

Historically, for rigid and large thoracic curves, in order to overcome the correctional inferiority and problems in thoracic spine associated with posterior instrumentation performed with hooks, anterior releases were advised to increase the curve flexibility resulting in greater correction and increased surface area for fusion expected to occur in future[23-25]. As a result of that principle, anterior release combined with PSF (APSF) became the traditional management strategy for large rigid curves, despite the fact that anterior surgery was associated with many complications including major pulmonary problems, increased time under general anesthesia and increased patient costs[8,9,24,26]. This is the main reason, why the authors of the present study mostly avoided applying anterior surgery and preferred posterior spinal instrumentation as shown (2 anterior, 5 antero-posterior approaches vs 81 posterior only approaches). TPS gained recently popularity because of providing three column fixation, improved correction of the curves in sagittal and coronal planes, being able to achieve great rotational correction together with lower rates of pseudoarthrosis, implant failure and need for postoperative bracing[14,15,27]. The placement of TPS were reported to be highly accurate, safe and successful despite the abnormal anatomy and orientation of the pedicles belonging to a severe rigid curve of a deformed spine of any patient without any neurological complications with more than 98% of precision in technique[28,29]. As a result of the aforementioned data, authors of the present study nearly always prefer to perform posterior only approaches by using pedicle screws only.

Despite many associated complications and risks, the correctional success of APSF reported many times (Kandwal et al.[2]: 77.2%, Bullmann et al.[19] 67%). However, it was recently shown by Luhmann et al.[8], that PSF undertaken with pedicle

screws only to rigid thoracic curves was able to yield equal correction as compared to antero-posterior combined surgery. This conclusion was supported by other comparative studies, so that posterior only approaches were encouraged[7,15].

Luhmann et al.[8] in their comparative study of 84 patients with minimum follow-up duration of 2 years created two matched groups of patients with APSF and PSF. APSF and PSF with TPS group was found out to yield 48.3°-47.5° of coronal correction with no statistical significance; in other words the improvement in rigid thoracic curve was not statistically significant. They reported a correction rate of 58.3%. The present study reported 68° of correction with a correctional rate of 70.8% underlining the correctional efficiacy of posterior only surgery with TPS. Luhmann et al.[8] also underlined, that over the last years for rigid curves above 70° they were always applying PSF with TPS only, because TPS could obviate the need for anterior surgery together with additional surgical procedural charge and total costs in addition to prevent from increased morbidity caused by chest wall violation of the anterior surgery.

Dobbs et al.[15] also underlined in his comparative study of 54 patients with rigid thoracic curves, that were applied either APSF or PSF with pedicle screws, that for rigid curves >90° PSF undertaken with pedicle screws provided the same coronal and sagittal correction as that with APSF. They reported, that both groups had a correctional rate of 44% (APSF: Mean preoperative Cobb: 92.3, Cobb at the last follow-up: 55°, PSF: Mean preoperative Cobb: 94.3°, Cobb at the last follow-up: 56°). In the present study PSF with TPS only was found out to improve the mean preoperative Cobb angle of 96° to 28°. Dobbs et al.[15] reported similar mean thoracic T5-T12 angles of PSF group pre-operatively and at the last follow-up. The present study reported that the mean thoracic kyphosis was improved from 49° preoperatively to 33° at the latest follow-up visit with low statistical significance.

Dobbs et al.[15] underlined that patients with rigid large thoracic curves already had significant restrictive pulmonary problems and ABSF should be avoided in that particular group to prevent from further declines in pulmonary functions, hence the PSF with TPS only was advised as a wiser choice, since it was able to yield the same correctional efficacy without creating further pulmonary problems. This is a very important point that we totally agreed upon.

The surgical technique by using free hand pedicle screw placement is similar to the techniques described in the studies of Luhmann et al.[8] and Dobbs et al.[15]. Dobbs et al.[15] and Luhmann et al.[8] reported neither any reoperation nor any implant related or neurologic complication besides the pulmonary complications associated with the APSF. The present study in conjunction with the aforementioned studies also reported neither any reoperation or any implant related or neurologic complication.

Shi et al.[7] also reported in their comparative study comprising patients with rigid thoracic curves, that were applied APSF or PSF with TPS only, that posterior only approach with all pedicle screws was able to provide the same curve correction as APSF without carrying any potential risks of anterior surgery. Similar to the present study, they utilized the SRS-22 scores pre- and postoperatively and detected significant improvement in total score and in all domains. Out results were in conjunction with that data, so that our patient population was also detected to have highly significant improvement in total SRS scores and also in every domain individually. Besides Shi et al.[7] reported an average duration of operations of 420 mins for PSF and an average of 4 days of hospital stay. The present study reported an average duration of operations of 317.4 mins for PSF, which was lower than Shi's data and an average of 3.6 days of hospital stay similar to Shi's data.

Coe et al.[11] utilized the morbidity and mortality database of Scoliosis Research Society (SRS), that contained 58,197 cases that were applied either anterior, or posterior or combined spinal fusion. He reported that as compared to posterior or anterior surgery alone, the anterior posterior combined surgery was doubling the rate of complications, while the combined surgery also was associated with a significantly higher rate of neurological complications[11]. In conjunction with Coe et al.[11] data, the authors of the present study avoided utilizing APSF, but performing PSF with pedicle screws only.

Study Limitations

This study comprises some limitations. The first one was the lack of a control group, who were applied APSF. But as reported in the flowchart, APSF was avoided as much as possible as a result of its potential serious complications and the high correctional efficacy of TPS applied with PSF. Another limitation was the limited number of patients, that were owed to the strict inclusion criteria. Another limitation was that SRS-22 score was not applied to all patients, but only to those after the validated Turkish version was available. This was owed to the long follow-up duration of the present study.

CONCLUSION

The present study concluded, that as a result of PSF undertaken with pedicle screws only, rigid thoracic scoliotic curves could be corrected with high success and low rates of complications. By utilizing PSF to rigid thoracic curves the possible complications of anterior surgery could be avoided, while highly successful clinical and functional outcomes could be obtained in the long term.

Ethics

Ethics Committee Approval: Institutional review board approval was taken İstanbul University İstanbul Faculty of Medicine, Department of Orthopedic Surgery and Traumatology (approval number: 2021/191).

Informed Consent: All patients were taken informed consents.

Authorship Contributions

Surgical and Medical Practices: T.P., M.Ö., M.K., Ö.K., Ş.K., T.A., F.D., Design: T.P., T.A., Data Collection or Processing: T.P.,

Analysis or Interpretation: T.P., M.Ö., M.K., Ö.K., Ş.K., T.A., F.D., Literature Search: T.P., T.A., Writing: T.P.

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Conflict of Interest: The authors have no conflicts of interest to declare.

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CHEST INJURIES ACCOMPANYING BLUNT SPINAL TRAUMA

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ABSTRACT

Objective: Only a few studies in the literature have evaluated chest injuries accompanying blunt spinal trauma. We aimed to evaluate chest injuries observed concomitantly with spine injuries as well as reveal their clinical importance.

Materials and Methods: Eighty-eight patients, who were treated and followed up by the authors after being admitted to the emergency department because of severe blunt spinal trauma, were evaluated retrospectively.

Results: Data from a total of 55 patients [30 (54.5%) male and 25 (45.5%) female] who met the study criteria were included. The mean age of patients was 58±15.8. Falling from height was the most common cause of trauma in 32 patients (58.2%) and was significantly more frequent than other causes such as traffic accident, assault, non-vehicle traffic accident, and motorcycle accident (p<0.001). Spinal fracture was observed in 38 patients with severe blunt spinal trauma (69.1%), while ligament and other soft tissue damage was found in 17 patients (30.9%). Spinal fractures were significantly more frequent in the thoracic vertebra (n=28; 50.9%) compared to other regions such as the cervical and lumbar spine (p<0.001). It was observed that chest injury accompanied 33 (60%) patients who experienced blunt spinal trauma. When the thoracic region was classified as per injured tissues; rib fracture (n=10; 30.3%) and pulmonary contusion (n=6; 18.2%) were observed most frequently.

Conclusion: Patients with thoracic spinal fractures should be considered at a high risk for chest injury, and this group of patients should be prioritized because of the possible life-threatening complications. In our study, we concluded that the rate of falling from height increased in the elderly group, as well as neurological losses. Moreover, the rate of neurological deficit following thoracic vertebral damage due to falling from height kept increasing, especially in the elderly group.

Keywords: Spine injury, vertebral body fracture, chest injury

INTRODUCTION

Traumas are major causes of morbidity and mortality[1]. In addition to spine injuries detected in 23.2% of post-trauma cases, 4.4% of patients had thoracic or lumbar vertebral fractures[2,3]. Injury to the spine does not always develop as an isolated trauma. An injury to the adjacent organs, which can cause life-threatening complications, increases the complexity of the trauma of this region[4]. Approximately 65% of thoracolumbar fractures are caused by motor vehicle accidents and falls from height, while others are due to blows and sports injuries[5]. Spine injuries caused by a high-energy trauma are accompanied by serious tissue injuries, such as rib fractures, pneumothorax, hemothorax, hemopericardium, diaphragmatic rupture, and major vascular injury[6,7]. However, pulmonary complications are often responsible for the morbidity and mortality in these cases[8]. Time is critical in managing the injury because there is a high risk of developing one or more life-threatening complications[9]. This study aimed to evaluate the relationship between spinal injury and chest damage as well as its significance by analyzing chest injuries accompanying severe blunt spinal trauma.

MATERIALS AND METHODS

The present study was conducted between October 2017 and October 2020 at the Faculty of Medicine, Çanakkale Onsekiz Mart University. Ethical approval was obtained from the Çanakkale Onsekiz Mart University local ethics committee (IRB number: 2021-01, date: 05.02.2021). Medical records of 88 patients, who were admitted because of severe blunt spinal trauma between October 2017 and October 2020 and whose follow-up and treatment were performed by the authors, were reviewed. A total of 17 patients with incomplete medical data and 16 patients who were presented with penetrating trauma were excluded from the study (Figure 1). The National Emergency X-Radiography Utilization Study method was used

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in the management of the patients admitted to our hospital (Figure 2)[10].

Fractures were categorized as per the following spinal regions: Cervical (C1-C7), thoracic (T1-T12), and lumbar (L1-L5). The demographic data (age and gender) of the patients, type of injury (falls from height, in-vehicle traffic accidents, blows, non-vehicle traffic accidents, motorcycle accidents), spinal injuries, accompanying thoracic injuries, and length of hospital stay were analyzed. The spinal fracture type, posterior ligamentous complex integrity, injury morphology and neurological status were evaluated using the thoracolumbar İnjury classification and severity score[11]. The abbreviated injury scale (AIS) was used to evaluate injuries in the chest area. AIS grades the type and severity of the injury and indicates whether an injury in a particular anatomical region is life-threatening[12]. Injuries were scored as minor (AIS 1 or 2) or severe (AIS>2) as per the AIS scale. Cases were evaluated using examination results, spinal and spinopelvic bidirectional radiographs, and computed tomography (CT) scans covering the entire spine and thorax region. Imaging modalities were supported by thoracolumbar magnetic resonance imaging (MRI) when there was an unspecified ligamentous injury in CT images or a neurological loss[13]. The blood analysis protocol routinely used in trauma was applied to all cases.

