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Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spinal Surgery Society. The 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 developing of spinal knowledge. The journal publishes original scientific research articles, invited reviews and case reports accepted by the Editorial Board, in English.

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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 participating in the study to a significant extent. All authors should confirm that they have read the study and agreed to the submission to the Journal of Turkish Spinal Surgery for publication. This should be notified with a separate document as shown in the "Cover Letter" in the appendix. Although the editors and referees make every effort to ensure the validity of published manuscripts, the final responsibility rests with the authors, not with the journal, its editors, or the publisher. The source of any financial support for the study should be clearly indicated in the Cover Letter.

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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.

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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

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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".

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ARTICLE WRITING

Clinically relevant scientific advances during recent years include the 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 rigour of the 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 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 a written permission letter, and it should be submitted along with the manuscript.

Review articles: The format for reviews substantially differ 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

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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 that 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 with 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.

-Keywords : 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.

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The first paragraph should introduce the general topic or problem and emphasize 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 the 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 historical precedent. Amplification of the citations may follow in the Discussion when appropriate. In establishing a rationale, new interventions of any sort are intended to solve certain problems. For example, new implants (unless conceptually novel) typically will be designed according to certain criteria to eliminate problems with previous implants. If the purpose is to report a new treatment, the premises of the study should include those explicitly stated problems (with quantitative frequencies when possible), and they should be referenced generously.

The final paragraph logically flows from the earlier ones, and should explicitly state the questions or hypotheses to be addressed in terms of the study (independent, dependent) variables. Any issue not posed in terms of study variables cannot be addressed meaningfully. Focus of the report relates to focus of these questions, and the report should avoid questions for which answers are well described in the literature (e.g., dislocation rates for an implant designed to minimize stress shielding). Only if there are new and unexpected information should data be reported apart from that essential to answer the stated questions.

- Materials - Methods (1000-1500 words): Epidemiological/ demographic data regarding the study subjects; clinical and radiological investigations; surgical technique applied; evaluation methods; and statistical analyses should be described in detail.

In principle, the Materials and Methods should contain adequate detail for another investigator to replicate the study. In practice, such detail is neither practical nor desirable because many methods will have been published previously (and in greater detail), and because long descriptions make reading difficult. Nonetheless, the Materials and Methods section typically will be the longest section. When reporting clinical studies, authors must state approval of the institutional review board or ethics committees according to the laws and regulations of their countries. Informed consent must be stated where appropriate. Such approval should be stated in the first paragraph of Materials and Methods. At the outset, the reader should grasp the basic study design. Authors should only briefly describe and reference previously reported methods. When authors modify those methods, the modifications require additional description.

In clinical studies, the patient population and demographics should be outlined at the outset. Clinical reports must state inclusion and exclusion criteria and whether 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 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 belong. Generally, one may need a paragraph or two to persuade the reader of the validity of the methods, one paragraph addressing each explicitly raised question or hypothesis, and finally, any paragraphs to report new and unexpected findings. The first (topic) sentence of each paragraph should state the point or answer the question. When the reader considers only the first sentence in each paragraph in Results, the logic of the authors` interpretations should be clear. Parenthetic reference to all figures and tables forces the author to textually state the interpretation of the data; the important material is the authors` interpretation of the data, not the data.

Statistical reporting of data deserves special consideration. Stating some outcome is increased or decreased(or greater or lesser) and parenthetically stating the p (or other statistical) value immediately after the comparative terms more effectively conveys information than stating something is or is not statistically significantly different from something else (different in what way? the reader may ask). Additionally, avoiding the terms 'statistically different' or 'significantly different' lets the reader determine whether they will consider the statistical value biologically or clinically significant, regardless of statistical significance.

Although a matter of philosophy and style, actual p values convey more information than stating a value less than some preset level. Furthermore, as Motulsky notes, "When you read that a result is not significant, don't stop thinking... First, look at the confidence interval... Second, ask about the power of the study to find a significant difference if it were there." This approach will give the reader a much greater sense of biological or clinical significance.

- Discussion (750 - 1250 words): The Discussion section should contain specific elements: a restatement of the problem or question, an exploration of limitations and 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 the 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 a 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 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

INSTRUCTIONS to AUTHORS

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 the 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:

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;8:5-9.

Book chapter:

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:

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:

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:

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

Book in press :

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

Symposium:

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:

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 abbreviations.

-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 the Acknowledgments section.

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- **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 a historical precedent. Instead, indicate the point in the manuscript by providing citation by superscribing.

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 the 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 significance 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

INSTRUCTIONS to AUTHORS

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

1. Morphometric analysis

Anesthesiology

Animal study

Basic Science

1. Biology
2. Biochemistry
3. Biomaterials
4. Bone mechanics
5. Bone regeneration
6. Bone graft
7. Bone graft substitutes
8. Drugs

Disc

1. Disc Degeneration
2. Herniated Disc
3. Disc Pathology
4. Disc Replacement
5. IDET

Disease/Disorder

1. Congenital
2. Genetics
3. Degenerative disease
4. Destructive (Spinal Tumors)
5. Metabolic bone disease
6. Rheumatologic

Biomechanics Cervical Spine

1. Cervical myelopathy
2. Cervical reconstruction
3. Cervical disc disease
4. Cervical Trauma
5. Degenerative disease

Complications

1. Early
2. Late
3. Postoperative

Deformity

1. Adolescent idiopathic scoliosis
2. Kyphosis
3. Congenital spine
4. Degenerative spine conditions

Diagnostics

1. Radiology
2. MRI
3. CT scan
4. Others

INSTRUCTIONS to AUTHORS

Epidemiology

Etiology

Examination

Experimental study

Fusion

1. Anterior
2. Posterior
3. Combined
4. With instrumentation

Infection of the spine

1. Postoperative
2. Rare infections
3. Spondylitis
4. Spondylodiscitis
5. Tuberculosis

Instrumentation

Meta-Analysis

Osteoporosis

1. Bone density
2. Fractures
3. Kyphoplasty
4. Medical Treatment
5. Surgical Treatment

Outcomes

1. Conservative care
2. Patient Care
3. Primary care
4. Quality of life research
5. Surgical

Pain

1. Chronic pain
2. Discogenic pain
3. Injections
4. Low back pain
5. Management of pain
6. Postoperative pain
7. Pain measurement

Physical Therapy

1. Motion Analysis
2. Manipulation
3. Non-Operative Treatment

Surgery

1. Minimal invasive
2. Others
3. Reconstructive surgery

Thoracic Spine

Thoracolumbar Spine

Lumbar Spine

Lumbosacral Spine

Psychology

Trauma

1. Fractures
2. Dislocations

Spinal cord

1. Spinal Cord Injury

Spinal stenosis

1. Cervical
2. Lumbar
3. Lumbosacral

Tumors

1. Metastatic tumors
2. Primary benign tumors
3. Primary malign tumors

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JOURNAL OF TURKISH SPINAL SURGERY

EDITORIAL

Dear Colleagues,

Once again, it is my privilege to be publishing this, the 4th issue, of our professional journal this year. As you have come to expect, it includes several clinical research studies. I hope that each of you will take the time to read this issue thoroughly and incorporate anything you find useful into your practice.

In this issue, there are six clinical research and one case report. The first study is a study concerning the "Main Curve Correction and Spontaneous Thoracic Curve Correction After Selective Thoraclumbar/Lumbar Fusion in Lenke Type 5c Adolescent Idiopathic Scoliosis: Up to 10 Years Follow-up". The second is a research study entitled "A Great Mimicker of Adolescent Idiopathic Scoliosis: Sciatic Scoliosis. A Retrospective Review of 18 Adolescent Patients with at least 2 Years of Follow-up". In the third, one can read a retrospective clinical study entitled, "Incidence of Asymptomatic Recurrent Laryngeal Nerve Palsy Following Anterior Cervical Spine Surgery". The fourth article is a retrospective study, "Utility of Routine Needle Biopsy During Kyphoplasty for Osteoporotic Vertebral Fractures". The authors of the fifth study examined the "Adding Epidural Injection to Vertebroplasty Improves Function in Patients with Vertebral Compression Fracture". The sixth study gives a clear answer to the question "Is Spinal Gunshot Wound Surgery Really Necessary?" while, in the seventh, the authors wrote a case report about "Intradural Disc Herniation Mimicking a Spinal Tumor, Case Presentation and Review of the Literature".

I hope you found this issue stimulating and informative. I do this in an effort to keep all of us on the cutting edge of the latest research and developments. My mission is, and has always been, to keep all of us on top of the most cutting-edge research in our field.

With kindest regards,

Editor in Chief
Metin Özalay, M.D.

ORIGINAL ARTICLE
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MAIN CURVE CORRECTION AND SPONTANEOUS THORACIC CURVE CORRECTION AFTER SELECTIVE THORACLUMBAR/LUMBAR FUSION IN LENKE TYPE 5C ADOLESCENT IDIOPATHIC SCOLIOSIS: UP TO 10 YEARS FOLLOW-UP

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ABSTRACT

Objective: Thoracolumbar/lumbar (TL/L) curves are a rare type of adolescent idiopathic scoliosis (AIS). Historically anterior selective fusion and posterior selective fusion provided satisfied results in terms of curve correction, maintenance of correction and spontaneous thoracic curve correction. Aim of our study was to present the results of selective posterior Cobb to Cobb TL/L fusion in patients lenke type 5c AIS patients with a single surgeon experience for up to 10 years of follow.

Materials and Methods: Patients who underwent selective TL/L posterior fusion for a diagnose of Lenke type 5c AIS were retrospectively analyzed. Patients who were followed up minimum 2 years and underwent full preoperative, early postoperative and follow-up radiologic work up and last follow-up SRS22r scores were included in descriptive statistical analysis performed.

Results: Fifty one patients (47 F, 4M) were included in the study. Mean age was 15 (12-17). Mean follow-up period was 84 months (24-120). The mean preoperative major TL/L curve improved to 6.3 (0-20) from 42.8 (38-71) with an 85% correction rate. The mean thoracic curve correction rate was %57. At follow main TL/L and upper thoracic curve did not show correction loss. Coronal imbalance has not been recorded. At last follow-up mean SRS22r was mean 4.3 (3.6-4.9).

Conclusion: Selective TL/L posterior Cobb to Cobb fusion improves main TL/L and upper thoracic curves in AIS lenke type 5c patients and maintains long-term stability for the uninstrumented upper thoracic curve.

Keywords: Adolescent idiopathic scoliosis, thoracolumbar curve, lenke type 5c curve, posterior instrumented fusion, selective thoracolumbar Cobb to Cobb fusion, spontaneous thoracic curve correction

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a structural spinal deformity consisting of lateral curvature in the coronal plane, rotation of the spine in the axial plane, and abnormal alignment in the sagittal plane[1]. The main goal in the treatment of scoliosis is to obtain a well balanced and mobile vertebral column with correction of the existing curvature. Anterior, posterior, combined anterior and posterior approaches and interventions are used for these purposes[1-5]. Lenke 5 curves subtypes are rarely seen subtype of AIS curve patterns and consist of structural thoracolumbar/lumbar (TL/L) and minor nonstructural thoracic curve components[1]. For lumbar modifier C, the central sacral vertical line (CSVL) falls completely medial to the concave lateral aspect of the TL/L apical vertebral body or bodies (if the apex is a disc). In the surgical treatment of Lenke type 5c curves, the selective fusion surgery via thoracoabdominal approach has been used very frequently, but nowadays, posterior approach and fusion techniques have become the standard approach. Posterior pedicle screw systems have came to the fore even more due to their superiority in sagittal plane control compared to anterior surgery[4-7].

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Selective fusion surgery, in which fewer spinal segments are fused, has been described in order to obtain a balanced and mobile spine[1,2,4]. It is aimed to preserve more mobile segments in cases with selective posterior fusion. In Lenke type 5 curves main TL/L curves included to the fusion site and by choosing lower end vertebra (LEV) as lower instrumented vertebra (LIV) more mobile lumbar segments preserved. It has been reported that non-structural thoracic curvature that is not included in the fusion has the potential for spontaneous improvement, does not progress over time, and has no correction loss[8,9]. Coronal imbalance (CIB) may develop in cases with selective thoracolumbar fusion in Lenke type 5 structural TL/L curves. Although upper instrumented vertebra (UIV) translation and preop LIV tilt were stated as a high risk factor for the development of CIB, it was observed that this CIB improved over time after selective fusion. Wang et al.[8] stated that LIV selection significantly correlates with 2-year correction maintenance and balance. A translation of 28 mm and a tilt of 25° may be used as a general criterion for selecting LIV[10-15]. In this study, we aimed to evaluate the clinical and radiological results of Lenke type 5 patients who were operated with the posterior Cobb to Cobb method in a single center by a single surgeon, and to evaluate the amount of spontaneous improvement and preservation of the thoracic curvature that did not included in the fusion.