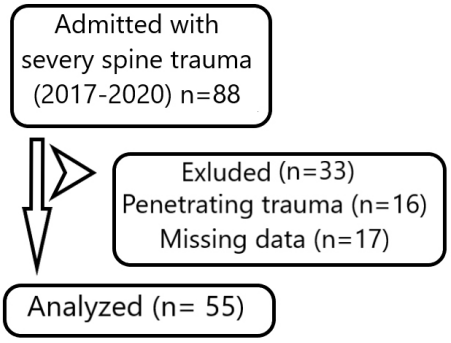

Figure 1. Study flow chart

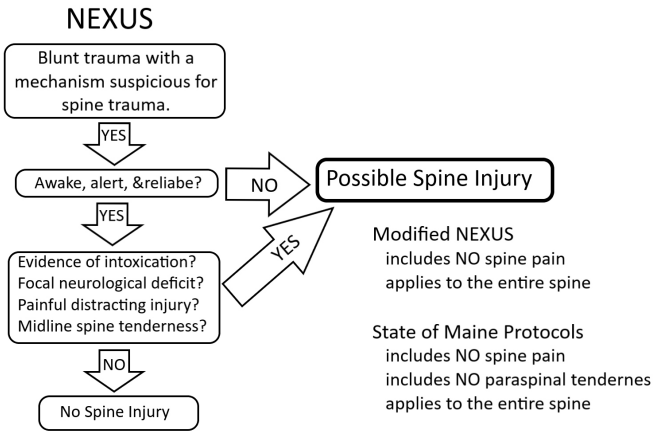

Figure 2. National Emergency X-Radiography Utilization Study method

Statistical Analysis

Descriptive statistics, such as percentages, mean, and standard deviation, which present the demographic distribution of cases, were calculated. The Kolmogorov-Smirnov normality test was used to decide on the application of a parametric or non-parametric test for the comparison of continuous variables. The Kruskal-Wallis test was used in the comparison analysis of continuous data of the groups. The relationship between categorical variables was analyzed using the crosstab and chi-square tests. When the expected frequencies in most of the cells in the chi-square and crosstab tests were $p<0.05$, the Fisher's exact chi-square test result was considered. The one-sample Kolmogorov-Smirnov test was used to examine a significant difference in a single sample.

RESULTS

Data of a total of 55 cases [30 (54.5%) male and 25 (45.5%) female] were included in the study. The mean age was 58±15.8 (range; 22-89, Table 1). Falling from height was the most common cause of trauma in 32 cases (58.2%) and was significantly more frequent than other causes such as traffic accident, assault, non-vehicle traffic accident, motorcycle accident ($p<0.001$, Table 2).

The cause of trauma in 17 (60.7%) cases aged >60 years and in 15 (46.9%) cases aged <59 was falling from height. There was no statistically significant relationship between the cause of injury and age ($p=0.670$). Of the severe blunt spinal trauma cases included in the study, 38 (69.1%) had spinal fractures and 17 (30.9%) had ligament and other soft tissue damage (Figure 3). Spinal fractures in the thoracic (n=28; 50.9 frequent compared to cervical and lumbar regions ($p<0.001$). When considering

Table 1. Demographic distribution of the cases

		n	%
Sex	Female	25	45.5
	Male	30	54.5
Age	20-59	47	49.1
	60 and above	28	50.9
Spinal fracture presence and level	No fractures	17	30.9
	Cervical	2	3.6
	Thoracal	28	50.9
	Lumbar	8	14.5
Presence of thoracic injury	None	22	40.0
	Chest	10	18.2
	Severe chest	23	41.8
Presence and severity of neurological loss	No deficit	34	61.8
	Quadriplegia	1	1.8
	Paraplegia	1	1.8
	Partial deficit	19	34.5

the distribution of chest injury cases according to the levels of spinal fracture, cases with thoracic vertebral fractures had more severe chest damage, although this difference was not statistically significant (p=0.110). After neurological evaluation, our cases mostly had a partial neurological deficiency (n=19; 34.5%), and there was a significant difference between the neurological loss levels of different groups (p<0.001; Table 1).

Spinal fractures were significantly more common in severe chest injuries (p<0.05). Cases with spinal fractures and severe chest injuries were significantly higher than those with severe chest injuries but without any spinal fractures (p<0.05). However, cases with severe chest injuries (AIS 3) were higher than cases with minor chest injuries (AIS 1 or 2) among cases with spinal fractures (p<0.05) (Table 3). Thoracic spinal fractures were more common in women (n=18; 85.7%), but the difference from men (n=10; 58.8%) was not statistically significant (p=0.132). Likewise, severe chest injury rates were higher in women (n=9; 39.1%) than men (n=14; 69.1%), but this difference was not statistically significant (p=0.225). When all thoracic injuries were evaluated, rib fractures (n=10; 30.3%) and pulmonary contusions (n=6; 18.2%) were observed most frequently. A significant difference was found between the frequency of rib fractures and other chest injuries (p<0.05). By contrast, clavicle fracture in six cases and sternum fracture in two cases accompanied other injuries (Table 4).

The follow-up and treatment of 51 (92.7%) cases were performed by hospitalization, and the mean length of hospital stay was 4.5±3.4 days (range, 0-15). Four (7.3%) patients with ligament injury and/or an isolated rib fracture in the spinal region and without any complications, which would prevent their daily activities, were followed up and treated in an outpatient setting. Patients with chest injuries had a longer hospital stay than patients without any chest injury, and the prolongation of this period was statistically significant (p<0.001).

Table 2. Demographic distribution of trauma mechanisms

Trauma mechanism	n	%
Falling from height	32[a]	58.2
Traffic accident	16	29.1
Assault	4	7.3
Non-vehicle traffic accident	2	3.6
Motorcycle accident	1	1.8

The difference was found to be statistically significant when "[a]" was compared with the others. Chi-square, One-Sample Kolmogorov-Smirnov test was applied and p<0.001 value was considered significant

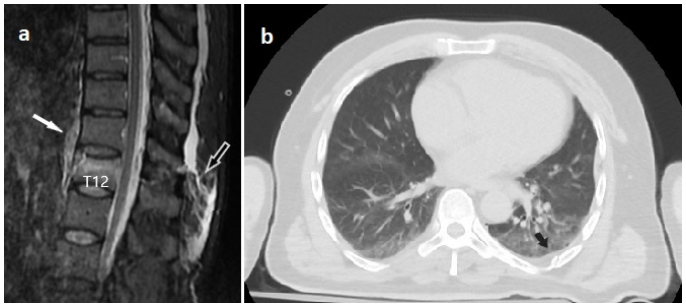

Figure 3. Radiological images obtained in the early post-traumatic period. **a)** Magnetic resonance image of the sagittal thoracic region made with FSE STIR sequence technique. The area of the hemothorax is shown by the white filled arrow, and the ligament tears and edema area in the thoracic spine area are shown by the black filled arrow. **b)** Image obtained by computed tomography of the thoracic region. Hemothorax, pulmonary contusion areas and fractured ribs are observed in the area indicated by the black filled arrow

DISCUSSION

Each year, between 250,000 and 500,000 people worldwide suffer from spinal cord injuries[14]. Spinal fractures occur in 4.4% of patients with general trauma and are particularly frequent in the thoracolumbar region[15]. The etiology of >90% of spinal injuries include traffic accidents, violence, sports, falls and similar trauma[14]. The rib cage provides an important biomechanical protection to the thoracic spine. Therefore, an injury to the thoracic spine means that the cause was a high-energy trauma. Thoracic and lumbar spine fractures are caused by a combination of trauma-producing vectors of force approaching from different directions. Injuries to the upper

Table 3. The relationship between the presence of a fracture in the spine and the severity of the thoracic injury

	Severity of thoracic injury	
Vertebrae fracture	Mild	Severe
Yes	2 (12.5%)$^{\alpha\gamma}$	14 (87.5%)$^{\alpha\beta}$
No	8 (47.1%)$^{\gamma\delta}$	9 (52.9%)$^{\beta\delta}$
Total	10	23

There is a significant difference between both "α", both "β", and both "γ" marked cells (p<0.05). It was seen that the difference between the cells marked with "δ" was not significant (p>0.05). Crosstabs, Pearson chi-square test was applied and p<0.05 was considered statistically significant

Table 4. Anatomical distribution of injuries in the thoracic region

Injured thoracic region	n=33	%
Rib fracture	10[a]	30.3
Pulmonary contusion	6	18.2
Pneumothorax	2	6.1
Hemothorax	1	3.0
Rib fracture with hemothorax	3	12.1
Rib fracture with pneumothorax	4	15.2
Rib fracture with pulmonary contusion	3	9.1
Multiple rib fractures	2	6.1

Cases with more than one thoracic injury were included. The difference was found to be statistically significant when "[a]" was compared with the others. chi-square, One-Sample Kolmogorov-Smirnov test was applied p<0.05 was considered statistically significant

or middle thoracic spine are often caused by a high-energy trauma, such as a motor vehicle accident[16]. In our study, falling from height was the most common cause of trauma with 32 (58.2%) cases, and it was significantly higher than other causes of trauma (p<0.001). Because agricultural activities are intense in the area where our hospital is located, falling from trees during harvests are common. Older adults presenting with trauma should be examined in more detail because the risk of spinal fractures increases with older age. These patients are particularly susceptible to traumatic spinal injury because of many factors, such as changes in bone quality with aging, medications, and increased prevalence of spinal stenosis and spinal diseases. Because of the increased risk of fractures, the rate of complications is higher in traumas suffered by older adults. Tissue damage due to trauma increases with age[17]. Adults aged >60 years suffer from graver spinal injuries than younger patients. In older adults, traumas due to falls from height occur more often, and fracture formation is the result of an age-related decrease in the load-bearing capacity of the bone. Because 50.9% of our cases were aged ⩾60 years, the frequency of thoracic injuries accompanying spinal fractures was quite high in our study.

A chest tissue injury missed by radiographic and physical examinations may lead to permanent physiological and neurological losses in patients[16,18]. To prevent such situations, it is necessary to use trauma algorithms and investigate carefully whether there is a chest injury in patients with spinal fractures, as demonstrated in our study. Damages to the spinal cord, soft tissues, and ligaments, that developed after spinal trauma, were detected by patient MRIs. This imaging method is extremely helpful in detecting damage to the intervertebral discs, ligaments, vascular structures, and the spinal cord, and for making differential diagnosis[16,19]. Some studies examined injuries accompanying spinal fractures and reported that extremity and cranial injuries were common[20,21]. However, it is well known that damage to the spine, ribs, and intrathoracic structures is frequently overlooked. Rib fractures are a highly painful and disabling type of injury commonly observed among trauma patients, and many studies have shown that the unexpected frequency of rib fractures has a negative impact on patients[22,23]. Leucht et al.[20] reported that thoracic injuries accompanied 18.5% of patients with spinal fractures and was the third most common injury accompanying vertebral fractures. Rib fractures are usually associated with pulmonary contusions that significantly increase pulmonary morbidity in patients with multiple traumas[24,25]. Thoracic pathologies accompanying vertebral fracture cases included in our study were mostly rib fractures and pulmonary contusions. In severe spinal trauma, the thoracic spine is affected more, and the fracture risk is higher than in the other spinal regions[26]. Likewise, in our study, thoracic fracture was significantly higher than cervical and lumbar (p<0.001). Neurological involvement following trauma in our cases was mostly at the level of partial neurological deficit (n=19; 34.5%; p<0.001).

Patients with stable thoracolumbar fracture without neurological loss and who are treated conservatively show better results than surgically treated patients[27]. We applied conservative methods to the patients with a partial neurological loss in our study, and no additional neurological loss developed during follow-up. The length of hospital stay was particularly prolonged in patients aged >50 years with multiple traumas accompanied by chest injuries[28]. In our study, 33 patients who were followed up for chest injuries, stayed in the hospital longer than patients without any chest injury (p<0.001).

Study Limitations

Our study has some limitations: The study was retrospective in nature and the number of cases was small. By contrast, we believe that the study provides valuable clinical data, particularly to emergency service providers, by contributing to the reduction of morbidity and mortality in such cases.

CONCLUSION

Chest injuries, which are the most important complications that accompany spinal injuries and threaten life, should be considered primarily in patients with multiple traumas. This risk is further increased in cases with thoracic spinal fractures. Coexistence of spine and chest injuries increases in the elderly patient group, especially in cases of falling from height. In our study, we concluded that the majority of injuries in the spine were thoracic vertebral fractures and these cases had a high risk of neurological loss. Imaging techniques, such as MRI and CT, should be among the diagnostic and follow-up modalities in addition to clinical evaluation in accordance with trauma protocols for diagnosing pulmonary and vascular complications as well as thoracic wall pathologies.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Çanakkale Onsekiz Mart University, Ethical Board of Clinical Studies (IRB number: 2021-01, date: 05.02.2021).

Informed Consent: Permission to use medical records for clinical studies were present on the routine patient consent forms received before the operation.

Authorship Contributions

Concept: H.O.K., Ü.A.M., Design: H.O.K., Ü.A.M., Data Collection or Processing: Ü.A.M., Analysis or Interpretation: H.O.K., Ü.A.M., Literature Search: H.O.K., Writing: H.O.K., Ü.A.M.

Conflict of Interest: The authors declare that they have no conflict of interest.

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ORIGINAL ARTICLE
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BIOCHEMICAL ANALYSIS FOR NEUROPROTECTIVE EFFECTS OF GANODERMA LUCIDUM IN EXPERIMENTAL RAT SPINAL CORD TRAUMA MODEL

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ABSTRACT

Objective: Injury of the spinal cord is studied in two separate mechanisms as primary and secondary injuries. During the secondary injury, spinal cord damage and related neurological defects could increase mostly because of oxidative damage. Treatments targeting this process are promising for reducing neuronal damage. Ganoderma lucidum (GL) has the potential to suppress the inflammatory response and oxidative stress. The aim of this study is to determine the neuroprotective effect of traditional GL hot-water extract during the secondary spinal cord injury (SCI) period on an experimental rat spinal trauma model by measuring the biochemical parameters.

Materials and Methods: A total of 34 rats were distributed randomly into 4 groups as trauma, vehicle, low-dose medication group (low-DMG) and high-dose medication group (high-DMG). A modified Walsh-Tator clip was applied extradurally to form an experimental SCI model. GL liquid extract was performed in medication groups with low and high (10 times higher) oral doses. Spinal cord specimens were collected after 5 days of treatment for biochemical analysis.

Results: In the low-DMG, both diphenypicrylhydrasyl (DPPH) and malondialdehyde (MDA) values were found statistically negligible when compared with the trauma group. Comparison of the Low-DMG and vehicle group showed a significant change in DPPH value, but an insignificant change in MDA value. A statistically significant positive change in both DPPH and MDA values was found in High-DMG when compared to trauma and vehicle groups.

Conclusion: Prevention of secondary SCI is very important, since the neurological condition of the patients may get worse during this period. Dose-dependent positive results were obtained in the favor of GL in terms of both antioxidant efficacy and prevention of lipid peroxidation after SCI. The results of this biochemical study is supporting the previous studies and showing that GL has the potential of reducing posttraumatic oxidative damage in the spinal cord when given at the appropriate dose.

Keywords: Ganoderma lucidum, spinal injury, rat model, oxidative damage, neuroprotection

INTRODUCTION

Spinal cord injuries (SCIs), which may cause permanent disabilities, have special importance for both prevention and treatment. Injury of the spinal cord could be studied in two separate mechanisms as primary and secondary injuries. The mechanical injury that occurred right in the time of spinal trauma is named as primary injury[1,2]. Injury by the hemodynamic, metabolic, biochemical and apoptotic mechanisms initialized after hours or days following the trauma is called secondary injury[1,3-5]. In most cases, spinal cord damage and related neurological defects increase during the secondary injury period[6,7]. Treatments targeting this inflammation process are promising to attenuate neuronal damage.

There are lots of theories on the development of secondary SCI such as neurogenic shock, excitotoxicity, electrolyte imbalance, inflammation, immunological injury, vascular injury, increased intracellular calcium, free-radical development, endogenous opioids and apoptosis[5,8]. Oxidative stress and inflammation are two subjects considered to be very important for secondary SCI development[9]. The lipid peroxidation process is known to be the main reason for the cell membrane degradation leading to irreversible neuronal injury[10,11]. Peroxidation of fatty acids reveals an intermediate product called malondialdehyde (MDA) which can be used for measuring the level of lipid

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peroxidation[10]. Although MDA is not a specific or quantitative indicator, it correlates with lipid peroxidation levels and could be measured by using thiobarbituric acid as applied in this study[10,12].

Ganoderma lucidum (GL) is one of the well-known mushrooms, named "Red Reishi" or "Lingzhi", which was being used for over 2000 years especially in far eastern countries because of the belief that the mushroom provides long and healthy life for the user[13,14]. This belief was supported by many scientific studies identifying active ingredients of GL such as bioactive triterpenes, polysaccharides and immunomodulatory proteins which have potent anti-tumor, anti-inflammatory and cytotoxic effects for malignant cells[15-18]. Besides, GL has the potential to suppress the inflammatory response and oxidative stress with its antioxidant, immunomodulatory and steroid-like bioactive ingredients.

The aim of this study is to investigate the neuroprotective potency of traditionally used hot-water extract of GL and if any, its' dose-dependent effects on oxidative stress by measuring the biochemical parameters, during the secondary SCI period.

MATERIALS AND METHODS

After ethical committee approval (2011-123-485/26.10.2011) from Ankara University Ethical Committee of Animal Experiments was taken, the experimental study and animal care were carried out at the Animal Experiments Laboratory of Ankara Hospital. Biochemical study was performed at the Pharmacology Department Laboratory of Gazi University. GL 30% extract was obtained from Erkel Food Industry and Trade Ltd., which was produced with the authorization of The Republic of Turkey Ministry of Food, Agriculture and Livestock (food production authorization no: G34-6054-00002-4). All the subjects were obtained from Saki Yenilli Laboratory of Experimental Animal Production as 240 – 260 grams weighted, male, Wistar-Albino rats.

Experiment and Surgical Procedure

Daily care was given to a total of 34 rats in a suitable standard environment at room temperature without any food or water restrictions. The subjects were distributed randomly into 4 groups as follows:

Group 1: Trauma group (n=8): Only spinal trauma was applied to the subjects in this group. No additional treatment was given other than standard care.

Group 2: Vehicle group (n=8): Subjects in this group were given 1 mL of distilled water in addition to standard care.

Group 3: Low-dose medication group (Low-DMG, n=9): The recommended daily human dose of GL hot-water extract was administered to the subject of this group in proportion of their body surface areas[19-21].

Group 4: High-dose medication group (High-DMG, n=9): A ten times more of the recommended daily human dose of GL hot-water extract was administered to the subject of this group in proportion of their body surface areas[19-21].

Under veterinary supervision, all the subjects were abstained from oral intake 6 hours before the anesthesia process. According to their previously calculated body surface areas, 2% xylazine hydrochloride (10 mg/kg) and 5% ketamine hydrochloride (50 mg/kg) were applied by intraperitoneal injection[21]. After appropriate surgical disinfection microsurgical procedure was started in the prone position with an interscapular midline incision. Bilateral subperiosteal blunt dissection and retraction of paravertebral muscles were followed by 3 adjacent thoracic laminectomies under extreme care for avoiding dura mater and SCI (Figure 1). A modified Walsh-Tator clip with 35 grams of closing pressure was extradurally applied for 60 seconds to all cases to form an experimental SCI as described by Rivlin and Tator[22]. A line-shaped bruising over the spinal dura mater was observed in all subjects before primary closure (Figure 1).

After the surgical procedure, all the subjects were observed as paraplegic as expected. Two hours after recovery, besides standard care without food or water restrictions, 1 mL of GL hot-water liquid extract in distilled water was started to both medication groups by orogastric cannula in two equal doses a day. Although a standardized dosage for GL hot-water extract is absent, the suggested effective dose for human usage is 1.5 g to 9 g daily for different ailments, which can be divided into 2 or 3 doses[19,20]. Recommended mean oral dose for human daily usage was proportioned to body surface area of the subjects as 13.3 mg/m^2/day (0,3%) for low-DMG and ten times more of the recommended dose, 133 mg/m^2/day (3%) for high-DMG[19,20,23]. Unlike the trauma group, an additional 1 mL of distilled water was given to the vehicle group besides standard care. No adverse effects were observed due to GL treatment.

All subjects remained paraplegic without any observable neurologic improvement during the study before, the spinal cord specimens were collected after 5 days of postoperative follow-up. The procedure was started under general anesthesia with a thoracotomy and left cardiac ventricle catheterization and followed by injection of 25 mL 0.1 M phosphate-buffered saline solution to clean the spinal cord specimens from blood elements. After cardiac arrest developed, previous surgical incisions were reopened. For each subject, a total of 2 cm spinal cord segment, centering the previously injured region was harvested and the specimens were immediately stored at -80º C without any contaminants.

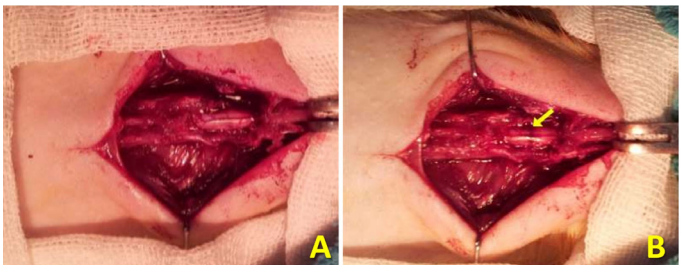

Figure 1. Spinal cord dissection after laminectomy procedure **(A)** and extradural marking (arrow) of spinal cord injury created with clip compression **(B)**

Biochemical Study

A ten times diluted solution of 0.01 M isotonic phosphate buffer at pH: 7.4 was prepared (9 gr NaCl, 2,575 gr $Na_2HPO_4.7H_2O$, 0.274 gr $NaH_2PO_4.2H_2O$, distilled water). Spinal cord samples were weighed and 10 µL of the buffer solution per sample weight in milligrams were added. Weights of the collected spinal cord samples were given in Table 1. Prepared samples were homogenized twice under ice-cooling using Ultra Turnax® T18 Basic Homogenizer at 14.000rpm for 30 seconds. The homogenates were centrifuged at 17,000 g, +4° C for 20 minutes, and 250 µL of the supernatants were separated for the biochemical study.

The samples were hydrolyzed in a 50 µL NaOH solution at 60° C for 30 minutes using an incubator and acidified by using 125 µL perchloric acid solution. After re-centrifugation at 14,000 g for 10 minutes, 250 µL of supernatants were separated in glass tubes. Then the samples were incubated with 25 µL 2.4-dinitrophenylhydrazine for 10 minutes and twice extraction with hexane was performed before the organic phases were dried at -40° C using nitrogen[24-26].

For total MDA quantity measurement, 20 µL of each sample was studied with 310 nm wavelength using high performance liquid chromatography (HPLC) at 30° C with a flow rate of 0.6 mL/min[26]. For antioxidant capacity determination 1.2 mg 2.2-diphenyl-1-picrylhydrasyl (DPPH) and 50 mL MetOH radical solutions were used. For 10 µL of each sample a 20 µL of MetOH was added on and the obtained solution was centrifuged at 15,000 g for 20 minutes. Obtained supernatant (15 µL) was mixed with DPPH solution (195 µL) and incubated for 30 minutes in total darkness. Then the samples and DPPH radical solution were studied for absorbance values at 515 nm wavelength using HPLC. Inhibition % values were calculated using "Inhibition $\%=A_{DPPH}-A_{sample}/A_{DPPH}x100$" formula[24,25].

Statistical Analysis

Obtained data from HPLC wavelength peak areas representing MDA levels and absorbance inhibition levels of the DPPH treated samples were calculated using the Statistical Package for the Social Sciences (SPSS v16.0.0) software. A Levene's test was used for the evaluation of homogeneity of variances and the study groups were compared with the independent samples t-test, including mean and standard deviations in %95 confidence intervals. P-value ⩽0.05 was considered as statistically significant and group comparisons were summarized in Table 2.

RESULTS

DPPH levels: For the Low-DMG, differences in DPPH levels were found statistically negligible when compared with the trauma group (p>0.05). Low-DMG and vehicle groups comparison showed a significant DPPH difference (p⩽0.05). High-DMG showed an evident statistically significant difference compared to the trauma group for the DPPH levels (p⩽0,05). High-DMG and vehicle group comparisons were also significant for DPPH levels (p⩽0.05). Comparisons for DPPH levels of High-DMG and Low-DMG showed an insignificant difference (p>0.05).