MATERIALS AND METHODS

After obtaining ethics committee approval (İstanbul Bilim University Ethics Commitee date no: 21/01/2016, approval no: 44140529-2016/06) for this pediatric deformity study, all AIS cases operated by a single surgeon in the same center were retrospectively reviewed by 2 authors. Inclusion criterias for study defined as; 1-Patients with a Lenke type 5 curve AIS 2-At least 24 months follow-up with full preoperative and postoperative radiologic work up 3-Patients underwent selective TL/L posterior spinal fusion (Cobb to Cobb). Patients with a history of previous surgery, anterior surgery, and a follow-up of less than two years were excluded from the study. For Lenke type 5 curves, it was accepted to choose upper end vertebra (UEV) as UIV and LEV as LIV in posterior fusion with selective TL/L Cobb to Cobb method[2,4,16]. Before starting the operation, the amount of correction of the curvature and the relationship of the LEV and pelvis with the horizontal plane were evaluated with traction X-ray under general anesthesia (TRUGA). For protection more mobile segment in the lumbar spine, LIV determined according to neutral rotation of most proximal vertebra with TRUGA. Cobb to Cobb instrumentation was performed between the UEV and LEV using pedicle screws and posterior instrumentation with 5.5 titanium rods. After the correction, the correction was confirmed by intraoperative X-ray. Fusion was achieved using an allograft after facet decortication.

Radiologic Evaluation

Preoperative radiographs were taken on long cassettes and the final follow-up radiographs were taken in the same center using EOS. Spine deformity group guidelines were used for the measurement of radiological parameters[17]. The radiological parameters evaluated were TL/L curve Cobb angle, coronal balance (C7-CSVL), thoracic kyphosis Cobb angle, lumbar lordosis angle, thoracolumbar transition kyphosis angle (T10-L2), sagittal balance. In addition to these measurements, LIV tilt angle, Disc wedging below LIV (Dw LIV) values were recorded. LIV tilt was defined as as the inclination in degrees of the inferior endplate to the horizontal line; disc angulation (disc wedging below LIV) was defined as angle between inferior end plate of LIV and superior end plate of the caudal vertebra of LIV.
The presence of stable sagittal and coronal balance along the instrumented segments, the absence of clinical and radiological findings without non-union or implant failure were evaluated as fusion.

Clinic Outcome

The Scoliosis Research Society-22r (SRS-22r) questionnaire was applied for the clinical outcomes[18].

Statistical Analysis

Statistical analyses were conducted by SPSS 25.0 (SPSS Inc., Chicago IL, USA). Normality exploration and descriptive statistic tests performed. Pretest post test analysis was performed for comparing preoperative and postoperative spine parameters.

RESULTS

Patient Demographics

This study was conducted with a total of 51 patients (47F, 4M) who met the inclusion criteria. The mean age was 15 (12-17) years and the mean follow-up was 84 months (24-120). It was observed that the UIV was T9 in the most proximal and T12 in the most distal. LIV was L2 in 2 patients; L3 in 40 patients and L4 in 9 patients.

Coronal Plane Parameter Analysis

TL/L structural curve Cobb angle was mean 42.8° (38°-71°) preoperatively, and 6.3° (0°-20°) at the last follow-up, with an 85% improvement rate. The mean upper thoracic curve (UTC) Cobb angle was 20.2° (6°-36°) preoperatively, and 7.8° (0°-20°) at the last follow-up, and the spontaneous recovery rate was 57% (Figure 1). Normality tests were applied and preoperative and postoperative comparison of spine parameters were performed with paired t-test. There were statistically significant diffrence between preoperative and postoperative main TL/L and non-structural thoracic curve Cobb angles (p=0.001). There was no statistical difference between postoperative and last follow-up TL/L curve Cobb angle (p>0.05). Dw angle below LIV was >5° in 21 patients (41%). Preoperative LIV tilt angle was mean 24.9° (13°-40°) and at last follow-up LIV tilt angle improved to a mean

3.5° (0°-9°) with a 86% correction rate. At the last follow-up coronal decompansation was not observed (Table 1).

Sagittal Plane Parameter Analysis

Mean thoracic kyphosis was 37.3° (12°-56°) preoperatively and 45.3° (24°-58°) at the last follow-up. Preoperative mean lumbar lordosis was 55.6° (32°- 84°), and 61.1° (40°-74°) at the end of follow-up. Preoperative thoracolumbar transition kyphosis (T10-L2) was >5° in 18 patients with a mean 13.4° (5°-33°), and it was measured mean 2.7° (-2°-11°) at the end of the follow-up. Mean preoperative sagittal sacral vertical line was -19.14 mm (-76 -45), it was measured as -6.5 mm (-34 -25) at the end of the follow-up.

Table 1. Patients demographic data, scoliosis research society-22r (SRS22r) outcome scores of the patients

	Patients
N	51
Age	14 (12-16)
Gender	47F, 4M
Follow-up (year)	7.5 (2-10)
SRS-22r scores at F/up [mean (range)]	
Pain	4.3 (2.4-5)
Self-image	4.1 (3-5)
Function	4.6 (3.6-5)
Mental health	3.9 (2.4-4.8)
Satisfaction	4.62 (3-5)
Sub-total	4.3 (3.6-4.9)

Clinical Outcome

SRS-22r evaluation improved from mean 3.7 (3.2-4.1) to 4.3 (3.6-4.9). One patient underwent a screw revision surgery because of loosening which was evaluated pseudoarhrosis. In the uninstrumented upper thoracic curve, curve progression did not detected. None of the patients underwent additional surgeries for superficial or deep infection and wound complications (Table 2).

DISCUSSION

Surgical goal of AIS aims to provide a well-balanced spine with more mobile segments. For this purpose Cobb to Cobb fusion became standart approach in selective conditions. Here we present long term results of Lenke type 5 AIS curves who underwent posterior Cobb to Cobb selective TL/L fusion. Our results with high satisfaction of patients were compatible with literature knowledge. Selective TL/L posterior Cobb to

Table 2. Radiologic spine parameters at preoperative and last follow-up

	Preoperative	Follow-up
Upper thoracic curve	20.2° (6-36°)	7.8° (0-20°)
Main TL/L curve	42.8° (38-71°)	6.3° (0-20°)
LIV tilt	24.9° (13-40°)	3.5° (0-9°)
Thoracic kyphosis	37.3° (12-56°)	45.3° (24-58°)
Lumbar lordosis	55.6° (32-84°)	61.1° (40-74°)
Thoracolumbar junction kyphois (T10-L2)	13.4° (5-33°)	2.7° (-2-11°)

TL/L: Thoracolumbar/lumbar, LIV: Lower instrumented vertebra

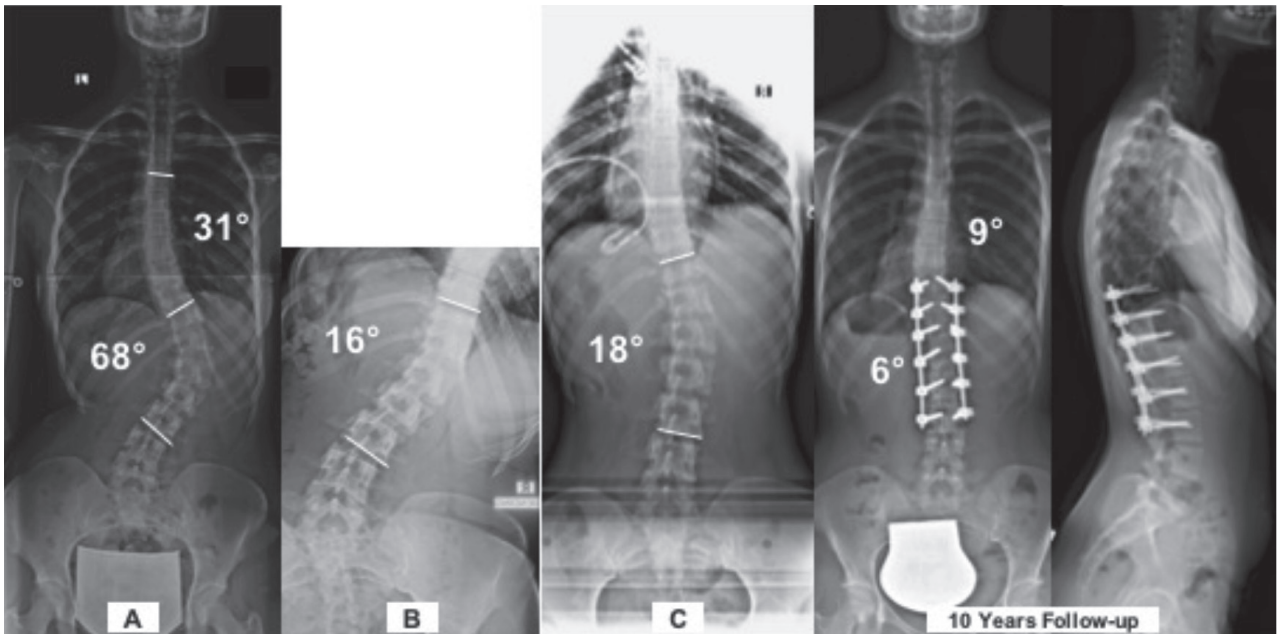

Figure 1. A patient with a 10 years follow-up. The patient was 16 at the age of surgery. A: Standing full spine anteroposterior X-ray; B: Preoperative supine bending X-ray; C: Traction anteroposterior X-ray under general anesthesia and last follow-up anteroposterior and lateral standing spine X-rays

Cobb fusion resulted well TL/L correction and spontaneous correction of uninstrumented upper thoracic curve early and last follow-up[5,19]. Up to date, many authors have published the results of fusion surgery with the anterior approach for the treatment of Lenke type 5 curvatures and have shown its effectiveness in providing coronal balance. Advantages such as requiring shorter level of fusion and excluding paralumbar muscle problems that occur with posterior approach have been reported as superiority of anterior surgery to posterior surgery[20,21]. Problems such as the development of kyphosis and high rates of non-union, respiratory problems after thoracoabdominal approaches, vascular injury and scarring that are more difficult to tolerate cosmetically have created the disadvantages of anterior approach[6,7]. Shufflebarger et al.[4] firstly reported the satisfactory clinical and radiologic results of of TL/L curve treatment with posterior approach using pedicle screw systems. In the comparison of anterior and posterior approaches, it was concluded that there are advantages such as more correction rate of the coronal curvature (84%) and less correction loss afterwards (2.4% at the end of 2 years of follow-up) and shorter hospital stay in patients who underwent posterior spinal fusion (PSF) using a pedicle screw. In the literature, 63-84% improvement rates in structural TL/L curvature have been reported with posterior selective fusion. This improvement with anterior spinal fusion (ASF) has been reported to be up to 66-87% in the early postoperative period, and it has been reported to decrease to 67% as a result of long-term follow-up[6,7]. In our study, the 85% improvement rate of the main curve after at least a mean follow-up of 2 years and the absence of correction loss support the effectiveness of Cobb to Cobb fusion with the posterior approach.

While it is recommended to add the structural TL/L curvature to the fusion in order to preserve more mobile segments in Lenke type 5 curves with posterior segmental fusion using pedicle screw, it has been stated that non-structural thoracic curvature does not progress and improves spontaneously[5,8,22,23]. Spontaneous thoracic curvature resolution after ASF in Lenke type 5 curves was found to be 19-34%, and improvement rates close to these rates (30-51%) were reported with PSF[9,20,21]. Wang et al.[15] reported a 51.8% spontaneous correction rate of nonstructural UTC. In our study, the rate of spontaneous recovery of the curvature that was not included in the fusion was found to be 57% with a minimum follow-up of 2 years. Numerous studies have been conducted to reveal which radiological parameters are associated with postoperative global coronal balance in terms of CIB development. LIV tilt, LIV translation and Dw below LIV parameters were found to be associated with local and global coronal balance after surgery with PSF[13-15]. It was concluded that if the LIV tilt, which was up to 25° preoperatively, could not be reduced to below 8° postoperatively, it was an important risk factor for the development of postoperative CIB[15]. In the present study preoperative LIV tilt was mean 23.7° and improved to mean 3.3° at the follow-ups with a 87.6% correction rate. CIB was not observed in our patients. Satake et al.[24], reported that the most important factors affecting the postoperative Dw under LIV in Lenke type 5 curvatures treated with the anterior approach are a near-horizontal position of the disc under LIV and choosing LIV as LEV-1 short segment fusion. Banno et al.[25] reported in their study when L3 was selected as LIV in Cobb to Cobb fusion, Dw under LIV was seen at a rate of 27% but they did not reveal a relation with CIB in their cases. The authors concluded that subjacent disc wedging could be a compensatory mechanism for UTC and fractional lumbar curve segments that are not included in the fusion.

Study Limitations

In our study there were certain limitations. First of all this study was conducted in a retrospective manner. All patients received selective Cobb to Cobb fusion so control group could not be added to study. More studies with different designs and comparison of the selective group with non-selective group and also with comparison of anterior and posterior spine fusion group with long term follow-up are needed to clarify this issue.

CONCLUSION

In conclusion, satisfactory results are obtained with Cobb to Cobb fusion in AIS lenke type 5 curves in the correction of both the main curve and the compensatory curve. There is no loss of correction in long-term follow-ups. LIV tilt and sub-LIV disc angulation, which are postop radiological inference markers, are important markers for coronal balance. Based on the radiological markers of our patients, it was concluded that the development of CIB can be prevented by keeping LIV tilt and Dw under LIV within the target values.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from İstanbul Bilim University Clinical Research Ethics Committee (date no: 21/01/2016, approval no: 44140529/2016-05).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: O.L.U., S.K., M.E., A.H., Concept: Ö.K., T.Ş., H.S.C., R.D., S.K., M.E., A.H., Design: Ö.K., S.K., M.E., A.H., Data Collection or Processing: Ö.K., T.Ş., H.S.C., O.L.U., R.D., Analysis or Interpretation: T.Ş., H.S.C., O.L.U., R.D., Literature Search: Ö.K., H.S.C., O.L.U., R.D., Writing: Ö.K., H.S.C., R.D., S.K., M.E., A.H.