MDA levels: Comparison of Low-DMG and trauma groups were insignificant for MDA values (p>0.05). Low-DMG and vehicle groups comparison was also insignificant for MDA (p>0.05) values. For high-DMG, differences in MDA levels were found statistically significant when compared to the trauma group (p⩽0.05). High-DMG and vehicle group comparisons were also significant for MDA values (p⩽0.05). Comparisons for MDA levels of high-DMG and low-DMG showed an insignificant difference (p>0.05).

DISCUSSION

SCIs have special importance for both prevention and treatment especially for causing personal and social health problems. Most of the patients suffer from permanent incapacities, severe labor loss, and high expenses for hospitalization followed by long-term rehabilitation programs. Preventing the primary spinal injury is golden for sure but, the patients are always at the secondary SCI period at the time of hospital admission. Relatively fortunate patients with incomplete SCI on hospital admission frequently get worse over hours or days during the

Table 1. Weights of the collected spinal cord samples in miligrams

Sample	High-DMG	Low-DMG	Vehicle Group	Trauma Group
1	174.0	221.7	156.5	190.4
2	95.6	114.4	196.8	314.6
3	161.8	180.0	154.3	209.7
4	188.8	167.0	205.0	141.3
5	230.2	204.7	152.6	140.3
6	232.9	209.6	209.4	138.0
7	151.9	248.8	63.5	168.4
8	201.2	115.0	225.6	202.0
9	154.3	134.6	-	-
Mean	176.7	177.3	170.5	188.1

DMG: Dose medication group

Table 2. Statistical comparisons of the experiment groups

	Groups	N	Mean	Standard Deviation	Standard Error Mean	Sig.
DPPH	Low-DMG	9	10.5509	2.84696	0.94899	p>0.05
	Trauma	8	11.2185	5.57615	1.97147	
MDA	Low-DMG	9	4.8560	1.33605	0.44535	p>0.05
	Trauma	8	2.8867	1.09488	0.38710	
DPPH	Low-DMG	9	10.5509	2.84696	0.94899	p≤0.05
	Vehicle	8	13.6134	7.12992	2.52081	
MDA	Low-DMG	9	4.8560	1.33605	0.44535	p>0.05
	Vehicle	8	3.8158	1.52369	0.53871	
DPPH	High-DMG	9	13.4827	2.31020	0.77007	p≤0.05
	Trauma	8	11.2185	5.57615	1.97147	
MDA	High-DMG	9	2.6651	0.57380	0.19127	p≤0.05
	Trauma	8	2.8867	1.09488	0.38710	
DPPH	High-DMG	9	13.4827	2.31020	0.77007	p≤0.05
	Vehicle	8	13.6134	7.12992	2.52081	
MDA	High-DMG	9	2.6651	0.57380	0.19127	p≤0.05
	Vehicle	8	3.8158	1.52369	0.53871	
DPPH	High-DMG	9	13.4827	2.31020	0.77007	p>0.05
	Low-DMG	9	10.5509	2.84696	0.94899	
MDA	High-DMG	9	2.6651	0.57380	0.19127	p>0.05
	Low-DMG	9	4.8560	1.33605	0.44535	

DPPH: Diphenypicrylhydrasyl, MDA: Malondialdehyde, DMG: Dose medication group

secondary injury period which makes the treatment of secondary injury so important[1,3,5,7,8,16,27]. Besides lots of factors that were accused for the development of secondary SCI, it is known that oxidative stress has a significant role in this mechanism, which makes it a good target for new treatment modalities[9]. This is the main reason that this study was focused on oxidative injury mechanisms.

There are many experimental spinal trauma models developed so far. One of these standardized methods is the clip-compression method described by Rivlin and Tator[28]. In this study, this clip-compression method was preferred because of its high reliability and similitude according to human spinal injuries[22,28,29]. By this method, ischemia and neuroinflammation related free oxygen radical formation and lipid peroxidation can be created. During and after the application of clip compression, a perfusion defect occurs in all circulatory levels (arteriolar, venular and capillary) similar to the changes that occur during human spinal traumas[1,30].

Although GL was being used traditionally for thousands of years especially in the far eastern countries, it was recognized and began to be researched in western medicine in the 1980s. These studies revealed a variety of biological activities for this mushroom such as anti-neoplastic, anti-inflammatory, immunomodulatory, immunotherapeutic, hepatoprotective and ACE inhibitory effects[31-37]. Pharmacologically active ingredients of GL are triterpenes, which have similar molecular structures like steroid hormones and polysaccharides (especially β-d-glucan). These pharmacologically active molecules were recognized both in vitro and in vivo studies for preventing free oxygen radical generation and reducing their cellular oxidative damage[32,36,38]. This antioxidant effect is highest in Terpenes such as ganoderic acid A, B, C and D, lucidenic acid B and ganodermanontriol[36]. At the same time, it was shown that the "GL peptide" can effectively eradicate hydroxyl and superoxide radicals dose-dependently[39]. Shi et al.[40] studied hot water extracts of eight different mushrooms for their potential of reducing hydrogen peroxide (H_2O_2) mediated oxidative stress and found that GL has a high antioxidant feature and it has the potential to protect cellular DNA from oxidative damage. In a following *in vitro* study by Abdullah et al.[41], an antioxidant index (AI) was generated for hot water extracts of different mushroom species and GL (IC_{50}=50 µg/mL) was found to be the most potent with a 30.1% AI.

There are various studies showing that GL treatment reduces oxidative damage both in vitro and *in vivo*[42-44]. These findings were also similar in the central nervous system, especially studied on cerebral oxidative injury models[45,46], and previous spinal trauma models. In a detailed clip-compression spinal trauma experiment on rats, pre-isolated GL polysaccharides (GLPS) were administered before SCI. This biochemical, histopathological and ultrastructural study by Gokce et al.[47], showed positive results on reducing oxidative damage in favor

of crude GLPS. In another detailed study by Kahveci et al.[48], ischemia-reperfusion injury was created in the spinal cord by clamping the aorta, and pre-isolated GLPS were given to the subjects before SCI. Successful results were obtained with GLPS in preventing oxidative damage[48]. In a weight-dropping spinal cord injury rat model by Ekinci et al.[49], isolated GLPS were used after SCI. Biochemical and histopathological evaluations showed that, the use of GLPS had positive results in preventing oxidative damage[49]. In all three SCI studies mentioned above, subjects were administered pre-isolated GLPS at a constant dose of 400 mg/kg/day. In the first two studies, GLPS treatment was started 7 days before the SCI and spinal cord tissues were obtained 24 hours after the injury. In the last study mentioned, GLPS treatment was applied for 7 days after SCI. As mentioned before, polysaccharides, triterpenoids and peptides in GL were also determined to be bioactive. Therefore, in our study, unlike these studies, traditionally consumed hot-water extract of GL was tested at different doses without pre-isolating GLPS. In daily practice, since the treatment of spinal cord injuries is usually started after the injury, it was preferred to start the GL application after the SCI was created in the experiment. In previous biochemical experiments, the levels of different tissue free oxygen radicals and antioxidants were measured and the positive effects of the use of GL were shown[47-49]. In our study, in addition to the MDA level measurement used for the evaluation of lipid peroxidation, the antioxidant capacity of spinal cord tissue after SCI was tried to be tested by measuring the DPPH level.

To the subjects in low-DMG, the average recommended GL hot-water extract dose for humans was applied, in proportion to the rats, while ten times more dose was applied to the subjects in high-DMG[19,20]. In this study, supporting the previous studies, it was found that the GL treatment after SCI, increases the absorbance values of the DPPH treated spinal cord samples, and decreases the MDA levels. These positive results could only be obtained in the high dose medication group when compared to the trauma and vehicle groups. It was determined that, only DPPH change is statistically significant for the comparison of the Low-DMG and the vehicle group but, it was insignificant for MDA values. In the comparison of high-DMG and low-DMG, insignificant results were found for both DPPH and MDA values. These findings suggest that GL treatment also had some efficacy at low doses, but since it is not affecting MDA values, the efficacy could be considered as inconsistent and negligible. Since, traditional GL hot-water extract started in a sufficient dose range during the secondary SCI period prevents the oxidative damage, it was thought to have therapeutic potential for secondary SCI. Previous studies have shown that the efficacy of methylprednisolone (MP), the commonly used drug in the treatment of spinal injury, and GL are similar[47,49]. However, various and sometimes serious side effects can be observed due to MP therapy[50]. There are no serious side-effects encountered previously for GL both in animal and human experiments[23,51,52]. Besides its potential, the lack of significant side effect even at high doses makes GL more clinically valuable. The common handicap of experimental studies on this subject, including ours, is the limited number of subjects. Studies with more subjects are needed to establish a treatment protocol for human use.

CONCLUSION

In this study, the antioxidant neuroprotective effect of GL was biochemically investigated in a spinal cord injury model created by clip compression in rats. After SCI was administered, traditional GL hot water extract was given for 5 days to the subjects in two different dose groups and spinal cord samples were compared with control groups. Positive dose-dependent results were obtained by GL treatment in terms of both tissue antioxidant efficacy and prevention of lipid peroxidation. The results of the study is supporting the previous work, and showing that GL has the potential of reducing oxidative stress that causes secondary SCI when given at the appropriate dose. As a result, it was determined that GL traditional hot-water extract has a preventive effect on oxidative damage when applied in the secondary SCI period in a dose-dependent manner.

Ethics

Ethics Committee Approval: The study was approved by the Ankara University Ethics Committee of Animal Experiments (2011-123-485/26.10.2011).

Informed Consent: Animal study, spinal cord injury.

Author Contributions

Surgical and Medical Practices: D.D., M.K., D.B., A.D., Concept: D.D., M.K., D.B., A.D., Design: D.D., E.M.S., M.K., D.B., S.A., A.D., Data Collection or Processing: D.D., E.M.S., M.K., G.G., S.A., D.B., A.D., Analysis or Interpretation: D.D., E.M.S., A.E.S., Ö.Ö., G.G., S.A., D.B., A.D., Literature Search: D.D., E.M.S., A.E.S., Ö.Ö., G.G., D.B., A.D., Writing: D.D., A.E.S., D.B., A.D.

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ADVERSE EVENTS FOLLOWING LUMBAR SPINE FUSION: THE IMPACT OF DIABETES MELLITUS

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ABSTRACT

Objective: Spinal surgery is becoming increasingly popular, but its complications cause substantial morbidity and mortality. Diabetes mellitus is prevalent in patients undergoing lumbar fusion surgery, yet the literature is divided on whether they are prone to a higher complication rate and worse outcomes. The aim of this study is to investigate the complication rates in patients undergoing elective lumbar fusion surgery and its relationship to diabetes mellitus and other potential risk factors.

Materials and Methods: A retrospective review of all adult patients undergoing instrumented lumbar fusion surgery in the past two years was performed. Demographic and clinical data were collected, and diabetic patients were compared with non-diabetic controls. Statistical analysis was performed to test for the significance of any difference, and multiple regression analysis was then done to assess the strength of this significance.

Results: Eighty patients were included in the study, 24 (30%) of whom were diabetic. Diabetic patients were older, had more comorbidities, shorter fusions, less blood loss, more complications but similar pain control and length of stay compared to non-diabetic patients. Diabetes was found as an independent significant predictor of adverse events, yet the other factors were not found.

Conclusion: Patients with diabetes mellitus have a higher risk of infection and other complications following instrumented lumbar fusion. Although maintaining good glycemic control is paramount, the higher risk necessitates close postoperative observation and extra care in the long term.

Keywords: Spine surgery, diabetes mellitus, complications

INTRODUCTION

The last two decades have brought about a substantial increase in lumbar spine fusion surgery globally[1-3]. Improved understanding of lumbar pathology and biomechanics led to improved outcomes when compared to nonoperative treatment[4,5]. An aging population and increasingly more complex procedures lead to concerns of higher complication rates in some instances[6,7].

A significant percentage of spine surgery patients suffer from diabetes mellitus (DM), up to 25%[8]. Numerous studies have looked into the association of DM with clinical outcomes following lumbar fusion surgery, and a clear association was found in most[9,10]. Patients with DM had worse clinical outcomes and were burdened with a higher rate of adverse events[8,11].

This realization caused an increased emphasis on tight control of DM prior to spine surgery, with clinical pathways incorporating a normal HgA1C as a precondition for considering elective lumbar spine surgery[12]. The assumption was that euglycemic patients should have similar outcomes to non-diabetic patients, as was stipulated in some published results[13,14]. The author noticed that complication rates were still more prevalent in diabetic patients, regardless of how controlled the serum glucose is. The goal of this study was to investigate the complication rates in patients undergoing elective lumbar fusion surgery and to investigate the modifiable risk factors associated with its incidence.

MATERIALS AND METHODS

The institutional research ethics board approval (21/0034/IRB) was obtained prior to the collection of the data. A retrospective chart review of all patients undergoing elective thoracolumbar fusion surgery in our institution from January 2019 to the end of December 2020 was performed. All these patients went through a pre-anesthesia evaluation that included confirmation of normal serum glucose (4.4-7.8 mmol/L) and hemoglobin A1c levels (<7.5%) for all patients suffering from DM. All patients that did not fulfill this condition had their procedure delayed until their blood sugar was well controlled. Data collected included demographics and numerous clinical data. That included the American Society of Anesthesiologists physical Status Classification System, the number of levels fused, the estimated

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blood loss intraoperatively, the length of anesthesia, the first day of mobilization out of bed, the length of inpatient stay, the numeric pain score on the day of discharge, the presence of any complications, the serum glucose level on the day of discharge (for diabetic patients) and patient's status when it comes to DM. Short-term follow-up was available for all patients (up to one year). All data was anonymized, coded, and tabulated electronically on a password-secured computer. The t-test and the Mann-Whitney test were used for the analysis of continuous data, while the chi-square test was used for the analysis of categorical data. Regression analysis was performed for the relevant variables to assess the strength of their association with the primary outcome of postoperative complications. All analysis was performed on SPSS version 27 software (IBM Corp, Armonk, NY, USA). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

RESULTS

Eighty patients were included in the study cohort, twenty-four out of which (30%) had DM. The demographic and clinical data are presented in Table 1.

The incidence of patients who had complications was 8.8% (n=7 patients). The complications were as follows: six wound infections requiring reoperation, one deep vein thrombosis, and one urinary tract infection (one patient had two complications). Univariate analysis showed that DM was significantly associated (p=0.026) with the incidence of complications (odds ratio=7,105, 95% confidence interval: 1.271-39,725). Multiple regression analysis revealed that DM alone was significantly associated with the development of complications (Table 2).
There were no deaths, and all patients left the hospital to their residence, mobilizing independently with minimal need for assistance.

DISCUSSION

DM is a global epidemic, causing substantial morbidity and mortality[15,16]. The continued rise of the incidence of DM is unequal, affecting developing countries at a higher rate and posing a significant challenge to the healthcare systems[17,18]. The pathophysiology is complex, but it has been proposed that glycosylation of tissue leads to irreversible fibrosis and angiogenesis resulting in end-organ damage[19]. The link between DM and surgical complications- infection particularly- has been repeatedly reported on[20,21]. The first series reporting

Table 1. Demographic and clinical information of the study sample

	Diabetic (n=24)	Non-diabetic (n=56)	p-value
Age (SD)	62.9 (13.3)	38.7 (18.1)	0.001
Female sex, n (%)	18 (75)	36 (64)	0.225
ASA class, n (%)			0.018
I	3	23	
II	14	27	
III	7	6	
Number of levels (SD)	1.54 (1)	4.34 (4.44)	0.003
EBL in ml (SD)	302 (128)	417 (267)	0.048
LOA in minutes (SD)	246 (74.9)	275 (96.7)	0.196
Days to mobilize (SD)	1.58 (1)	1.79 (1)	0.246
NPS on DOD (SD)	1.87 (1.74)	1.86 (1.29)	0.972
RSG on DOD in mmol/L (SD)	7.8 (1.8)	N/A	N/A
LOS in days (SD)	5.54 (4.3)	4.77 (1.7)	0.252
Complications, n (%)	5 (21)	2 (3.6)	0.012

SD: Standard deviation, EBL: Estimated blood loss, LOA: Length of anesthesia, NPS: Numeric pain score, DOD: Day of discharge, RSG: Random serum glucose, LOS: Length of admission

Table 2. Multiple regression analysis of factors associated with complications

	Odds ratio	95% confidence interval	p-value
DM	13.21	1.175-148,452	0.037
ASA	1.166	0.316-4,299	0.818
EBL	1.003	0.999-1.007	0.146
Number of levels	0.997	0.714-1.393	0.987

DM: Diabetes mellitus, ASA: American Society of Anesthesiologists, EBL: Estimated blood loss

on this issue was by Simpson et al.[22] in 1997. Reporting on 62 lumbar fusion cases performed in the 1980s, longer hospital stay, delayed wound healing, and poor clinical results were noted in the DM group. Of note is that the mean serum glucose in that series was 10 mmol/L (6-14), which shows that there was no strong control on DM for that cohort. The second study was published by Glassman et al.[23]. It involved a retrospective review of 94 cases against a matched control group. Again, complication rates were higher in the DM group (53% vs. 21%). Subgroup analysis for multi-level fusions showed a higher complication rate, a finding that was not confirmed in our series. In fact, the diabetic group had less blood loss and shorter fusion in our study yet still had more complications. That may be attributed to the employment of less invasive approaches in the diabetic patients to reduce complication rates. Cho et al.[24] reported on the impact of DM on outcomes in spinal deformity cases. They reported on a cohort of 23 adult deformity cases with DM utilizing a matched case-control design. They did not find any difference between hey two groups and attribute that to the matching by age, sex, body mass index (BMI), and operative details. This was possible as they selected the control group from over 5000 such cases in their database. Our study did not match for age or comorbidity, but regression analysis confirmed that DM alone has the strongest association with complication occurrence. Shortly after, Takahashi et al.[25] published their series of 41 patients with DM who underwent lumbar fusion. They compared their cohort with 124 non-diabetic patients and were the first to link a higher hemoglobin A1c (HgA1C) level with poor outcomes. They also found that patients who have had diabetes for more than 20 years had worse outcomes. Sharma et al.[26] published their series in the same year and contradicted Takahashi et al.[25] by confirming a higher complication rate in DM patients (29% vs. 13%). The rest of their clinical data was not different between the groups except for the length of stay, which was higher in the DM group[26]. Their results are very close to the findings from this current study, especially noting that they reported relatively good glycemic control -measured by HgA1C- for their DM cohort. Golinvaux et al.[27] made a distinction between non-insulin-dependent DM (NIDDM) and insulin-dependent DM (IDDM). They reported that an increase in complication rates was found in the IDDM group, and that the complications themselves were more severe. The NIDDM group did differ in some clinical data-such as BMI-and in none of the groups was there any mention of glycemic control. We did not make any distinction based on insulin dependence, as the literature supports the notion that good glycemic control is paramount regardless of the type of DM[28]. Guzman et al.[29] addressed the issue of glycemic control in their study. A direct comparison of controlled DM and uncontrolled DM patients undergoing lumbar spine surgery showed that diabetic patients had a higher complication rate in general, and uncontrolled DM led to a longer hospital stay and higher mortality.

Study Limitations

This study had some limitations, such as a retrospective design, short-term follow-up, and a relatively small sample size. Nevertheless, the data comparison and analysis clearly showed that -regardless of glycemic control and despite smaller operations and less blood loss-diabetic patients are more prone to adverse events, and as such extra care needs to be taken in their postoperative clinical follow-up.

CONCLUSION

Patients with DM have a higher risk of infection and other complications following instrumented lumbar fusion. Although maintaining good glycemic control is paramount, the higher risk is present regardless.

Ethics

Ethics Committee Approval: The institutional research ethics board approval (21/0034/IRB) was obtained prior to the collection of the data.

Informed Consent: Retrospective study.

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THE FATE OF ABSTRACTS PRESENTED AT TURKISH SPINE CONGRESSES IN 2015 AND 2017

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ABSTRACT

Objective: Publication rates of the abstracts presented in the congress demonstrate the scientific quality of the meeting. This study aims to evaluate the fate of the abstracts presented at the Turkish Spine Congress in 2015 and 2017.

Materials and Methods: Abstracts of the meeting were searched using Pubmed and Google Scholar databases. The title of the abstract and corresponding author's names were searched in these databases. If the title of the abstract was in Turkish, only the author's names were used. The presentations were classified according to presentation type, publication date, indexing information of the journals, the main subject of the study, and consistency of the publication and the abstract.

Results: Thirty-seven of 78 oral papers and 24 of the 73 poster presentations in the 2015 congress were published. The average time to publication was 31.2 months. The main topic of the publications was deformity. The study title change ratio was 43%, the author name change ratio was 57%, and the sample size change ratio was 32% in 2015. The journal indexes were Science Citation Index/Science Citation Index Expanded (SCI/SCIE) in 48 studies, other international indexes in 10 studies, and ULAKBIM in 4 studies. Forty-four of 136 oral presentations and 10 of 72 poster presentations in the 2017 congress were published. The average time to publication was 15.5 months. The main topic of these publications was general spine knowledge/basic module. The study title change ratio was 13%, the author name change ratio was 35%, and the sample size change ratio was 22% in 2017. The journal indexes were SCI/SCIE in 33 studies, other international indexes in 9 studies, and ULAKBIM in 12 studies.

Conclusion: Although there were inconsistencies between the presentations and full-text articles, a respectable number of presentations of Turkish Spine Congresses were published.

Keywords: Abstract, congress, scientific meeting, publication rate, spine

INTRODUCTION

Scientific meetings provide an opportunity to share research ideas among the scientific community. Also, feed-backs acquired from these meetings can increase the quality of subsequent publication of the study. The publication rate of the abstracts in a congress can demonstrate the scientific quality of the meeting[1,2]. Many abstracts of different scientific meetings remain unpublished. The publication rates of the abstracts vary in a wide range depending on the field and accessibility of the meeting to the scientists[3-5]. The average rate of publication found 44.5%, and the average time to publication was 18.4 months in a Cochrane review[4]. The publication rates of orthopedic or neurosurgery congress were around 30-35%[6,7]. This study aims to evaluate the fate of the abstracts presented at the Turkish Spine Congress in 2015 and 2017. Also, the publication time and inconsistencies between the abstract and the article were assessed.

MARERIALS AND METHODS

The list and abstracts of the oral and poster presentations of The International Turkish Spine Congress in 2015 and 2017 were obtained from the website of The Turkish Spine Society. Abstracts of the meeting were searched using PubMed and Google Scholar databases in May 2021 at the fourth year of the congress of 2017. The title of the abstracts and corresponding author's names were searched in these databases. If the title of the abstract is in Turkish only the author's names were used. The names of other authors were searched if previous searches did not yield any results. The presentations were classified according to presentation type, publication date, indexing information of the journals, the main subject of the study (Eurospine module), and consistency between the publication and the abstract. To evaluate the consistency between the abstract and the publication the titles, the number of authors, the names of authors, sample sizes, the hypothesis of the studies were compared.

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Statistical Analysis

All statistical analyses were conducted via SPSS for Windows (version 20.0, IBM Corp.). Descriptive statistics were reported, and the chi-square test was used to compare these proportions. The statistical significance level was set at $p<0.05$.

RESULTS

A total of 151 abstracts (78 oral, 73 poster presentations) were included in the booklet of the International Turkish Spine Congress in 2015. There were 21 case reports and all were belong to the poster presentations. Thirty-seven of 78 oral papers (47%) and 24 of the 73 poster presentations (33%) were published full-text in the journals. The overall publication rate of the congress was 40.3%. Six studies were published before the congress, 39 published within the first two years, and 16 studies were published after 2 years. The average time to publication was 31.2 months when studies that were published before congress were excluded. The journal indexes were Science Citation Index/Science Citation Index Expanded (SCI/SCIE) in 48 studies, other international indexes in 10 studies, and ULAKBIM in 4 studies. The most preferred journal was the European Spine Journal (6 oral, 2 poster presentations).