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

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A GREAT MIMICKER OF ADOLESCENT IDIOPATHIC SCOLIOSIS: SCIATIC SCOLIOSIS. A RETROSPECTIVE REVIEW OF 18 ADOLESCENT PATIENTS WITH AT LEAST 2 YEARS OF FOLLOW-UP

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ABSTRACT

Objective: Sciatic scoliosis (SS) induced by lumbar disc herniation (LDH) is a great mimicked of adolescent idiopathic scoliosis (AIS). This study aimed to evaluate the clinical-radiographic presentation of SS in adolescents caused by LDH, while reporting on the average 3 years results of lumbar microdiscectomy in terms of radiographic and functional outcomes.

Materials and Methods: Eighteen adolescent patients who presenting for evaluating SS with radiculopathy were enrolled. They had an average age/follow-up duration of 17.1 years/36.8 months. Lumbar microdiscectomy was applied to them. Radiographic measurements, including the analysis of curve pattern, major curve magnitude and coronal balance were undertaken.

Results: A short lumbosacral curve combined with an opposite sided long thoracic and/or thoracolumbar curve was detected. 16/18 patients were detected to have LDH at the convex side of the lumbosacral curve. 14/18 were detected to have a trunk shift directed to the opposite side of the LDH. Average major curve magnitudes pre-op and at the last follow-up (FU) visit were 25.1°/4.2° respectively (p=0.001). Patients had an average pre-operative coronal imbalance of 4.1 cm reduced to 1.3 cm at the last FU (p=0.003). Average visual analogue scale leg-back and Oswestry Disability Index scores improved from 7.1-4.2 and 36.1% pre-operatively to 1.3-0.7 and 6.2% at the last FU (p<0.001). SF-36 scores were detected to be improved with high statistical significance at the last FU.

Conclusion: SS was associated with short lumbosacral curves accompanied by long thoracic and/or thoracolumbar curves, while the LDH was often located at the convex side. In adolescent cases, microdiscectomy could yield an immediate recovery of the radicular pain in addition to excellent functional outcomes, while successfully restoring the coronal balance in the long term follow-up.

Keywords: Scoliosis, lumbar disc herniation, lumbar microdiscectomy, trunk shift, non-structural curve, coronal imbalance, resolution

INTRODUCTION

Lumbar disc herniation (LDH) was reported to result in sciatic scoliosis (SS), which was defined as a non-structural curve secondary to nerve root compression[1-3]. While the association between LDH and non-structural/SS was clearly defined, the pathophysiology and significance were not clarified[4-7]. It was repeatedly reported, that the SS was a compensatory postural adjustment of the patient to relieve the nerve irritation[1,3,8]. Hence, in conjunction with the non-structural nature of the SS, an improvement of the deformity and trunk list was expected if the pain generating pathology -the herniated disc- was removed[3,7]. Lumbar (open/endo-/micro) discectomy was advised as the ideal treatment option for LDH associated with SS in adolescents, while improvement of the non-structural curve as a result of discectomy was reported as well[1,6,9]. LDH was seldomly reported in adolescents with the incidence up to 5% with genetic predisposition and trauma being reported as the predisposing factors[10-12]. SS caused by LDH in adolescent patients, could easly be mistaken for adolescent idiopathic scoliosis (AIS) which rarely causes pain resulting in the delay of the definitive treatment and increasing the risk for residual deformity and pain[3,8,13]. Besides, unlike the adults, scoliotic list could be the initial symptom of LDH in adolescents, because of the superior adaptive capacity of pediatric spine to protect the neural structures by performing lateral flexion[2,6,8]. The aim of the present study to evaluate the clinical and radiographic presentation of SS in adolescents caused by LDH, while reporting on the average 5 years results of microdiscectomy in terms of the coronal balance and functional outcomes. It was questioned, whether the SS was associated with a certain type of curve and certain side of the herniated disc related to that curve.

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MATERIALS AND METHODS

After obtaining Institutional Review Board of EMSEY Hospital (approval date: 02/02/2021, approval no: 1121077) approval, a retrospective analysis was undertaken to detect a consecutive group of patients with SS and LDH operated in a single institution between 2018 and 2020 with lumbar microdiscectomy technique. One hundred fifty four consecutive patients were detected. Patients were enrolled in the present study on the basis of the following inclusion criteria: (1) Being adolescent (age 10-18); (2) having a magnetic resonance imaging (MRI) confirmed diagnosis of LDH; (3) having been operated with lumbar microdiscectomy technique, (4) having a documented negative Adam's forward bending test (indicating a non-structural curve); (5) having a minimum follow-up (FU) period of 2 years; (6) being willing to participate in the study Table 1. Exclusion criteria comprised: (1) Being adult (age >18); (2) having no pre-operative MRI in the picture archive and communication system (PACS); (3) having been operated with open lumbar discectomy technique, (4) having a history of spinal infection-tumor; (5) having a concomitant diagnosis of AIS or positive Adam's forward bending test Table 1. As a result of the exclusion criteria 136 patients were excluded from the study (127: adults; 4: having a concomitant diagnosis of AIS-positive Adam's forward bending test; 2: has an history of spinal tumor, 2: has an history of spinal infection; 1: no MRI in PACS system) Table 2.

Radiographic Outcome Parameters (ROP)

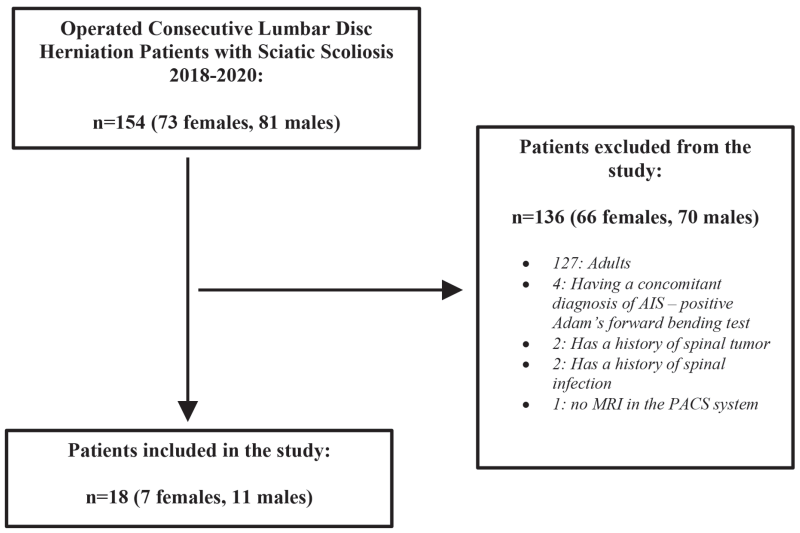
Pre-operative and post-operative radiographic measurements were undertaken on standing whole spine X-rays. The radiographic examination protocol was standardized for all patients. ROP was composed of the major curve magnitude in the coronal plane measured by using the Cobb angle, and coronal balance by using central sacral vertical line [(CSVL) to C7-plumb line (C7PL) distance]. MRI was used to confirm the level and side of LDH. All patients had pre-operative MRI, while AIS cases were also reviewed by the radiologist regarding a history of conservatively treated LDH. The radiographic measurements were undertaken by one independent spine surgeon with Surgimap software (Nemaris

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Being adolescent (age 10-18)	Being adult (age >18)
Having a MRI confirmed diagnosis of LDH	Having no pre-operative MRI in the PACS
Having been operated with lumbar microdiscectomy technique	Having been operated with open lumbar discectomy technique
Having a documented negative Adam's forward bending test (indicating a non-structural curve)	Having a history of spinal infection-tumor
Having a minimum follow-up period of 2 years	Having a concomitant diagnosis of AIS or positive Adam's forward bending test.
Being willing to participate in the study	Being unwilling to participate in the study

MRI: Magnetic resonance imaging, LDH: Lumbar disc herniation, PACS: Picture archive and communication system, AIS: Adolescent idiopathic scoliosis

Table 2. Flowchart of the study population



MRI: Magnetic resonance imaging, AIS: Adolescent idiopathic scoliosis, PACS: Picture archive and communication system

Inc., New York, NY, USA). The radiographs were obtained as standing whole spine X-rays in posterior-anterior and lateral standard position. X-rays were taken pre-operatively, immediate post -operatively, at the 1st (first outpatient visit), 3rd and 6th month, annually and at the latest FU appointment.

Clinical Outcome Parameters (ROP)

As patient reported outcome questionnaires Oswestry Disability Index (ODI) scores (section 8 - sex life was omitted), visual analogue scale (VAS) back-leg scores were applied to evaluate the clinical and functional outcomes. Short form 36 (SF-36) score was applied to evaluate health related quality of life.

Surgical Technique

Standard lumbar microdiscectomy procedure was applied to all of the patients from the symptomatic side.

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 1st post-operative month.

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 +/- 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

Eighteen patients (7 females, 11 males) had an average age of 17.1 (range 14-18) and average duration of FU of 36.8 months (range 24-48). Among them, 10 patients (55.6%) had low back + leg pain, 5 patients (27.8%) had only low back pain, 3 patients (16.6%) had only leg pain. Straight-leg raise (SLR) was positive in 16 patients (88.9%), while contralateral SLR test was positive in 2 patients (11.1%). Level of LDH was L4-L5 in 11 patients (61.1%) and L5-S1 in 7 patients (38.9%), while no patient had two levels of LDH Table 3. 16 patients (88.9%) were detected to have the LDH at the convex side of the lumbosacral curve. Patients were all diagnosed as AIS before presenting to us and were treated for AIS (13 patients were applied thoracolumbosacral orthosis (TLSO), 5 patients were followed up conservatively). All patients underwent one level (L4-L5: 11 patients or L5-S1: 7 patients) microdiscectomy after having been presented to us. Average duration from the onset of SS, until lumbar microdiscectomy was 6.1 months (range 3-10) Table 3.

Radiographic Outcomes

Patients had an average pre-operative Cobb angle of 25.1° (range 18°-29°), which was corrected to 4.2° (range 3.3°-7.2°) at the final FU (p<0.001). Sixteen patients (88.9%) were detected to have the herniated lumbar disc at the convex side of the lumbosacral curve. Fourteen patients (87.5%) were detected to have a trunk shift toward the opposite side of the LDH. It was detected, that all patients had a short lumbosacral curve accompanied with long thoracic curve directed mostly to the opposite side (14 patients, 87.5%) of the LDH. Patients were detected to have average CSVL to C7PL distance of 4.1 cm (range 2.7-6.4) reduced to 1.3 cm (range 0.2-1.4 cm) at the latest FU (p=0.003), indicating the restoration of coronal balance and resolution of SS Table 4. At the 6th post-operative month, 15 (83.3%) of patients were detected to have a complete resolution of scoliosis, while at the latest FU none of the patients was detected to have any residual curve.

Table 3. Data regarding the patients' demographics, clinical exam and operative information

Number of patients (n)	18 (7 females, 11 males)
Average age of patients	17.1 (range 14-18)
Average duration of follow-up (months)	36.8 (range 24-48)
Pain (n) (%)	10 (55.6%): Low back + leg 5 (27.8%): Only low back 3 (16.6%): Only leg
Straight-leg raise test (n) (%)	16 (88.9%)
Contralateral straight-leg raise test (n) (%)	2 (11.1%)
Level of lumbar disc herniation (LDH) (n) (%)	11 (61.1%): L4-L5 7 (38.9%): L5-S1
Average duration from the onset of sciatic scoliosis, until lumbar microdiscectomy (months)	6.1 (range 3-10)
Type of operation for all: One level lumbar microdiscectomy	11 (61.1%): L4-L5 7 (38.9%): L5-S1

Clinical Outcomes

Patients were detected to have a pre-operative average ODI score of 36.1% (range 33.7-46.1), improved to 6.2% (range 3.8-7.2) at the latest FU (p<0.001). Pre-operative VAS leg-back scores of 7.1 (range 6-8)-4.2 (range 3-5) were improved to 1.3 (range 0-2)-0.7 (range 0-1), respectively (p<0.001 for both). Patients' average pre-operative SF-36 physical component score - mental component score of 44.2 (range 43.1-45.3)-46.8 (45.7-48.4) were improved to 56.2 (range 55.3-57.6)-57.3 (range 56.9-57.4) at the latest FU (p=0.003) Table 4. Figure 1.