Two hundred and eight abstracts (136 oral, 72 poster presentations) were published in the booklet of congress of 2017. Four abstracts were duplicates (2 oral, 2 poster presentations) and excluded from evaluation. Forty-four of 136 oral presentations (33%) and 10 of 72 poster presentations (14%) of the congress of 2017 were published in full-text. Three of the oral presentations, 38 of the poster presentations were case reports. Four presentations were published before the congress, while 40 presentations were published within the first two years and 10 presentations were published after 2 years. The average time to publication was 15.5 months. The journal indexes were SCI/SCIE in 33 studies, other international indexes in 9 studies, and ULAKBIM in 12 studies. The most preferred journal indexed international indexes were Turkish neurosurgery (6 oral presentations) and the most preferred journal indexed in ULAKBIM was The Journal of Turkish Spinal Surgery (3 oral, 4 poster presentations). When the main topic of the abstracts of the congresses was classified according to the Eurospine education modules the hottest topic was "Spinal Deformities" in 2015 (20 oral, 7 poster presentations) and it is "Basic-Comprehensive" in 2017 (15 oral, 3 poster presentations) (Table 1). The publication rate of oral presentations was higher than poster presentations ($p<0.001$)

There were changes in the study title for 26 presentations in 2015 (42.6%), and for 7 presentations in 2017 (12.9%). The changes in the author names include changes in the number of authors, the first author's name, and the names of other authors. Thirty-five studies had changes in the author names in 2015 (57.3%) and 19 studies had changes in the author names in 2017 (35.1%). Sample sizes were different from the abstract in 20 studies (32.7%) of the 2015 congress while the sample size was changed in 14 studies (25.9%) in 2017. There were changes of study hypothesis in two studies from the 2015 congress (Table 2).

DISCUSSION

The publication rate of the abstracts presented in the 11th International Turkish Spine Congress in 2015 was 40.3% while it was 25.9% in the 12th meeting in 2017. The rate of the meeting in 2015 was close to the Cochrane review that included 79 reports and 29,729 abstracts and found an overall publication rate of 44.5%. The authors concluded that randomized or controlled clinical trials were most likely to be published in full text[4]. The studies that evaluated the publication rates in spine meetings demonstrated the publication rates 37-55 %[8-11]. The publication rate of the 11th meeting was similar to the previous studies that report publication rates of the abstract in the congress subjected spine surgery. The publication rate of the abstracts of the meeting in 2017 was relatively low. In our opinion, the higher number of abstracts accepted in the

Table 1. Distribution of the abstract according to the Eurospine Modules

	Presentation	Basic	Trauma	Deformity	Degenerative	Destructive
2015	Oral	4	5	20	6	2
	Poster	4	2	7	6	5
2017	Oral	15	5	11	12	1
	Poster	3	1	1	3	2

Table 2. Consistency between the abstracts and the publications

	Inconsistency	Study title	Author names	Sample size	Study hypothesis
2015	Yes	26	35	20	2
	No	35	26	41	59
2017	Yes	7	19	12	0
	No	47	35	42	54
p		0.003	0.027	0.123	0.234

meeting, and the higher number of case report abstract in 2017 caused lower publication rates.

The time lag to publication was varying 14-21 months in congress subjected spine surgery and 18.4 months in the all medical congress[4,8,10]. In this study, the time lag between the congress time and the publication date was high for the congress of 2017 while it was similar to the previous studies for the congress of 2015. Many factors are affecting the time between the congress and the publication time including the author-related factors (writing the manuscript, increasing the sample size, etc) and journal-related factors[10,12]. Thirty-nine (63.9%) abstracts of the 2015 meeting were published within the first two years while 40 (74%) abstracts of the 2017 meeting were published within the first two years. Previous studies demonstrated that the publication rate of the oral presentations was higher than the poster presentations in the congress of neurosurgery, orthopedics, or spine surgery[4,7,8,13,14]. In this study publication rates of oral abstracts were higher in both meetings.

Indexing information of a journal demonstrates the journal's scientific universality and the effectiveness of the articles on the scientific society. Most of the articles from both congresses were published in the journals indexed in SCI/SCIE. The journal indexes were SCI/SCIE in 48 studies (78.6%), other international indexes in 10 studies (16.3%), and ULAKBIM in 4 studies (6.1%) in the 11th meeting in 2015. The journal indexes were SCI/SCIE in 33 (61.1%) studies, other international indexes in 9 studies (16.7%), and ULAKBIM in 12 studies (22.2%) in the 12th meeting in 2017.

To evaluate the hot topics in the congresses we assessed the main topic of the abstracts published in full-text according to the Eurospine education modules. The hottest topic in 2015 was spinal deformities and the majority of these studies were about adolescent idiopathic scoliosis followed by early-onset scoliosis [12 (44%), and 7 (26%) respectively]. The hottest topic was the subject of Eurospine "Basic Comprehensive Course" such as anatomy of the spine, radiology of the spine, etc.

The discrepancy between the abstract and the full-text article is common. Reviewer suggestions in the peer-review process or academic expectations of authors can cause inconsistency [7,15,16]. Major inconsistencies may lead to differences in the conclusions and should be avoided[7]. In this study, minor consistencies like the change in the title, the change in the author names or order were common. The sample size was changed in 34 studies (29.5%) but there were no changes in the results and conclusions in full-text articles. There were only 2 changes in the study hypothesis from the 2015 congress. The changes were adding another group to compare the results.

Study Limitations

One of the limitations of this study was the time of the study. Although this study was conducted after 4 years from the 12th International Turkish Spine Congress, more abstracts can be published later. But the publication rates after 4 years were insignificant[5,10]. Also, we may have overlooked some publications especially due to the Turkish abstract in 2017. To find all publications we searched the most common databases Pubmed and Google Scholar but again there may be some shortcomings to detect all abstracts.

CONCLUSION

The abstracts of International Turkish Spine Congresses in 2015 and 2017 have a 32% publication rate. Although the overall publication rate was lower than other spine meetings, the publication rate of the meeting in 2015 was consistent with these meetings. The abstract selection preferences of the meeting in 2017 decreased the publication rate. Oral presentations had higher publication rates and most of the studies were published in full-text within the first two years. All abstracts are the core of a study and with some effort, they can be published. Authors should try to find a suitable journal for their studies.

Ethics

Ethics Committee Approval: Ethical committee approval is not applicable for this study.

Informed Consent: Informed consent is not applicable for this study.

Authorship Contributions

Concept: Ö.E., F.E., T.E., Design: Ö.E., T.E., Data Collection or Processing: A.M.B., A.Ö., F.E., Analysis or Interpretation: F.E., A.M.B., Literature Search: A.Ö., Ö.E., A.M.B, Writing: Ö.E, T.E.

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PROGNOSTIC CRITERIA FOR POST-OPERATIVE SUCCESS IN PATIENTS UNDERGOING SURGERY FOR ADULT SPINAL DEFORMITIES

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ABSTRACT

Objective: The current reported rate of revision after surgery for adult spinal deformities (ASDs) is up to 45%. The aim of this study was to analyze patients with ASD who underwent failed primary surgery and required revision surgeries, in order to identify the reasons for failure and revision, while assessing possible prognostic criteria.

Materials and Methods: Thirty-two patients (27 women, 5 men) with a mean age of 69.8 years and follow-up period of 44.6 months were included. Before first revision, patients had a mean sagittal vertical axis (SVA) of 94.2 mm, lumbar lordosis (LL) of 33.3°, thoracic kyphosis (TK) of 35.3°, pelvic incidence (PI) of 56.9°, pelvic tilt (PT) of 27.8°, PI-LL of 24.9°, and coronal Cobb angle of 22°. Mean duration from the initial surgery until the first revision was 34.8 months. Fusion levels extended from T1 to S2. Twenty patients received transforaminal lumbar interbody fusion and 9 received anterior lumbar interbody fusion cages. Five patients underwent corpectomy combined with anterior cage. Three patients underwent ponte-, and 7 underwent pedicle subtraction osteotomies.

Results: After the last revision surgery, patients' sagittal plane parameters were significantly corrected ($p<0.001$ for mean SVA, LL, PT, PI-LL mismatch and coronal Cobb). The most frequent reason for revision was found as advanced sagittal malalignment (ASM) in 29 patients (90.6%) followed by proximal junctional kyphosis (PJK) in 13 patients (40.6%). The most common surgical planning mistakes leading to revision were detected as proximal short fusion extending to thoracolumbar junction and not to T10, thus avoiding the stabilizing effect of the rib cage in 18 patients (56.3%); followed by no bone cement [polymethylmethacrylate (PMMA)] augmented screw application despite documented osteoporosis in 17 patients (53.1%).

Conclusion: The present study concluded that ASM and PJK were the most common reasons for revision following ASD surgery, while short proximal level of instrumentation and not placing PMMA augmented pedicle screws in patients with documented osteoporosis were the most common surgical planning pitfalls leading to revision.

Keywords: Adult spinal deformity, spinal deformity correction surgery, revision surgery, causes of failure, prognostic criteria, pitfalls of surgical planning

Introduction

Adult spinal deformity (ASD), which might be the result of the developmental deformities at younger ages or might occur de novo in older ages as a result of degenerative changes in addition to tumors, infections or traumas as well as to a wide range of other etiologies, constitute a serious public health problem especially for geriatric population by causing physical limitations leading to remarkably diminished quality of life[1-3]. With the increase of life expectancy, the ideal treatment of ASD was shifted towards surgical options, especially for patients over the age of 60, and in cases accompanied by the progression of spinal deformity and neurological compression resulting in intractable pain and severe physical limitations yielding a remarkable decline in quality of life[4,5]. Hence, the often extensive surgical treatment for ASD was aimed to provide clinical amelioration by reducing the pain together with the deformity and allowing the patients to be freed from physical restrictions providing an improved quality of life[6,7].

Surgeries for ASD were reported to be prone to risks including neurologic and cardiovascular complications[8]. Despite modern instrumentation techniques, rates of revision surgeries after primary ASD surgeries were detected to be on the rise, ranging from 9% to 45%, with implant failure, pseudoarthrosis and

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adjacent segment disease and infection has been reported frequently as common reasons[9,10].

Revision ASD surgery is a more technically demanding procedure as compared to primary surgery for ASD with 20 to 50% rates of complications[11,12]. The aim of this study was to analyze the potential risk factors of patients who underwent failed surgery due to ASDs and required revision surgeries, and to assess possible pitfalls regarding surgical planning, which might be associated with a potential revision surgery, in addition to the evaluation of the sagittal parameters, clinical and functional outcomes together with the health related quality of life of patients revised after failed primary surgery for ASD.

Materials and Methods

After obtaining institutional review board approval (İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedic Surgery and Traumatology, Nr: 2019/068), a retrospective analysis was undertaken to detect a consecutive group of patients, who had a primary diagnosis of ASD and was operated in a single institution between 2010-2015. Two hundred and eighteen consecutive patients were detected to be operated in the aforementioned time interval in a single institution for the management of ASD.

Patients were enrolled in the present study on the basis of the following inclusion criteria: (1) Having a diagnosis of primary ASD; (2) being skeletally mature (>18 years of age); (3) having been revised after the primary operation for ASD for following reasons: Advanced sagittal imbalance, proximal junctional kyphosis (PJK), pseudoarthrosis, implant failure, infection, neurologic deficit; (4) having a minimum follow-up duration of 2 years; (3).

Exclusion criteria comprised: (1) Having a diagnosis other than primary ASD; (2) being skeletally immature (<18 years of age); (3) having only primary surgery for ASD with no revision; (4) having a minimum follow-up duration of less than 2 years; (5) having a diagnosis of acute trauma or tumor; (6) incomplete radiographic documentation; (7) being unwilling to participate in the study (Table 1).

As a result of the exclusion criteria 186 patients (143: Having only primary surgery for ASD with no revision; 18: Having a diagnosis of acute trauma-tumor; 11: Having a diagnosis other than primary ASD; 8: Incomplete radiographic documentation; 6: Unwilling to participate) were excluded from the study. The remaining 32 patients (27 women, 5 men) were included in the study (Table 2).