DISCUSSION

SS was defined as a non-structural scoliosis, which occurred as a natural result of nerve root irritation caused by LDH in most of the cases[1,14]. While the association between SS and LDH well documented, the mechanism and significance was not clearly perceived[7,15]. SS was characterized with a trunk shift, which as hypothesized was tilted laterally to one side as in response to nerve root irritation or hyperactivity of the paraspinal muscle spasm, with the effort to decompress the irritated neural structure and alleviate the pain accompanied to it[4,16,17]. Because of the higher spinal flexibility of the adolescent spine as compared to adult spine, SS was also reported with higher incidence in adolescents varying between 9% to 82%[1,7,18-20]. Zhang et al.[1] reported an incidence of 34.6% for SS in adolescents, while Ozgen et al.[20] reported, that 47% of adolescent LDH patients concomitantly had SS. The present study reported an incidence of 11.7% for SS in adolescents with LDH. Presentation of LDH in adolescents might be radically different than in adults. While neurologic signs including sensory and motor losses was rarely reported in adolescents, SS on the contrary was reported to be a frequent symptom in adolescents, who might also present with SS as the first sign of LDH[21,22]. Due to this fact, a thorough history taking and physical exam is paramount in adolescents presenting with scoliotic posture and vague signs of LDH[2,7,20]. The present study reported, that 55.6% of patients were presented with low back+leg pain, while 27.8% had only low back pain and 16.6% only had leg pain. Adam's forward bending test was shown to distinguish between a structural and non-structural curve. Because of the lack of rotation in non-structural curves, like in sciatic scolisos, Adam's forward bending test would also be negative[1,3]. In fact, the authors of the present study used this test as a criterion of inclusion and only those patients with a negative test were included as mentioned before. On the other hand, lack of a thorough physical exam was reported in long delays of definitive treatment of LDH and in mistreatments as if the diagnosis was AIS, as well[1,2]. Zhu et al.[2] reported, that 4 adolescent patients with LDH accompanied with SS were misdiagnosed as AIS and tried to be managed with bracing. In the present study 13 patients were misdiagnosed as AIS and were applied TLSO.

L4-L5 is the most frequently reported level for LDH in adolescent patients presenting with SS[1,3,7,18]. This information was backed up with the fact, that bilateral iliolumbar ligaments originating from the transverse process of L5 had an important stabilizing role at the level of L5-S1, while L4-L5 level which

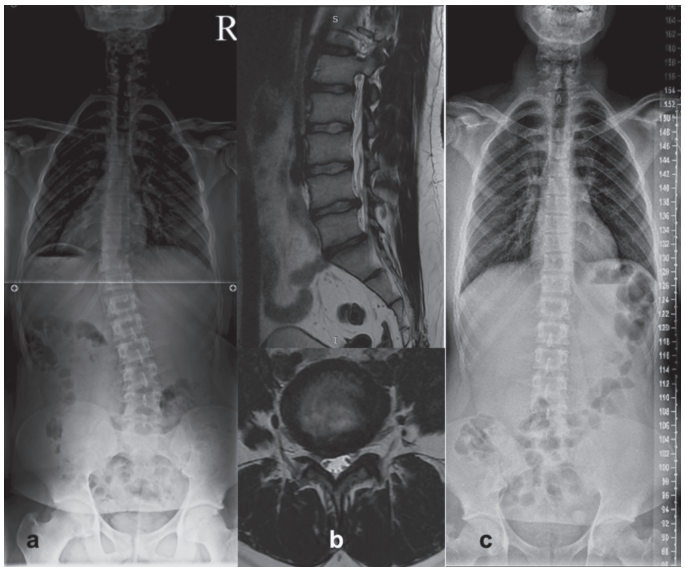


Figure 1. Seventeen year old male patient with lower back and leg pain. **a.** Short lumbosacral curve with long thoracolumbar curve (23.7°). CSVL-C7PL: 3.1 cm **b.** L4-L5 right sided lumbar disc herniation located on the convex side of the curve and creating sciatic scoliosis toward the opposite side **c.** Patient after 38 months as pain free. Sciatic scoliosis completely resolved. Coronal balance restored (CSVL-C7PL: 0.6 cm)

CSVL: Central sacral vertical line, C7PL: C7-plumb line

Table 4. Radiographic, clinical, functional outcomes and scores regarding the health related quality of life

	Pre-operative	At the last follow-up	p-value
Average major curve magnitude	25.1° (range 18°-29°)	4.2° (range 3.3°-7.2°)	<0.001
CSVL-C7PL distance (cm)	4.1 (range 2.7-6.4)	1.3 (range 0.2-1.4 cm)	0.003
Average ODI score	36.1% (range 33.7-46.1)	6.2% (range 3.8-7.2)	<0.001
Average VAS leg score	7.1 (range 6-8)	1.3 (range 0-2)	<0.001
Average VAS back score	4.2 (range 3-5)	0.7 (range 0-1)	<0.001
Average SF-36 PCS	44.2 (range 43.1-45.3)	56.2 (range 55.3-57.6)	0.003
Average SF-36 MCS	46.8 (range 45.7-48.4)	57.3 (range 56.9-57.8)	0.003

CSVL: Central sacral vertical line, C7PL: C7-plumb line, ODI: Oswestry Disability Index, VAS: Visual analogue scale, SF-36: Short form 36, PCS: Physical component score, MCS: Mental component score

was not surrounded by the pelvic cavity might increase its chance to progress to shift and result in SS[23,24]. Kim et al.[18] reported, that having a herniated disc at L4-L5 was a risk factor for developing SS. In conjunction with the literature, 61.1% of the herniated level in adolescent patients with SS was reported as L4-L5 in the present study. Adolescent patients with LDH was reported to be less responsive to conservative treatment, which was attributed to healthy discs with high elasticity and viscosity[6,9,21]. The present study also reported a failure of conservative management in 6 adolescent patients with LDH and SS. Nevertheless, the conservative treatment was suggested to be brief for patients with persisting disability, even in the absence of neurological deficits[2,21]. Surgical treatment was aimed to provide immediate pain relief, quicker recovery and fewer complications[3,7,25]. Good to excellent results were reported as a result of lumbar discectomy in adolescents with LDH[2,3,7]. Zhu et al.[2] suggested, that earlier discectomy could provide greater opportunity for correction and stabilization of SS, without risking the SS to progress into a persistant curve defining a structural scoliosis. Suk et al.[3] suggested to remove not only the herniated disc fragment, but also hypertrophied ligamentum flavum, hypertrophied medial facet together with the decompression of the neural foramen. The present study, in conjunction with the recent literature reported excellent clinical and functional outcomes as a result of meticulously performed lumbar microdiscectomy, performed similarly to Suk et al.[3] suggestions, applied to adolescent patients with LDH and SS. Suk et al.[3] underlined the importance of SLR test as the only factor effecting the clinical outcome by mentioning, that the more limited the SLR test, the better the clinical outcome as a result of surgery. Khuffash and Porter[26] reported, that contralateral SLR test positivity was associated with poor prognosis as managed conservatively. This argument was also confirmed by the study conducted by Suk et al.[3]. In conjunction with the literature, the present study reported, that adolescent patients with highly restricted SLR test [which was the case in all 16 patients (88.9%) included in the present study] had excellent clinical outcomes including ODI and VAS scores in addition to high quality of life evaluated with SF-36 scores at the latest FU visit, while contralateral SLR test was positive on two patients with successful outcomes. According to Finneson's[27] hypothesis, not based on a clinical study, when LDH was lateral to nerve root, the list was towards the opposite side of the sciatica to decompress the nerve root, on the contrary, when LDH was located medial to nerve root, the list was towards the side of the sciatica to decompress the nerve root. However, there are studies contradicting with the hypothesis of Finneson[7,27-29]. It was repeatedly reported, that adolescent LDH patients with SS had short lumbosacral curves, accompanied with long thoracic or thoracolumbar curves directed toward the opposite side, while LDH was noted at the convex side of the lumbosacral curve[1-3,7,18]. Zhu et al.[2] reported 73.1% as the rate of the truncal shift toward the opposite side of disc herniation, by speculating, that this position might decrease the amount of weight bearing on the affected leg providing alleviation of the nerve root irritation. The present study, in conjunction with the literature reported, that all patients had a short lumbosacral curve accompanied with long thoracic curve; while the trunk shift was directed mostly to the opposite side (14 patients, 87.5%) of the LDH, which was on the convex side of the lumbosacral curve in 88.9% of patients. Now that, the SS was secondary to nerve root irritation, it was hypothesized, that it should be resolved, when the painful compression was removed[3,7,25]. The reversibility of the SS together with improvement of symptoms were reported by many studies[1,3,4,19]. However, data regarding the period of curve resolution is conflicting. Matsui et al.[7] reported a complete disappearance of trunk shift in 45% of patients with average 107 days after surgery, while an average curve magnitude of 10.7° was reduced to 2.7° after 7.5 months. Kim et al.[18] reported the reversibility of trunk shift with an average of 6 months. Suk et al.[3] reported, that SS with an average pre-operative magnitude of 9.8° was reversible to 1.8° at the first post-operative week and was less than 5° in 82.2% of cases in the last FU. Zhu et al.[2] reported, that 94.2% of patients recovered to normal in the 2.5th post-operative year. Zhang et al.[1] reported, that 85.71% of adolescent patient obtained scoliosis resolution at the 6th post-operative month. The present study reported, that at the 6th post-operative month, 15 (83.3%) of patients were detected to have a complete resolution of scoliosis, while at the latest FU patients were detected to have an average curve magnitude of 4.2° indicating the almost total resolution of scoliosis. It was also detected, that the slight pre-operative coronal imbalance was successfully restored at the last FU in conjunction with the literature. Highly improved clinical and functional outcomes following discectomy to adolescent patients with LDH and SS have been reported in the literature. Zhang et al.[1] reported average VAS back-VAS leg- and ODI scores of 0.72-0.42 and 7.52 at the final FU. Zhu et al.[2] reported an average ODI score of 7.3% at the final FU. The present study reported average VAS back-VAS leg-ODI scores of 0.7-1.3-6.2%, respectively at the final FU underlining the efficacy of the microdiscectomy. For the first time in the literature, by utilizing SF-26 scores, the present study also reported about the significant improvement of healthy related quality of life regarding this particular group of patients.

Study Limitations

This study has some limitations. First of all it is a retrospective review of patients. Another limitation is, that the number of patients are limited, but this fact was owed to strict inclusion criteria. The strengths of this study are, that contains a homogenous group of patients with regard to their diagnosis, surgical treatment modality and FU duration, and that patients have been enrolled in the study under very strict inclusion criteria to minimalize the potential reasons of bias. Considering the average FU duration of the present study, it is one of the largest in the literature. We believe having presented the

long-term objective results of this very homogenous group of patients to enlighten the controversy with regard to optimal treatment strategy of this rare entity.

CONCLUSION

LDH in adolescents is a rare entity comprising unique clinical characteristics. SS in was mainly associated with short lumbosacral curves accompanied with long thoracic and/or thoracolumbar curves, with minimal or no rotation at all, while the LDH was often located at the convex side of the curve. Lumbar microdiscectomy was able to yield an immediate relieve of the radicular pain in addition to excellent functional outcomes, while successfully restoring the coronal balance in the long term follow-up.

Ethics

Ethics Committee Approval: The study was approved by the Institutional Review Board of EMSEY Hospital (approval date: 02/02/2021, approval no: 1121077).
Informed Consent: Retrospective study.
Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Y.E., T.P., Concept: Y.E., T.P., Design: Y.E., T.P., Data Collection or Processing: Y.E., T.P., Analysis or Interpretation: Y.E., T.P., Literature Search: Y.E., T.P., Writing: Y.E., T.P.
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INCIDENCE OF ASYMPTOMATIC RECURRENT LARYNGEAL NERVE PALSY FOLLOWING ANTERIOR CERVICAL SPINE SURGERY

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ABSTRACT

Objective: Anterior cervical spine surgery (ACSS) has become the most preferred surgical approach for the subaxial cervical spine. To understand the laryngeal complications, the recurrent laryngeal nerve (RLN) is the most important anatomical landmark. Because RLN palsy are often subclinical, there are few data on the incidence of total RLN palsy, and for this reason, asymptomatic RLN injuries are thought to be even more common. In this prospective study, we aimed to determine the incidence of asymptomatic RLN palsy after ACSS.

Materials and Methods: A total of 46 patients who underwent ACSS between November 4, 2019 and June 30, 2021 during the corona disease pandemic, were enrolled in this single-centre, prospective study. Only anteromedial approaches were evaluated. Preoperative video laryngoscopic intubation was performed before ACSS to assess the vocal cords. Indirect laryngoscopy was performed to assess postoperative status.

Results: ACSS was performed at one level in 36 patients and at two levels in 10 patients. The average duration of the procedure was 128.13 minutes and the average retraction time was 69.19 minutes. Dysphonia after ACSS was observed in 3 patients (6.52%), whereas asymptomatic RLN palsy was noted in only 2 patients (4.34%). These patients showed only unilateral vocal cord paralysis on indirect laryngoscopy, which was consistent with RLN injury.

Conclusion: The RLN is susceptible to injury during ACSS. Our relatively low rate of asymptomatic RLN paresis may be due to respect for the tissue, careful handling during dissection, and the use of periodically released retraction.

Keywords: Anterior cervical spine surgery, asymptomatic recurrent laryngeal nerve palsy, dysphonia, recurrent laryngeal nerve

INTRODUCTION

The anterior approach has been used for 70 years to access the cervical spine, particularly the vertebral body between C3 and T1[1]. With the development of internal fixation, instrumentation, and retraction devices, as well as the development of technology with imaging and microscope as part of the surgical treatment, anterior cervical spine surgery (ACSS) has become the most preferred surgical approach for the subaxial cervical spine[2]. The trachea and esophagus, the recurrent laryngeal nerve (RLN), the superior laryngeal nerve, the cervical sympathetic trunk, and the accessory spinal nerve have been implicated in this approach[3,4]. In particular, to understand laryngeal complications after ACSS, the anatomy and nerve supply of the larynx should be studied[5].

The RLN innervates the posterior cricothyroid muscles, the only muscles that can open the vocal cords[6]. Thus unilateral RLN paresis results in unilateral paralysis of the vocal cords, causing an inability to adduct or abduct. Inadequate laryngeal closure during phonation results in a breathy and raspy voice, hoarseness with increased vocal effort, and fatigue[7]. Because RLN palsies are often subclinical, data on the incidence of total RLN palsies are limited and while asymptomatic RLN injuries have been hypothesized to be even higher[4]. In this prospective study, we aimed to determine the incidence of asymptomatic RLN palsy after ACSS using preoperative video laryngoscope intubation and postoperative indirect laryngoscopy.

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MATERIALS AND METHODS

This study was approved by by the University of Health Sciences Turkey, Okmeydanı Training and Research Hospital Ethics Committee (approval date no: 24/10/2019, approval no: 48670771-514.10). A total of 46 patients undergoing ACSS between November 4, 2019, and June 30, 2021, were enrolled in this prospective single-centre clinical trial. The study population was determined with G*power program by taking α=0.05, power (1-β)=0.90.

Inclusion Criteria: Patients who underwent surgery with the anterior cervical approach, were over 18 years of age and younger than 65 years, and consented to participate in the study were included.

Exclusion Criteria: Exclusion criteria were patients younger than 18 years or older than 75 years, patients with previous vocal cord pathology, difficult intubation history, patients with American Society of Anesthesiologists III (ASA III) and above, and patients who did not consent.

Preoperative Evaluation: Patient age and sex, ASA score, height, weight, and body mass index (BMI) were noted. Comorbidities and surgical history, especially previous cervical spine surgery, were reviewed in detail.

Anesthesia: Patients placed supine on the operating table were carefully intubated with a video laryngoscope. The vocal cords were thus examined before intubation, and if pathology was present, the patient was excluded from the study. During intubation, excessive flexion and extension of the neck was avoided. Endotracheal tube (ETT) cuff pressures (ETCPs) were measured. The ETT was set to a cuff pressure of 20 mmHg or less.

Surgical Procedures: Only the anteromedial approaches were evaluated. After careful dissection and adequate mobilization of soft tissues using hand retractors, the surgical field was routinely created with the retraction of trachea and esophagus medially, the sternocleidomastoid muscle and carotid sheath laterally up to the prevertebral fascia. We had avoided sharp dissections and stay away from the tracheoesophageal groove. The RLN was not visualized in any case. After palpation of the vertebral body, the prevertebral fascia and anterior longitudinal ligament were separated from the midline and a subperiosteal release of the longus colli muscle was obtained. Caspar (Aesculap) and Cloward (Codman) automatic retractor systems are routinely used as self-retaining automatic retractors in our clinic for ACSS, so the types of retraction were standardized. The cuff of the ETT was deflated after retractor insertion and then re-inflated to less than 20 mmHg. Anterior cervical discectomy and fusion (ACDF) with or without corpectomy with anterior plate was performed. The surgical technique during the operation and the structural differences in the cervical spine of the patients were recorded.

Postoperative Evaluation: Complications of postoperative extubation were noted. Peroperative methylprednisolone administration if needed was added to the case report forms. Routine radiographs of the cervical spine were evaluated after mobilization on the first postoperative day. Neck and cranial nerve examinations were performed. In the final stage, a detailed examination of the vocal cords was performed by the department of otolaryngology via the indirect laryngoscopy (Figure 1).

Statistical Analysis

The SPSS (Statistical Package for the Social Sciences) program (IBM Statistics version 25.0 inc., an IBM Co., Somers, NY) for Windows was used for statistical analysis. Descriptive statistics: Numbers and percentages for categorical variables, mean, standard deviation, minimum, maximum, and median for numerical variables. Subgroup analyzes were performed with the Mann-Whitney U test and interpreted with the Bonferroni correction. Rates in groups were compared with the chi-square test. The statistical alpha significance level was accepted as $p<0.05$.

RESULTS

In our neurosurgery department, a total of 64 patients underwent ACSS during the pandemic corona virus disease-2019 (COVID-19). Four patients older than 75 years, 2 patients with preoperative vocal cord pathology detected during intubation with the video laryngoscope, 2 patients with difficult intubation history, 5 patients who did not consent to the study, and 5 patients with ASA III and above were excluded. A total of 46 patients were evaluated. Twenty-two patients were women and 24 were men. The age of the patients ranged from 23 to 74 years, with a mean of 46.87 years. The BMI of the patients ranged from 18.92 to 37.33, with a mean of 28. A total of 14 patients (30%) had a previous comorbidity. Among these patients, 4 patients had a history of hypertension, 3 had diabetes mellitus, and 3 had both. Two patients had chronic obstructive pulmonary disease, and 2 patients had neurodegenerative disease. Three patients had prior ACDF, and 3 patients had prior thyroidectomy. Patients

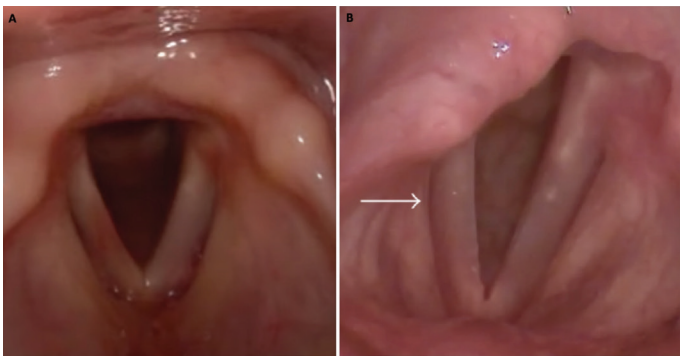

Figure 1. Postoperative assessment during indirect laryngoscopy
A. Non-pathologic vocal cords
B. Pathologic; movement of the right vocal cords is restricted

were hospitalized for a mean of 5 days (range, 2-12 days). ACDF with cage/prosthesis was performed in 40 patients, ACDF with corpectomy in 4 patients, ACDF with an anterior plate in 2 patients. Surgery was performed at one level in 36 patients and at two levels in 10 patients. The levels involved were C3-C4 in 3 patients, C4-C5 in 12 patients, C5-C6 in 24 patients, and C6-C7 in 17 patients. Forty-three patients operated in the radiculopathy clinic. Arm pain was localised on the left side in 23 patients, on the right side in 13, and on both sides in 7. In 38 patients, a right-sided approach was chosen. A transverse or oblique incision through the skin and subcutaneous fat was made on the selected side. The average duration of the procedure was 128.13 minutes (range, 85-240 minutes). The average retraction time was 69.19 minutes (range, 30-130 minutes). The range of Cloward retraction was between 2-3 cm in 33 patients and between 3-4 cm in 13 patients (average 2.8 cm). Postoperative anesthetic complication was observed in 2 patients: Postintubation bronchospasm. A total of 3 patients had postoperative dysphonia (6.52%). Methylprednisolone was administered in these patients. No aspiration or dysphagia was observed. Dysphonia developed in 2 female and 1 male patients with ACDF with cage. Two of them underwent surgery at a single level: one at the C5-6 level and the other at the C6-7 level, and the last patient underwent surgery at C4-5 and C5-6. These patients showed only unilateral vocal cord paralysis consistent with RLN injury on indirect laryngoscopy. The observed RLN complication resolved spontaneously in all these patients in our series. The mean recovery time of dysphonia was 3 weeks (range, 2-5 weeks). Asymptomatic RLN palsy was found in only 2 patients (4.34%) who underwent surgery at multiple levels: one involved levels C5-6 and C6-7, and the other involved levels C4-5 and C5-6. The average duration of surgery in these 2 patients was 200 minutes, and the average retraction time was 57.5 minutes. The Cloward retraction range in both was between 3-4 cm.

DISCUSSION

RLN injuries are frequently reported as ACSS-related complications[4,8,9]. Two terms for RLN injury appear in the literature: the incidence of clinical dysphonia and vocal cord paralysis as a result of RLN palsies. This is the first prospective study to show the incidence of actual asymptomatic RLN palsy after ACSS.

The proposed mechanisms of RLN injury were direct injury to the nerve during exposure and traction injuries[1,10,11]. Traction injury can be accepted as stretch-induced neuropraxia[1]. Incorrect placement of the retractor or excessive retraction of the larynx, entrapment of the nerve between the inflated cuff of the ETT, and postoperative edema are the main types of these injuries in which neuropraxia is caused by local ischemia[12].

Revision surgery and surgery requiring more extensive dissection or retraction had a significantly increased rate of injury[13,14]. In a prospective study conducted by Curry and Young[15], laryngoscopic examinations were performed before revision ACDF and 17.3% (4 of 23 patients) of patients had abnormalities. Paniello et al.[16] found that of 47 patients who underwent screening for revision ACSS, 13 (26%) had laryngeal abnormalities, including 11 cases (22%) who had vocal cord paresis, 5 of whom were asymptomatic. In our cases, no clinical or subclinical RLN palsy was observed in any of the patients with previous ACDF surgery.

ETCPs and their effects on the mechanism of injury at the RLN have been described in the literature by Apfelbaum et al.[17,18]. ETTs can cause nerve ischemia by exerting pressure on the RLN and submucosal surface[19]. In contrast, another prospective study by Audu et al.[20] concluded that ETT cuff deflation/reflation and pressure adjustment did not reduce the incidence of RLN injury in ACSS. Nevertheless, in our cases, the ETT was adjusted to a cuff pressure of 20 mmHg or less for standardization. And ETCP monitoring with deflation during retraction was also used in all patients. The reported incidence of RLN injury in the early postoperative period after ACSS ranged from 0 to 15.4% in prospective studies and from 0.2 to 7.9% in retrospective studies[8,9,14,21-26]. Zeidman et al.[27] reported a 0.2% retrospective incidence of RLN palsy in 4,589 patients who underwent surgical procedures such as anterior cervical discectomy, ACDF, corpectomy, laminectomies, posterior arthrodesis, laminoplasty, and cervical plating. A systematic review by Tan et al.[14] found that the incidence of RLN palsy with vocal cord palsy after ACSS ranged from 0.2 to 24.2%. Gokaslan et al.[28] conducted a multicenter retrospective study as part of the AOSpine North America Clinical Research Network and reported that the incidence of RLN palsy after subaxial cervical spine surgery ranged from 0.6 to 2.9% between centers. Consistent with the literature, the incidence of clinical RLN palsy in our study was 6.52%.

Because RLN palsy is often subclinical, data on the incidence of total RLN palsy are limited, whereas asymptomatic RLN injuries were thought to be even more common[4].

The actual incidence of RLN palsy is understudied in the literature, with some surgeons accepting it as a minor symptom, short duration of this symptom, or even mostly asymptomatic. RLN injury is usually asymptomatic but can manifest in a spectrum ranging from hoarseness, vocal fatigue, dysphonia, impaired phonation, dysphagia, aspiration to impaired cough reflex, airway obstruction, stridor, and permanent tracheostomy[29]. Jung et al.[4] used preoperative and postoperative direct laryngoscopy in patients underwent ACSS, including ACDFs, cervical corpectomies, and anterior osteosynthetic fusion procedures. They found that the incidence of asymptomatic and symptomatic RLN palsy was 24.2%, with 15.9% of their patients developing clinically silent RLN palsy after surgery. Dimopoulos et al.[30] used intraoperative laryngeal electromyography to predict the development of RLN palsy in 298 patients who underwent ACDF. They detected significant laryngeal activity in 14.4% of patients, of whom 2.3% developed RLN palsy. Our incidence of subclinical RLN injury was 4.34%. We have assumed

the intensity of retraction to be the sum of the retraction time and the degree of retraction. Retraction must be applied for a short period (<175 minutes) and relaxed intermittently[31]. We adhered to this rule of timing for retraction. The average retraction time in our cases was 69.19 minutes. Although our durations were not exceeded, RLN paresis occured. Some authors prefer the use of hand-held retractors where the pressure can be controlled[11]. But with experienced hands, static self-holding retractors, which we prefer, can also be an effective and noninjurious method. In the Weisberg et al.[1] cadaver model that supported stretch neuropathy, stretch was significant only when the retractor opening was greater than 3 cm, which corresponds to the degree of traction. In our cases, the width of the retractor opening is usually about 2.8 cm. The width of the retractor is limited by the placement of its blades under the longus colli muscle. Therefore, we placed the retractor sufficiently under the longus colli muscle to place it well. Possible explanations for our relatively low rate of asymptomatic RLN palsies could be respect for the tissue, care in handling blunt and sharp instruments, and use of careful, periodically released retraction.

Study Limitations

The limitation of our study is the small sample size. Because our study was conducted during the COVID-19 pandemic, the number of elective surgeries decreased. Given the quality-of-life-impairing consequences of vocal cord paralysis, prevention is important, no matter how low the incidence.

CONCLUSION

ACSS is the most commonly performed surgical procedure for subaxial cervical spine pathology. Serious complications await the surgeon if he does not pay attention to the course and location of the RLN during ACSS. In this single centre prospective study of asymptomatic RLN palsies after ACSS, the incidence was 4.34%. Avoiding overly wide retractor opening via the longus colli muscle anatomy and intermittent release of retraction could reduce the incidence of RLN palsy.

Ethics

Ethics Committee Approval: This study was approved by the University of Health Sciences Turkey, Okmeydanı Training and Research Hospital Ethics Committee (approval date no: 24/10/2019, approval no: 48670771-514.10).

Informed Consent: Written informed consents were obtained from patients included in this study.