Radiographic Outcome Parameters (ROP)

Pre-operative and post-operative radiographic measurements were undertaken on standing whole spine posteroanterior and lateral X-rays. Computer tomography scans were utilized to evaluate implant placements and the stage of bony union; while magnetic resonance imaging was used to evaluate the current status of neural structures as well as the posterior ligamentous structures, if necessary and available.

The radiographic measurements regarding the sagittal parameters including sagittal vertical axis (SVA), pelvic incidence (PI), pelvic tilt (PT), thoracic kyphosis (TK), lumbar lordosis (LL) and PI-LL mismatch together with coronal Cobb angle of the de novo scoliotic curves were undertaken by one independent senior spine surgeon with Surgimap software (Nemaris Inc., New York, NY, USA). X-Rays were taken pre-operatively, immediate postoperatively, at the 1st (first outpatient visit), 3rd and 6th month, annually and at the latest FU appointment.

Clinical Outcome Parameters

As patient reported outcome questionnaires including visual analogue scale (VAS) score for pain and oswestry disability index (ODI) scores were applied to evaluate the clinical and functional outcomes pre-operatively and at the latest follow-up appointment. To assess the quality of life, SF-36 scores [mental component score (MCS) and physical component score (PCS)] were utilized.

Post-operative Rehabilitation Protocol

Patients were mobilized immediately after surgery and were allowed to return to daily activities after discharge, while return to sportive activities (including non-contact sports, swimming and light gym) were allowed after 6th post-operative month if they required to exercise.

Information of Informed Consent

All patients were taken informed consents, so that their pre-, intra- and post-operative data including the X-rays could be used for publication by hiding their identity.

Statistical Analysis

For the statistical analysis, SPSS software (Version 22.0; SPSS Inc, Chicago, IL, USA) was used. Data are expressed as mean +/- SD (standard deviation). The chi-square test and Fisher's exact test were used for the analysis of categorical variables and to compare different time points where appropriate. One-Way analysis of variance (ANOVA) was used to determine a significant difference at various time points. A p-value less than 0.05 was considered as statistically significant.

Results

Thirty-two patients (27 females, 5 males) with a mean age of 69.8 (range 60-84) and mean follow-up duration of 44.6 months (range 24-120) were included Table 3. Thirty-one patients were confirmed to have osteoporosis by using bone densitometry (96.9%).

Patients had primary diagnoses before the index surgery for ASD as: Isolated lumbar degenerative spondylolisthesis and sagittal malalignment in 2 patients (6.3%); degenerative spondylolisthesis and sagittal malalignment accompanied by neural compression due to disc herniation and/or spinal stenosis in 12 patients (37.5%); sagittal imbalance due to osteoporotic

vertebrae fractures (4 isolated lumbar, 1 lumbosacral junction, 1 multiple thoracic and lumbar) in 6 patients (18.7%); isolated coronal imbalance due to de novo scoliosis accompanied by lumbar disc herniation in 3 patients (9.4%); coronal imbalance due to combined sagittal imbalance and de novo scoliosis accompanied by lumbar disc herniation and/or spinal stenosis in 9 patients (28.1%) Table 3.

The rate of revision in the present study population was calculated as 14.7%. Patients had a mean time from the primary surgery to the first revision as 34.8 months (range 6-120), while 6 patients were revised more than 1 time (18.8%) (Table 3).

Main reasons for revision were detected as: Advanced sagittal imbalance in 29 patients (90.6%); PJK in 13 patients (40.6%); pseudoarthrosis (L5-S1:7, L4-L5:2, L3-L4:2) in 11 patients (34.4%); coronal imbalance due to de novo scoliosis in 8 patients (25%); implant failure (screw pull-out) in 7 patients (21.9%). In some patients, more than more than one pre-revision diagnosis was present at the same time (Table 4).

Main mistakes regarding the surgical planning leading to revision were detected as: Short proximal fusion extending to thoracolumbar junction and not to T10, thus avoiding the stabilizing effect of the rib cage in 18 patients (56.3%); no bone cement polymethyl methacrylate (PMMA) augmented screw application despite documented osteoporosis in 17 patients (53.1%); continuing sagittal imbalance as a result of the failed primary surgery and/or failed previous revision surgery in 15 patients (46.9%); avoiding to perform transforaminal lumbar interbody fusion (with cage) despite the instrumentation of L5-S1 in 7 patients (21.9%); problems regarding the design of the constructs leading to biomechanical failure in 5 patients (15.6%); application of kyphoplasty only without further correction of sagittal imbalance in 2 patients (6.3%). In some patients, more than one pre-revision surgical planning mistake was present at the same time (Table 4).

Revision procedures together with types of osteotomies, applied to the study population, were summarized in Table 5, Figure 1.

Patients' pre-operative mean VAS-back score of 7.4 (range 6-8) and VAS-leg score of 6.1 (range 5-7) were improved to 2.6 (range 2-4) and 2.8 (range 1-4), respectively at latest follow-up with high statistical significance ($p<0.001$ for both). Pre-operative ODI scores of 68.4 (range 61-73) were detected to be improved to 21.3 (range 17-28) at latest follow-up with high statistical significance as well ($p<0.001$). Pre-operative SF-36 MCS of 46.2 (range 45.8-49.7) and PCS of 45.1 (42.6-48.3) indicating health related quality of life were detected to be improved to 54.8 (range 52.6-57.2) and 55.7 (54.3-57.2) respectively at the latest follow-up with high statistical significance ($p<0.001$ for both) (Table 6).

Sagittal parameters including SVA, PT and PI-LL mismatches were detected to be improved with high statistical significance at the last follow-up ($p<0.001$ for all), together with the remarkable improvement of LL ($p<0.001$), while the TK and PI at the last follow-up remained similar to pre-operative values ($p>0.05$) (Table 7).

No intraoperative complications were acquired. All patients were neurologically intact early post-op and at the latest follow-up visit. Three patients at developed radicular pain with

Table 2. Flowchart of the study population

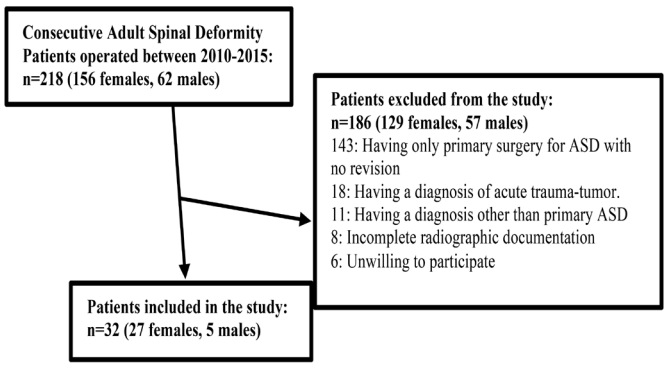

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Having a diagnosis of primary adult spinal deformity (ASD)	Having a diagnosis other than primary adult spinal deformity (ASD)
Being skeletally mature (>18 years of age)	Being skeletally immature (<18 years of age)
Having been revised after the primary operation for ASD for following reasons: -Advanced sagittal imbalance -Proximal junctional kyphosis (PJK) -Pseudoarthrosis -Implant failure -Infection -Neurological deficit	Having only primary surgery for ASD with no revision
Having a minimum follow-up duration of 2 years	Having a follow-up duration of less than 2 years
	Having a diagnosis of acute trauma or tumor
	Incomplete radiographic documentation
	Being unwilling to participate in the study

no motor deficit early postoperative and were managed with conservative therapy. Two patients early post-operatively had superficial wound problems resolved with local wound care and appropriate dressings. No major complications including implant failure or pseudoarthrosis were encountered at the latest follow-up visit.

Table 3. Data regarding the patients' characteristics

Number of patients	**32 (27 females, 5 males)**
Mean age of patients	69.8 (range 60-84)
Average duration of follow-up	44.6 (range 24-120)
Primary diagnoses of patients before the index surgery for ASD	**12 Patients:** degenerative spondylolisthesis and sagittal malalignment accompanied by neural compression due to disc herniation and/or spinal stenosis **9 Patients:** Coronal imbalance due to combined sagittal imbalance and de novo scoliosis accompanied by lumbar disc herniation and/or spinal stenosis **6 Patients:** sagittal imbalance due to osteoporotic vertebrae fractures (4 isolated lumbar, 1 lumbosacral junction, 1 multiple thoracic and lumbar) **3 Patients:** Isolated coronal imbalance due to de novo scoliosis accompanied by lumbar disc herniation. **2 Patients:** Isolated lumbar degenerative spondylolisthesis and sagittal malalignment
Rate of revision	14.7%
Mean time from the primary surgery to the first revision	34.8 months (range 6-120)
Patients revised more than one time	6 (18.8%)

Table 4. Reasons for revision-surgical planning mistakes leading to revision

Main reasons for revision	**29 Patients (90.6%):** Advanced sagittal imbalance **13 Patients (40.6%):** Proximal junctional kyphosis (PJK) **11 Patients (34.4%):** Pseudoarthrosis (L5-S1:7, L4-L5:2, L3-L4:2) **8 Patients (25%):** Coronal imbalance due to de novo scoliosis **7 Patients (21.9%):** Implant failure (screw pull-out)
Main mistakes regarding surgical planning leading to revision	**18 Patients (56.3%):** Short proximal fusion extending to thoracolumbar junction and not to T10, thus avoiding the stabilizing effect of the rib cage **17 Patients (53.1%):** No bone cement (PMMA) augmented screw application despite documented osteoporosis **15 Patients (46.9%):** Continuing sagittal imbalance as a result of the failed primary surgery and/or failed previous revision surgery **7 Patients (21.9%):** Avoiding to perform TLIF (with cage) despite the instrumentation of L5-S1 **5 Patients (15.6%):** Problems regarding the design of the constructs leading to biomechanical failure **2 Patients (6.3%):** Application of kyphoplasty only without further correction of sagittal imbalance in 2 patients

TLIF: Transforaminal lumbar interbody fusion, PMMA: Polymethyl methacrylate

Table 5. Revision procedures

Number of patients	**Revision procedure**
32 (100%)	Elongation of posterior fusion levels (between T1-S2)
12 (37.5%)	Extension of distal fusion level to S2 and performing spinopelvic fixation by using S2-iliac-alar screws
20 (62.5%)	Posterior interbody fusion by using TLIF with autograft filled cages (between L1-S1 at various levels)
9 (28.1%)	Anterior interbody fusion by using ALIF with autograft filled cages (at L5-S1 only)
5 (15.6%)	Total -/ hemicorpectomy + insertion of an autograft filled expandable cage (2: L1 hemicorpectomy, 1 T11 hemi-, T12 total, L1 hemicorpectomy, 1 L2-3 hemicorpectomy, 1 T12 hemi-, L1 total corpectomy)
24 (75%)	Bone cement (PMMA) augmented, fenestrated pedicle screws
3 (9.3%)	Ponte osteotomy (1 one level, 1 two levels)
7 (21.9%)	Pedicle subtraction osteotomy (PSO) (6 L3, 1 L3 and L4)

PMMA: Polymethyl methacrylate, ALIF: Anterior lumbar interbody fusion

Discussion

Revision procedures following primary surgeries or previous revisions of patients with ASD could be considered as one of the most challenging procedures among all operations in context of spine surgery, because these particular operations were reported to be prone to many complications and further revisions as a result of individual patients' characteristics, co-morbidities and technical problems related to prior surgeries; thus they must be individualized in order to obtain optimal results with the aim to reduce further revisions[3,13].