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Authorship Contributions

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UTILITY OF ROUTINE NEEDLE BIOPSY DURING KYPHOPLASTY FOR OSTEOPOROTIC VERTEBRAL FRACTURES

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ABSTRACT

Objective: Pathologic vertebral fractures are most commonly caused by osteoporosis, and kyphoplasty is one of the most common minimally invasive surgical treatments. In osteoporotic vertebral fractures, the underlying pathology may not be recognized. Therefore, a needle biopsy may be essential during kyphoplasty. This study investigated the incidence of unsuspected malignancies in patients undergoing kyphoplasty for osteoporotic vertebral fractures.

Materials and Methods: Data from 56 patients (29 women, 27 men) who underwent kyphoplasty and had needle biopsy were retrospectively reviewed. Patients in whom no bone biopsy was performed and those in whom kyphoplasty was performed for reasons other than osteoporosis were excluded from the study. Patients who did not experience relief after medical treatment and who had a visual analog scale score of 6 were included in the study.

Results: Five patients not suspected to have malignant disease were diagnosed with malignancy after pathological examination. Two of them were thought to have metastases from a primary tumor (one breast cancer and one prostate cancer). The incidence of unexpected malignancy was 8.9%.

Conclusion: Percutaneous needle biopsy is a low-cost highly effective method. Therefore, we recommend routine needle biopsy during kyphoplasty.

Keywords: Osteoporosis, vertebral fracture, kyphoplasty, needle biopsy, malignancy

INTRODUCTION

Pathologic vertebral fractures (PVF) are often caused by osteoporosis and metastatic disease without preceding trauma. Osteoporosis is one of the most common causes of PVF, especially in the older population. PVF is defined as a reduction in vertebral body height of 20% or ≥4 mm[1]. In osteoporotic VFs, back pain is the chief complaint. Depending on the severity of fractures, symptoms can range from functional limitations to impaired lung capacity. The initial treatment of PVFs includes conservative therapy. Patients who no longer respond to therapy are candidates for surgical intervention[2]. Vertebroplasty and kyphoplasty are the two most common minimally invasive surgical procedures[3]. Bone biopsy is not a routine procedure for kyphoplasty because of osteoporosis. Although most fractures in these patients are caused by osteoporosis, underlying pathologic conditions such as malignancies may be missed. Previous studies have used needle biopsies of the fractured vertebral body to determine whether unrecognized pathologies are associated with osteoporotic diseases[4-14]. In light of previous studies, we aimed to investigate the incidence of unsuspected malignancies in patients undergoing kyphoplasty for osteoporotic vertebral fractures (VFs).

MATERIALS AND METHODS

This retrospective study was performed at Ankara City Hospital. Ethical approval was obtained from the ethics committee of the Ankara City Hospital before the start of the study (approval date: 08/06/2022, approval no: E2-22-1949). The study protocol was performed according to the principles of the Declaration of Helsinki. Data of patients who underwent kyphoplasty between July 2019 and March 2022 were collected by retrospective review of hospital records. Fifty-six patients who underwent kyphoplasty and had a bone biopsy were included in the study. Of these patients, 29 were female and 27 were male. Patients who did not undergo bone biopsy and who underwent kyphoplasty for reasons other than osteoporotic VFs were excluded from the study. The results of preoperative radiologic imaging [radiographs and magnetic resonance imaging (MRI)-short tau inversion recovery (STIR) MRI in all cases and gadolinium-enhanced MRI in cases with suspected malignancy] were evaluated from the recorded data. None of the patients had a history of systemic steroid therapy. All patients had back pain consistent with radiological findings. The visual analog scale (VAS) score of the patients included in the study was ≥6, and the patients had not experienced significant relief after back

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splinting and medical treatment. Preoperative images showed 14 L1, one L1 + L3, one L1 + L3 + L4, one L2 + L3, eight L2, nine L3, three L4, two L5, one T11, one T11 + T12, two T12 + L2, 10 T12, one T5, one T5, T6, one T7, and one T9 compression fractures. Five of the patients had a history of malignancy (two breast cancer, one prostate cancer, one Wilson tumor, and one lung cancer). Demographic characteristics and final pathologic diagnosis were recorded. Percutaneous kyphoplasty was performed under local anesthesia in the prone position under the guidance of a scopist. All patients received prophylaxis with 1 g intravenous cefazolin sodium before the procedure. An 11-gauge Jamshidi needle was inserted into the fractured portion of the vertebral body through a transpedicular approach. A cannula was then inserted into the vertebral body. Bone biopsy was obtained via an obturator. The bone samples were sent to the hospital pathology department for histopathological examination. A bone biopsy was taken in a single plane from each patient. After the biopsy, a drill was inserted into the fractured vertebral body by rotation, and a balloon catheter was placed. Kyphoplasty surgery was performed accordingly.

Statistical Analysis

Statistical analyzes were performed using the Statistical Package for the Social Sciences (SPSS) package program (IBM SPSS Statistics 24). Descriptive statistics were used to interpret the results. Results were presented as mean + standard deviation.

RESULTS

In all patients, radiological imaging findings were compatible with osteoporotic VFs. The radiologic images left no doubt about malignancy. Five patients were diagnosed with pathologic malignancy based on the biopsy specimens. Two of them were metastases of a primary tumor (one breast cancer and one prostate cancer). The unexpected malignancy incidence was 8.9%. The demographic and clinical characteristics of the patients are shown in Table 1. Results of the pathological examination revealed two cases of breast cancer metastases, one prostate cancer metastasis, one carcinoma metastasis, and one lung cancer metastasis. Nine of the specimens were unsuitable for pathological evaluation. The remaining 42 specimens had osteoporotic bone features. None of the patients experienced complications related to the surgical procedure.

DISCUSSION

VFs may be associated with several diseases other than osteoporosis. However, the underlying pathology cannot always be accurately determined before surgery. MRI, computed tomography, and other imaging modalities can help in differentiating benign from malignant spinal lesions. Acute VFs show as hypointensity on T1 images and hyperintensity on sequenced MRI with STIR. Pathologic conditions other than osteoporosis may produce an osteoporosis-like appearance on MR images. Uzunoglu et al.[15] claimed that MRI changes occur in Paget's disease depending on the disease stage. Thus, acute fractures are isohypointense on T2-weighted MRI, whereas chronic ones are hyperintense. In another study, T1/T2-weighted MRI was found to depict plasmacytoma as hypointense, whereas STIR-weighted images showed hyperintensity[16]. In this study, all MR images showed hypointensity on T1-weighted images and hyperintensity on T2-weighted images. The preoperative MR images of a patient with osteoporosis (Figure 1) and a patient with breast cancer (Figure 2) were comparable.

In the past, MRI has been claimed to detect malignant lesions in the preoperative period with a success rate of up to 98%[17].

Table 1. Demographic and clinical characteristics of the patients

Variables	Patients (n=56)
Age (years, mean ± SD)	67.29±8.01
Gender (n, %)	
Male	27 (48.21%)
Female	29 (51.79%)
Biopsy results (n, %)	
Breast cancer	2 (3.57%)
Prostat cancer	1 (1.79%)
Carcinoma	1 (1.79%)
Lung cancer	1 (1.79%)
VAS score (mean ± SD)	
Preoperative	7.44±1.4
Postoperative	3.82±0.86

SD: Standard deviation, VAS: Visual analog scale

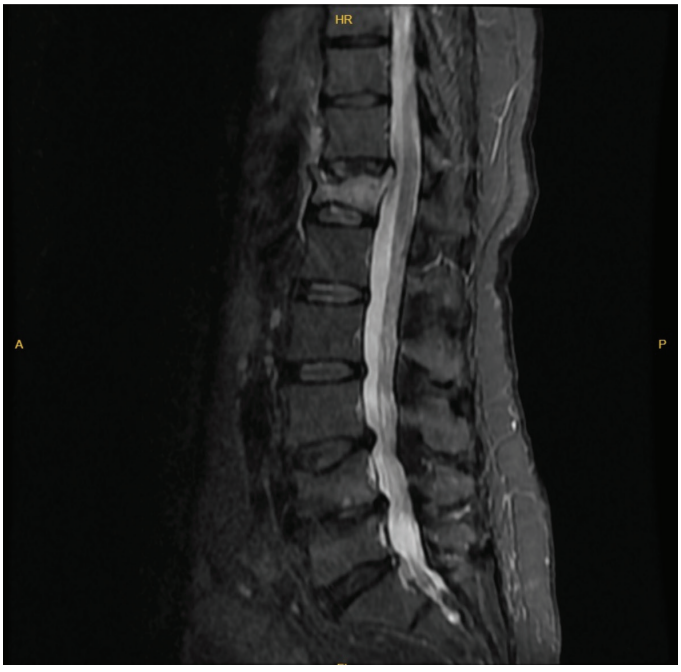

Figure 1. The preoperative MRI images of the osteoporotic patient
MRI: Magnetic resonance imaging

Despite this high rate, unexpected results may occur in clinical practice after pathologic examination. One systematic review found that transpedicular biopsies revealed unexpected malignancy of vertebral compression fractures (VCFs) in 0.4-6% of cases[11,12,15,18-20]. Therefore, most authors recommend routine transpedicular bone biopsies during kyphoplasty, whereas some authors recommend performing biopsies only in patients with strong suspicion[13,21]. In the present study, five malignant pathologic findings were detected in 56 (8.9%) patients, with findings consistent with a primary malignancy in two patients. All malignancies were metastases, two of which were breast cancer, one prostate cancer, and one lung cancer, which are among the most common malignancies in the older population. Previously, Uzunoglu et al.[22] found 15 malignant tumors among 269 biopsies from 201 patients. The pathologic diagnosis was six gastrointestinal adenocarcinomas, three gynecologic adenocarcinomas, three breast cancers, and two lung adenocarcinomas. In another study, three malignant tumors were found among the biopsy results of 67 patients, two of which were multiple myelomas and one was renal cell carcinoma metastasis[23]. Li et al.[12] reported that among 151 biopsies from 97 patients, two cases were multiple myeloma, one was Paget's disease, and one was chronic osteomyelitis. Metastasis of a malignant tumor found in vertebral biopsy revealed an advanced stage of cancer. However, among the cancers that most commonly metastasize to the spine, some cases of breast and prostate cancers can be successfully treated even at advanced stages. Therefore, even considering the cost-benefit ratio and possible complications, a transpedicular biopsy is relatively inexpensive, has high sensitivity and specificity and very low morbidity[12,24], and can help improve the prognosis of malignant disease by providing a relatively early diagnosis. In this study, the mean preoperative VAS score of patients was 7.44, whereas it was 3.82 postoperatively; no complications related to the procedure occurred. The mean VAS score decreased by approximately half. Regardless of the etiology, we can claim that kyphoplasty is a useful technique to cure VF-related back pain. Obtaining appropriate specimens by percutaneous needle biopsy is not always possible. In our study, there were 9 (16%) inadequate biopsy specimens for pathologic evaluation, similar to previous studies[8,9]. We performed a single-stage biopsy in all patients. In the literature, most authors perform biopsies in multiple stages[9,14]. In their study, Li et al.[12] performed biopsies in all the levels they operated and found osteoporosis and malignancy at different levels in one patient. Therefore, they advised biopsies from all levels of VCFs. Taking multiple specimens may improve the diagnostic accuracy of the procedure.

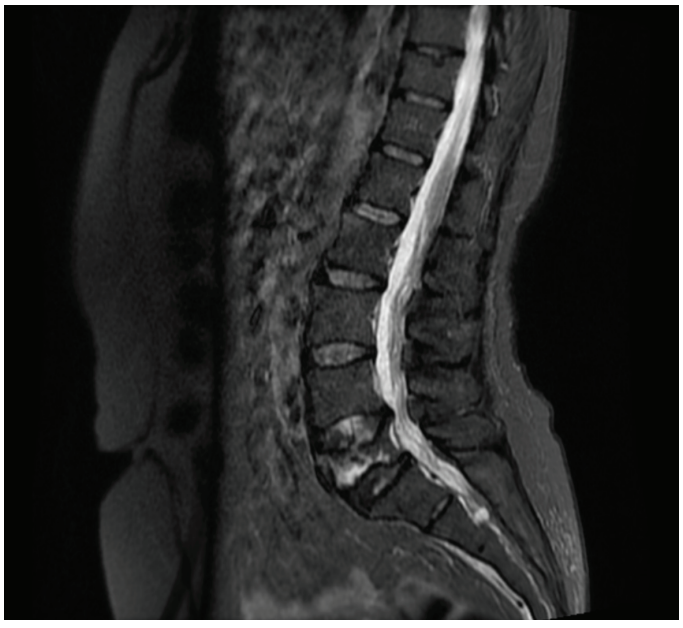

Figure 2. The preoperative MRI images of the patient with breast cancer

MRI: Magnetic resonance imaging

Study Limitations

The main limitation of this study is the relatively small number of patients. Another limitation is that a biopsy was performed at one level rather than at multiple levels.

CONCLUSION

The results of this study revealed that a considerable number of unexpected malignant findings can be detected by percutaneous needle biopsy during kyphoplasty in osteoporotic VFs. Because of its low cost, low complication rate, and high efficacy, we recommend routine biopsy during kyphoplasty.

Ethics

Ethics Committee Approval: Ethics Committee approval was received from Ankara City Hospital (approval date: 08/06/2022, approval no: E2-22-1949).
Informed Consent: Retrospective study.
Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Ö.Ö., G.G., D.D., A.E.S., U.K.G., B.S., D.B., A.D., Concept: Ö.Ö., A.D., Design: D.B., A.D., Data Collection or Processing: G.G., A.E.S., U.K.G., B.S., Analysis or Interpretation: D.B., A.D., Literature Search: D.D., U.K.G., B.S., Writing: Ö.Ö., A.D.
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ADDING EPIDURAL INJECTION TO VERTEBROPLASTY IMPROVES FUNCTION IN PATIENTS WITH VERTEBRAL COMPRESSION FRACTURE

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ABSTRACT

Objective: Pain may not resolve, and even new painful conditions may arise in a certain proportion of patients after vertebroplasty/kyphoplasty procedure performed for vertebral compression fractures. This study assessed the efficacy of targeting multiple pain generators, i.e., simultaneous use of vertebroplasty and epidural injections, in patients with vertebral compression fractures.

Materials and Methods: A total of 58 patients who underwent percutaneous vertebroplasty (PVP) at the lumbar level because of osteoporotic compression fracture of the lumbar vertebra were included in this retrospective study. The patients received PVP alone or PVP plus epidural injection. The two groups were compared in terms of pain severity using visual analog scale (VAS) as well as Oswestry disability index (ODI) scores during the 3-month follow-up period. Additionally, requirements for narcotic analgesics and additional interventions were compared.

Results: The two groups did not differ regarding the change in VAS scores over time (p=0.201). They differed regarding ODI scores, where the vertebroplasty plus epidural group had significantly lower ODI scores at 1 week (22.4±3.6 vs. 17.2±2.8), 1 month (21.1±3.8 vs. 15.7±2.4) and 3 months (22.9±5.5 vs. 15.0±2.7) (p<0.001 for all). Additionally, more patients in the vertebroplasty alone group required additional intervention (28.6% vs. 3.3%, p=0.011) and more were still requiring narcotics at three months (32.1% vs. 6.7%, p=0.013).

Conclusion: Interlaminar epidural injections combined with PVP appear superior to PVP alone in improving lumbar function and in reducing the need for additional narcotics and interventions after such procedures. Further studies are warranted to confirm these observations.

Keywords: Vertebroplasty, epidural injection, visual analogue scale (VAS), Oswestry disability index (ODI), vertebral compression fracture, narcotic need

INTRODUCTION

Vertebral compression fracture (VCF) is the most common type of fracture associated with osteoporosis and represents a major global health problem[1]. Studies have reported prevalence rates between 18% and 28% among women aged 50 years or older[2], while data from Europe have indicated a prevalence of 12% in males between 50 and 79 years of age[3].

Bed rest, back brace, multimodal physical therapy and analgesics are the mainstay of treatment in patients diagnosed with symptomatic VCFs. Medical strategies targeting treatment and prevention of osteoporosis are also essential components of multidisciplinary management. Despite some controversy regarding the use of minimal invasive interventions such as vertebroplasty/kyphoplasty in selected patients, these methods are commonly used both to achieve stabilization of the spine and to alleviate pain[4]. Percutaneous vertebroplasty/kyphoplasty (PVP) is an interventional technique suitable for patients with severe pain unresponsive to conservative management and is based on the injection of materials such as polymethyl methacrylate (PMMA) into the body of the compressed vertebra under radiological imaging guidance.

It has been well established that pain may not resolve, and even new painful conditions may occur in a certain proportion of patients undergoing vertebroplasty due to severe pain. Persistent or new back pain following vertebroplasty have been reported to occur in 5% to 22% of patients following vertebroplasty[5-10]. Pain associated with VCF or pain occurring after vertebroplasty may arise from pain eliciting factors other than the compression fracture of the body of the vertebra, and may also be associated with underlying or newly developing conditions resulting in chronic pain[9-11].

The importance of the central and peripheral nervous systems in the treatment of spine-related acute or chronic pain is well known. Clinical and experimental studies have clearly established the very critical role of dorsal root ganglions and other components of the epidural space in the generation, transmission, and modulation of pain[9,10,12,13]. Despite relatively

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limited evidence, epidural injections for blocking dorsal root ganglions have been effectively utilized not only for the treatment of VCF pain, but also for new or residual pain after vertebroplasty[9,12,14].

Although epidural injections have been shown to be effective for the control of acute or chronic low back pain of spinal origin and for the recovery of functional capacity in affected patients, until now no studies have described simultaneous use of epidural injections and vertebroplasty for residual or newly emerging pain after the intervention. The multimodal mechanisms involved in VCF pain may be more amenable to a therapeutic strategy that targets multiple pain generators all at once.

This study was undertaken to assess the ability of the simultaneous use of vertebroplasty and epidural injections to prevent or alleviate pain that persist or occur after vertebroplasty and to assess functional pain-related outcomes, using visual analogue scale (VAS) and Oswestry disability index (ODI).

MATERIALS AND METHODS

Patients

A total of 58 patients undergoing PVP at lumbar levels (L1 to L5) due to osteoporotic compression fracture of the lumbar vertebra between 2015 and 2019 were included in this retrospective study. Indications for PVP were acute or subacute severe axial low back pain unresponsive to medical treatment and confirmed diagnosis of vertebral body compression fracture(s), as documented by radiological imaging. Failure of medical treatment was defined as minimal or no reduction of pain despite bed rest for 1 to 3 weeks and analgesics. Prior to the procedure, computed tomography or magnetic resonance images were assessed in each patient. Patients with a vertebral height loss exceeding 75% or those having significant stenosis (>25%) at the level of the fracture with radiculopathy findings and American Society of Anesthesiologists 3 or higher scores were excluded. Also excluded were patients with abnormal neurological examination findings, patients that underwent vertebroplasty outside of lumbar levels, and those requiring bilateral intervention after failure on one side during the procedure. Patients who had undergone vertebroplasty alone and those who had received additional epidural injections were included and compared in terms of VAS and ODI changes during the 3 months following the procedure.

Interventions

Percutaneous vertebroplasty only

The procedure was performed under conscious sedation with continuous monitoring of blood pressure, electrocardiography, and oxygen saturation. Patients were placed in face-down position on the surgical table. The skin covering the site of intervention was cleansed with antiseptics and the pertinent vertebrae were identified fluoroscopically. Local anesthesia with spinal needle was administered to the skin and subcutaneous tissues, including the periosteum of the bone at the site of planned entry. In all patients, a unilateral intervention was performed after radiological determination of the safer side for transpedicular approach. A 10 or 2 o'clock position for the right/left peduncles, respectively, was used for entry to vertebra. Under anterior-posterior (AP)/lateral fluoroscopic guidance and via transpedicular approach, a 11-13 gauge (G) vertebroplasty cannula was advanced up to anterior third of the vertebral body to reach a safe location near the midline. For each vertebral body to be treated, a total of 2-3 mL of PMMA was injected. After AP/lateral fluoroscopic control, the procedure was terminated, and skin was closed with dressings.

Percutaneous vertebroplasty plus epidural injection

In patients undergoing PVP plus epidural injection, after completion of the vertebroplasty as described above, interlaminar epidural injection one level below the vertebral fracture was administered using the loss of resistance method under fluoroscopic guidance. A 16 G Tuohy epidural needle was placed into the epidural space, and a 16 G silicon catheter (B/Braun, Germany) was advanced 4 cm upwards into the epidural space through this needle. A radio-contrast solution consisting of 5 cc of iohexol (Omnipaque, Opakim, Turkey) + 5 cc of physiological saline was prepared and injected into the catheter to check accurate dispersal within the epidural space, followed by the administration of methylprednisolone (Depomedrol, Pfizer, Turkey) 40 mg + lidocaine (Aritmal, Osel, Turkey) 80 mg diluted with physiological saline to a total of 10 cc. The catheter and Tuohy needle was removed, and skin dressings were applied.

In both groups, patients were kept under medical observation for 6 to 8 hours and were discharged after wearing supportive corsets. A multi-modal physical therapy program including osteoporosis treatment and prevention was scheduled, starting 3 days after discharge.

Assessments

In all patients, pain severity was assessed before, and one week, one month, and three months after vertebroplasty using a VAS with a score range of 1 to 10. Also, ODI scoring tool was used to assess the low back function before the procedure as well as one week, one month, and three months after[15]. At the end of 3 months, patients who required narcotic analgesics were determined in both groups.

After the 3-month follow-up was completed, patients with a VAS score of >5 despite medical treatment and multimodal physical therapy underwent interventional injections following clinical and radiological examinations.

Ethical approval for the study was obtained from the Demiroğlu Bilim University Clinical Research Ethics Committee (date no: 23/06/2020, approval no: 44140529/9270).

Statistical Analysis

SPSS (Statistical Package for Social Sciences) version 21 software was used for data analysis. Hypothesis tests and graphical methods were used to test normality. Between-group comparisons of continuous variables were done using student t-test for independent samples or Mann-Whitney U test, depending on data distribution. Pearson chi-square test or Fisher's Exact test was used for the between-group comparison of categorical variables, where appropriate. Two-way ANOVA test for repeated measurements was used to examine the significance of changes and differences between groups in ODI and VAS scores over time. Between-subject comparisons were done using student t-test or Mann-Whitney U test, where appropriate. Two-sided p values <0.05 were considered indication of statistical significance.

RESULTS

Table 1 shows the comparison of the patient characteristics of the two study groups. Groups did not differ regarding demographical characteristics, multiple versus single procedure level, previous history of low back pain before the development of VCF, additional magnetic resonance imaging findings, baseline VAS or ODI scores, and osteoporotic medications following the procedure (p>0.05 for all). Table 2 shows the distribution of vertebroplasty levels. Residual post-procedure pain was of axial nature in all patients, but five patients (8.6%) had radicular pain in addition to axial pain.

Changes in VAS Scores Over Time

Figure 1 shows changes in VAS scores over a 3-month period. A significant change in VAS scores was evident over time (p<0.001). However, the two groups did not differ regarding the change in VAS scores (p=0.201).

Changes in ODI Scores Over Time

Figure 2 shows changes in ODI scores over a 3-month period. A significant change in ODI scores was evident over time (p<0.001) and the two groups differed regarding the change in ODI scores (p<0.001). At baseline, the two groups had similar ODI scores (p>0.05, Table 1). However, vertebroplasty plus epidural group had significantly lower ODI scores compared to the vertebroplasty alone group at 1 week (22.4±3.6 vs. 17.2±2.8), 1 month (21.1±3.8 vs. 15.7±2.4) and 3 months (22.9±5.5 vs. 15.0±2.7) (p<0.001 for all comparisons).

Comparison of Patients with and without Previous History of Back Pain

At baseline, patients with previous history of back pain had higher VAS (8.6±0.8 vs. 7.9±1.2, p=0.032) and ODI scores (38.3±3.2 vs. 35.7±4.5, p=0.030), when compared to the patients without such history. In addition, the two groups differed regarding the course of VAS (p=0.010) and ODI scores (p=0.038) over time. Regarding VAS scores, the two groups differed at baseline (p=0.032), 1 month (p=0.005), and 3 months (p=0.011), with worse scores in patients with previous history of pain; nevertheless, both groups exhibited improvements during the study period. On the other hand, the two groups differed only at baseline regarding ODI scores. Figures 3 and 4 show the VAS and ODI changes in the two groups.

Other Outcome Measures

During a 3-month period, more patients in the vertebroplasty alone group required additional intervention (epidural, sacroiliac, facet or trigger point injection, or a combination) when

Table 1. Patient characteristics

Characteristic	All patients (n=58)	Vertebroplasty alone (n=28)	Vertebroplasty plus epidural (n=30)	p
Age, y	60.6±6.6	60.1±6.6	61.0±6.7	0.611
Female gender, n (%)	34 (58.6%)	16 (57.1%)	18 (60.0%)	0.825
Body mass index, kg/m^2	25.9±2.9	26.0±3.1	25.8±2.7	0.805
Multiple level, n (%)	11 (19.0%)	6 (21.4%)	5 (16.7%)	0.644
Previous history of low back pain*	19 (32.8%)	9 (32.1%)	10 (33.3%)	1.000
Additional MRI findings†				
Degenerative changes	53 (91.4%)	26 (92.9%)	27 (90.0%)	0.533
Spinal stenosis	5 (8.6%)	3 (10.7%)	2 (6.7%)	0.467
Spondylolisthesis	4 (6.9%)	2 (7.1%)	2 (6.7%)	0.667
Baseline VAS score	8.1±1.1	8.4±0.9	7.9±1.2	0.136
Baseline ODI score	36.5±4.3	36.8±4.1	36.3±4.4	0.668
Osteoporotic medications following procedure				
Vitamin D plus calcium	51 (87.9%)	25 (89.3%)	26 (86.7%)	0.540
Anabolic agent (parathyroid hormone)	24 (41.4%)	12 (42.9%)	12 (40.0%)	0.825
Antiresorptive agent (denosumab)	15 (25.9%)	7 (25.0%)	8 (26.7%)	0.885

*History of back pain before the development of vertebral compression fracture. †MRI findings other than vertebral fracture. Unless otherwise stated, data presented as mean ± standard deviation. VAS: Visual analogue scale, ODI: Oswestry disability index, MRI: Magnetic resonance imaging

compared to the vertebroplasty plus epidural group (28.6% vs. 3.3%, p=0.011). In addition, more patients in the vertebroplasty alone group were still requiring narcotic prescription after 3 months (32.1% vs. 6.7%, p=0.013).

DISCUSSION

The results of this study show that combined use of PVP and epidural injections in patients with VCFs was associated with significant improvements in low back functions, as documented by the changes in ODI scores, in addition to reducing the need for narcotic analgesics as well as the need for additional interventions for new or residual pain after vertebroplasty. To the best of our knowledge, the efficacy of the combined use of PVP and epidural injection in terms of pain control has not been tested in patients with symptomatic osteoporotic VCF.