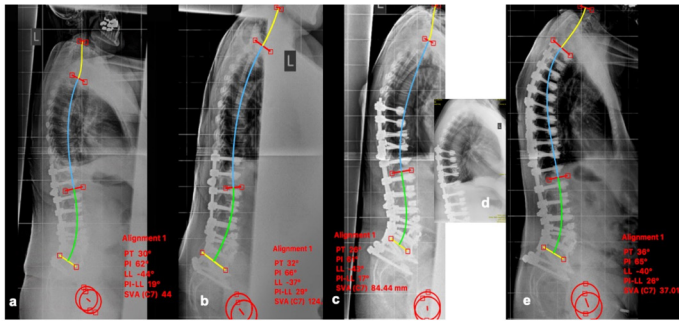

Figure 1. A 77-year old female patient primarly operated for ASD **a:** Standing early post-op lateral X-ray showing good global sagittal balance. **b:** 1st year postoperative. Advanced positive sagittal imbalance due to implant failure. Revision planned: Extension of the instrumentation to: T8-S2. S2-alar-iliac instrumentation. Spinopelvic fixation. PMMA augmented, fenestrated pedicle screw application. **c:** Standing early postperative lateral X-ray showing restored global sagittal balance (1st revision). **d:** PJK detected 6 months after the first revision. 2nd revision planned: Proximal extension of the construct to T1. **e:** 1st year after the second revision. Global sagittal balance is restored
ASD: Adult spinal deformity, PMMA: Polymethyl methacrylate, PJK: Proximal junctional kyphosis

The present study reported a rate of revision of 14.7%, which was in conjunction with the current literature reporting a wide spectrum of rates of revision ranging from 9% to 45%[2,10]. Hence, that particular wide range of rates of revision procedures were attributed by previous studies to individual patients characteristics including age, comorbidities, status of osteoporosis, as well as types of previously applied procedures, length of follow-up and advancements in surgical strategies[1,2,9]. Nevertheless it is an inevitable fact, that despite the surgical advancements including the application of modern instrumentation methods and advanced methods to treat osteoporosis, and osteobilogics, rates of revisions for ASD surgery were not detected to be improving in recent years[11,13,14]. The most common reason for revision was reported as implant failure by many studies. The results of the present study were also in conjunction with the current literature, with advanced sagittal imbalance due to implant failure was reported a common reason for revision. Implant failure was reported by Poorman et al.[15] (43.1%), Pitter et al.[2] (38.2%) and Martini et al.[3] (36%) as the most common reason for revision. The present study reported an implant failure rate of 21.9% resulted in revision surgery especially attributed to screw pull-out in the fusion construct. In addition to that, in line with the numbers in the recent literature, among patients with advanced sagittal imbalance, 12 cases with a rate of 37.5% were found out to have implant failure as well. To overcome implant failure, proximal and distal extension of the construct with various rod combinations has been advised. While Kelly et al.[10] reported to extend the construct to ilium as standard of care in revision

Table 6. Clinical and functional outcomes

	Pre-operative	At the last follow-up	p-value
Mean VAS-back	7.4 (range 6-8)	2.6 (range 2-4)	<0.001
Mean VAS-leg	6.1 (range 5-7)	2.8 (range 1-4)	<0.001
Mean ODI score	68.4 (range 61-73)	21.3 (range 17-28)	<0.001
Mean SF-36 MCS	46.2 (range 45.8-49.7)	54.8 (range 52.6-57.2)	<0.001
Mean SF-36 PCS	45.1 (range 42.6-48.3)	55.7 (range 54.3-57.2)	<0.001

VAS: Visual analogue scale, ODI: Oswestry disability index, MCS: Mental component score, PCS: Physical component score

Table 7. Radiographic outcomes

	Pre-operative	At the last follow-up	p-value
Mean SVA (mm)	94.2 (range -14.2-226.7)	46.5 (range 2-122.8)	<0.001
Mean coronal malalignment (mm)	81.4 (range 47.1/-121.9)	12.1 (range 3.5-62.1)	<0.001
Mean thoracic kyphosis (°)	35.3 (range 2-47)	37.9 (range 21-49)	0.37
Mean lumbar lordosis (°)	33.3 (range 3-54)	46.2 (range 20-71)	<0.001
Mean pelvic incidence (PI) (°)	56.9 (range 35-82)	57.3 (range 39-88)	0.42
Mean pelvic tilt (PT) (°)	27.8 (range 12-49)	24.4 (range 10-48)	<0.001
Mean PI-LL mismatch	24.9 (range 1-48)	13.4 (range 0-39)	<0.001
Mean coronal cobb angle (°)	22 (range 9-35)	3 (range 2-4)	<0.001

SVA: Sagittal vertical axis

surgery, Martini et al.[3] recommended the application of delta-rod, tie-rod and kickstand rod configurations. We preferred to expand the construct to S2 and to apply S2-alar-iliac screws resulting in spinopelvic fixation in conjunction with the literature.

PJK was reported by many studies as the second most common (after implant failure) reason for revision after ASD surgery[3,10], while Kim et al.[16] reported PJK as the most common cause of revision surgery after primary surgery for ASD. The present study, in conjunction with the majority of the current literature also reported PJK as the second most common cause of revision surgery following primary surgery for ASD. To overcome PJK, more proximal extension of the instrumentation in addition to less constrained instrumentation at the transition zone and application of prophylactic vertebroplasty to adjacent level while augmenting those levels with bone cement has been suggested and reported varying rates of success regarding the prevention of PJK[17-20]. In the present study, to prevent further PJK, proximal extension of the instrumentation while keeping it less constrained at the transition zone together with protection of the integrity of posterior ligamentous structures at the most proximal level of the construct was undertaken.

Pseudoarthrosis was reported to be one of the main causes for revision surgery after primary interventions for ASD[2,15]. Kelly et al.[10] underlined, that pseudoartrosis was the most common reason for the index revision surgery regarding patients with ASD. A repeat surgery rate of 10% was reported by some literature to underline pseudoarthrosis, which if multiple was likely to provide subsequent pseudoarthrosis especially at transitional areas (thoracolumbar and lumbosacral junctions) necessitating multiple revision surgeries[21,22]. To overcome pseudoarthrosis, the importance of anterior and posterior interbody fusion by using interbody cages filled with autografts was underlined[3,14,21]. It was also suggested, that the usage of bone morphogenic protein might be helpful to achieve fusion with better quality[15,23]. In line with the current literature, the present study also utilized anterior and posterior interbody fusion by using autograft filled interbody cages especially at the level of L5-S1 as a routine in revisions for ASD, while L5-S1 pseudoarthrosis was also reported frequently necessitating L5-S1 interbody fusion and spinopelvic fixation[24,25].

The usage of major osteotomies by aiming optimal correction in both coronal and sagittal planes has been accepted as a current standart of care in terms of primary and revision surgeries for ASD[3,6,26]. Among the high variety of osteotomies, pedicle subtraction osteotomy (PSO) has especially been used more frequently because of the high angular correctional efficacy up to 30°[27,28]. In the present study, in conjunction with the literature 7 PSOs and 3 ponte osteotomies were utilized.

Restoration of global sagittal alignment was reported to be of crucial importance by yielding improved clinical outcomes, while the magnitude of kyphosis -sagittal imbalance- was positively correlated with the worsening of quality of life[6,13]. Martini et al.[3] showed a successful restoration of the global sagittal balance with improved PT and PI-LL values, correlated with the improvement of clinical and functional scores (including VAS, ODI, SF-36), as did Hu and Lieberman[7]. The present study, in conjunction with the literature reported, that restoration of sagittal balance was accompanied with significantly improved VAS led/back, ODI and SF-36 MCS/PCS scores underlining the excellent clinical-functional outcomes together with remarkable improvements regarding the health related quality of life.

Study Limitations

One of the limitations of the present study is its retrospective nature. Another limitation is the relatively limited number of patients, which is owed to the strict inclusion criteria that were defined to obtain a homogenous group of patients.

Conclusion

The present study concluded, that 14.7% of patients who had a primary surgery for ASD required one or more revision surgeries. Advanced sagittal malalignment followed by PJK were the most frequent reasons for revision following ASD surgery, in addition to short proximal level of instrumentation and not placing PMMA augmented pedicle screws in cases with documented osteoporosis, which were detected as the most frequent surgical planning pitfalls leading to revision following primary ASD surgery. It was concluded, that with individualized surgical planning, the global sagittal alignment could be restored and excellent clinical and functional scores could be obtained.

Ethics

Ethics Committee Approval: Institutional review board approval was taken from İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedic Surgery and Traumatology (Nr: 2019/068).

Informed Consent: A retrospective analysis was undertaken to detect a consecutive group of patients, who had a primary diagnosis of ASD.

Peer-reviewed: Internally peer-reviewed.

Authorship Contributions

Concept: T.P., Design: T.P., U.T., Data Collection or Processing: T.P., T.A., S.B., K.S., F.D., U.T., Analysis or Interpretation: T.P., U.T., Literature Search: T.P., T.A., S.B., K.S., F.D., U.T., Writing: T.P.

Conflict of Interest: The authors declare that they have no conflict of interest.

Financial Disclosure: The authors declared that this study received no financial support.

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ERRATUM
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The changes made in the article titled "LUMBAR SPINAL CANAL DIAMETERS AND AREA MEASUREMENTS IN HEALTHY INDIVIDUALS" in the research articles section published in JTSS 2017 28(3) are as follows.

J Turk Spinal Surg 2017;28(3):151-154

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Published;

Results: Lumbar spinal canal measurements; Lumbar DSAPD L3-4 (24,46± 2,12) mm, L4-5 (22,86± 2,07) mm, L5-S1 (20,36± 2,13) mm, DSTD L3-4 (27,16± 2,10) mm, L4-5 (27,06± 2,03) mm, L5-S1 (26,46± 2,47) mm, lumbar DSCSA L3-4 (27,20± 2,14) mm2, L4-5 (25,46± 2,07) mm2, L5-S1 (23,46± 2,27) mm2 were measured in healthy individuals.

Reported Correction;

Results: Lumbar spinal canal measurements; Lumbar DSAPD L3-4 (24,46± 2,12) mm, L4-5 (22,86± 2,07) mm, L5-S1 (20,36± 2,13) mm, DSTD L3-4 (27,16± 2,10) mm, L4-5 (27,06± 2,03) mm, L5-S1 (26,46± 2,47) mm, lumbar DSCSA L3-4 (272,0± 21,4) mm^2, L4-5 (254,6± 20,7) mm^2, L5-S1 (234,6± 22,7) mm^2 were measured in healthy individuals.

Page 153;

Published;

RESULTS

Lumbar spinal canal measurements; Lumbar DSAPD L3-4 (24,46± 2,12) mm, L4-5 (22,86± 2,07) mm, L5-S1 (20,36± 2,13) mm, DSTD L3-4 (27,16± 2,10) mm, L4-5 (27,06±2,03) mm, L5-S1 (26,46± 2,47) mm, lumbar DSCSA L3-4 (27,20± 2,14) mm2, L4-5 (25,46± 2,07) mm2, L5-S1 (23,46±2,27) mm2 were measured in healthy individuals (Table-1,2).

Reported Correction;

RESULTS

Lumbar spinal canal measurements; Lumbar DSAPD L3-4 (24,46± 2,12) mm, L4-5 (22,86± 2,07) mm, L5-S1 (20,36± 2,13) mm, DSTD L3-4 (27,16± 2,10) mm, L4-5 (27,06±2,03) mm, L5-S1 (26,46± 2,47) mm, lumbar DSCSA L3-4 (272,0± 21,4) mm^2, L4-5 (254,6± 20,7) mm^2, L5-S1 (234,6±22,7) mm^2 were measured in healthy individuals (Table-1,2).

Published;

Table 1. Lumbar spinal canal anterior-posterior diameter and transverse diameter measurements.

Reported Correction;

Table 1. Lumbar spinal canal anterior-posterior diameter and transverse diameter measurements (mm).

Published;

Table 2. Lumbar spinal canal cross-sectional area measurements.

Lumbar Levels	Spinal canal cross-sectional Area Mean± SD
L3-4	27,20± 2,14
L4-5	25,46± 2,07
L5-S1	23,46± 2,27

Reported Correction;

Table 2. Lumbar spinal canal cross-sectional area measurements (mm2).

Lumbar Levels	Spinal canal cross-sectional Area Mean± SD
L3-4	272,0± 21,4
L4-5	254,6± 20,7
L5-S1	234,6± 22,7