Persistent or new occurrence of pain after PVP is not uncommon[5-10]. Two approaches regarding the origin of the pain due to symptomatic VCF should be considered collectively. One of these relates to the fact that the aging spine harbors multiple possible pain generators, and the other relates to the concept of chronic pain, which is an important consideration in current therapeutic strategies[9-11].

While most systematic reviews and placebo/sham controlled studies do not suggest a clinically significant benefit for vertebroplasty, studies comparing vertebroplasty (PVP) with conservative treatments generally indicate superiority of vertebroplasty for reduction in pain and disability[16-18]. A conclusion that can be drawn from this controversy is that the body of the vertebra with the compression fracture may not always represent the sole source of pain, and that more successful results can be obtained with multi-modal therapeutic strategies targeting other pain generators as well. The leading hypotheses regarding the mechanisms of pain reduction by vertebroplasty include decreased micro-mobility in the fracture, neurolysis effect within the vertebral body resulting from the heat generated by the cement material (PMMA), and restoration of the impaired biomechanics[19,20].

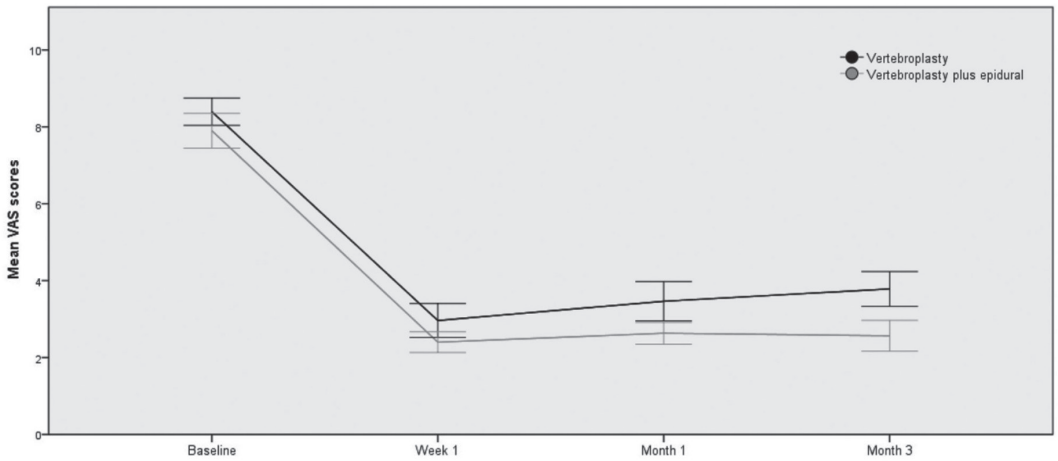

Figure 1. Changes in mean visual analogue scale (VAS) scores over time in vertebroplasty alone versus vertebroplasty plus epidural group. Error bars indicate 95% confidence intervals

Table 2. Distribution of vertebroplasty levels

Characteristic	All patients (n=58)	Vertebroplasty alone (n=28)	Vertebroplasty plus epidural (n=30)
Single level			
L1	13 (22.4%)	6 (21.4%)	7 (23.3%)
L2	12 (20.7%)	5 (17.9%)	7 (23.3%)
L3	12 (20.7%)	6 (21.4%)	6 (20.0%)
L4	8 (13.8%)	5 (17.9%)	3 (10.0%)
L5	2 (3.4%)	0 (0.0%)	2 (6.7%)
Multiple level			
L1 + L2	5 (8.6%)	3 (10.7%)	2 (6.7%)
L2 + L3	1 (1.7%)	0 (0.0%)	1 (3.3%)
L3 + L4	4 (6.9%)	2 (7.1%)	2 (6.7%)
L4 + L5	1 (1.7%)	1 (3.6%)	0 (0.0%)
Data presented as n (%)			

In a study by Kamalian et al.[10], where 23% of the patients experienced low back pain after PVP, it was concluded that the pain was generally not related with a failed procedure, and it was rather associated with the sacroiliac or facet joints, as shown by the therapeutic test injections. Other documented causes of pain persisting after PVP include costal fractures,

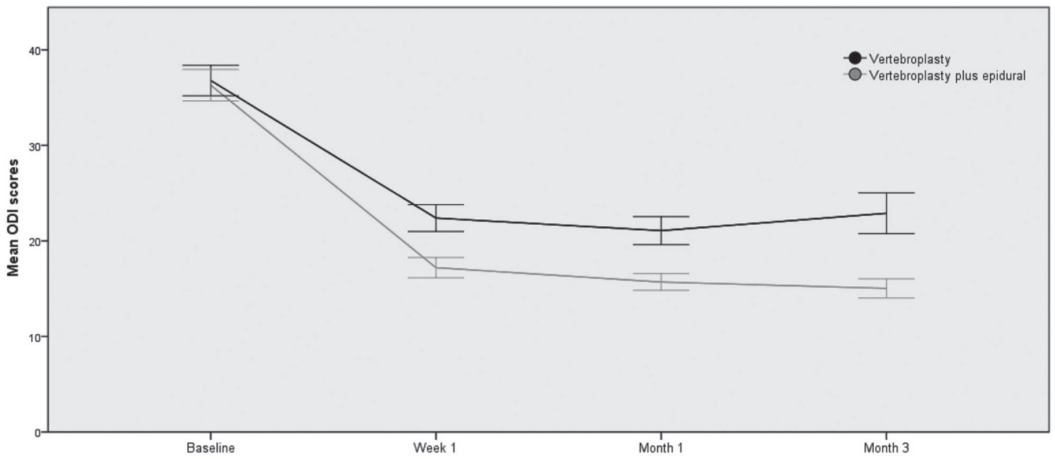

Figure 2. Changes in Oswestry disability index (ODI) scores over time in vertebroplasty alone versus vertebroplasty plus epidural group. Error bars indicate 95% confidence intervals

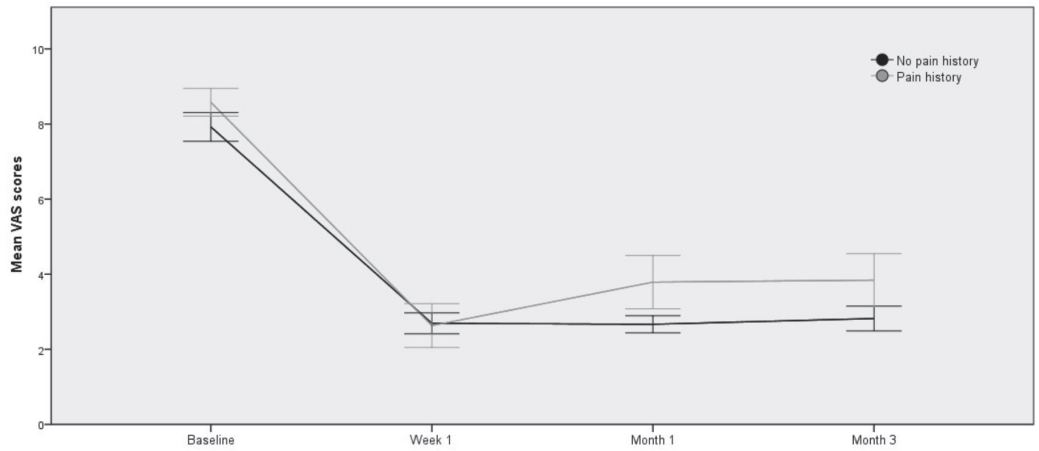

Figure 3. Changes in mean visual analogue scale (VAS) over time in patients with and without previous history of low back pain. Error bars indicate 95% confidence intervals

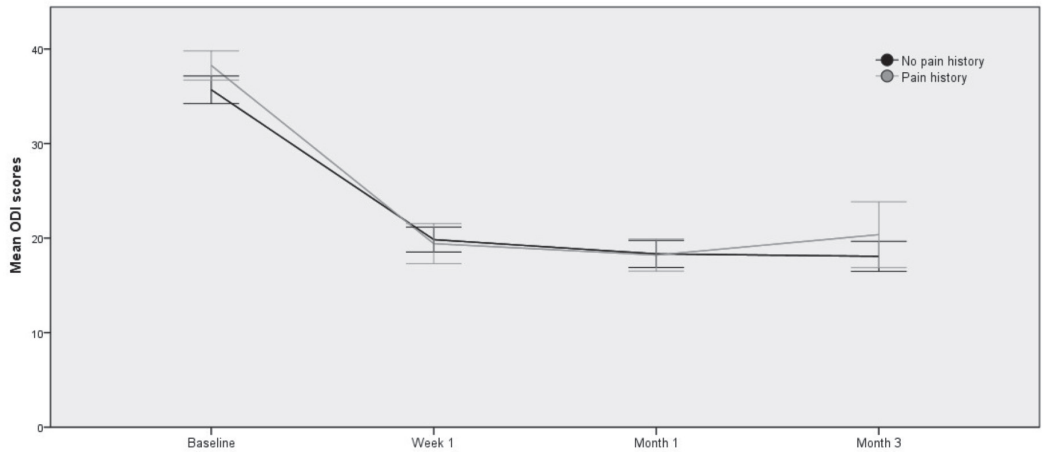

Figure 4. Changes in Oswestry disability index (ODI) scores over time in patients with and without previous history of low back pain. Error bars indicate 95% confidence intervals

compression of spinal cord and radicular nerves by cement leakage, spondylitis, non-healing bone-cement interface, and newly occurring VCFs, as well as thoracolumbar fascia injury during PVP, as suggested by some studies[21,22].

In another study involving 144 patients who underwent PVP, Georgy[9] reported improvement of residual pain in 26 of the 34 patients with epidural injection, while the remaining subjects received interventional pain treatment such as intercostal block, and sacroiliac, facet joint, and trigger point injections. It has also been reported that epidural injection targeting dorsal root ganglia may also provide an effective monotherapy for pain associated with VCFs[12,14]. Other published systematic reviews also suggested that pain due to VCFs may be associated with the posterior elements, and that successful results can be obtained using facet joint injections and medial branch radiofrequency ablation[19].

Multimodal therapeutic strategies have a well-established role in pain management. In the current study, patients receiving epidural injections together with PVP had significant improvement in ODI scores, while no significant differences could be observed in terms of the improvement in VAS. We believe that supplemental use of narcotics for pain management might have contributed to this result. Likewise, smaller proportion of patients undergoing PVP plus epidural injection was on narcotic prescription at the end of follow-up. This latter observation may be particularly valuable since it may avoid side effects of narcotics. Furthermore, the number of patients requiring additional procedures due to uncontrolled pain with medical treatment was lower in subjects who received PVP and epidural injections together.

Osteoporosis and degenerative changes comprise two fundamental and independent processes in spinal aging. Pain and immobilization due to symptomatic osteoporotic compression fractures may lead to impaired stability of the spine, potentially inititating a downward vicious cycle with further pain, immobility, and vertebral fractures[23]. In addition to age-related degeneration and structural pathologies, many other factors including occupational[24], lifestyle-related[25,26] and psychological factors may contribute to the development of chronic low back pain. Pain lasting more than three or six months is considered chronic. Since pain leads to further immobility and confinement, it is critically important to restore the spinal functions and to control the pain as soon as possible, in order to reduce morbidity and mortality.

It has been reported that chronic low back paint develops in nearly one fourth of all patients with VCFs, regardless of treatment with conservative measures or PVP[11]. Generally, the disc degeneration in the aging spine is considered the origin of low back pain. Primary pain is thought to occur due to sensitization of the nociceptive nerve fibers within the disc by cytokines and neuropeptides released as a result of degeneration[27]. However, other sources of nociception within a spinal unit, i.e. muscles, ligaments, and facets, should not be disregarded. Interconnected nociception arising from different tissues complicates the process of accurately identifying the actual source of pain. In addition, it should be borne in mind that pain is not only due to nociception, and hypersensitivity mechanisms involving both the process of pain transmission at the peripheral level and also at the central nervous system play a role in the development of chronic low back pain[28]. In some recent reviews, the level of evidence reported for the efficacy of epidural injections was rated between I and III when this treatment modality was used in a number of clinical conditions including acute or chronic pain of spinal origin, particularly disc herniation, axial or discogenic pain, central spinal stenosis, and failed back surgery syndrome[29].

We believe that the results of our study hold some promise for the treatment of new or residual pain after PVP as well as for prevention of chronicity of such pain. Treatment of osteoporotic vertebral fractures, which generally occur in the elderly population, is rather challenging due to common occurrence of secondary comorbid conditions. We recommend concomitant use of epidural injections with PVP to achieve more rapid and effective symptomatic relief, as these injections represent a practical, cost-effective, and safe therapeutic modality, even in high-risk patients.

Study Limitations

Due to the retrospective nature of this study, it could not be designed as randomized. Even if indicating insignificance differences for demographics, clinical and radiological findings in the treatment groups potentiate the study, designing a prospective study with more number of patients would be more convenient.

CONCLUSION

Interlaminar epidural injections combined with PVP appear to be superior to PVP alone in improving lumbar functions and in reducing the need for additional narcotics and interventions after such procedures. Further studies with larger sample size are warranted to confirm these observations.

Ethics

Ethics Committee Approval: Ethical approval for the study was obtained from the Demiroğlu Bilim University Clinical Research Ethics Committee (date no: 23.06.2020, approval no: 44140529/9270).

Informed Consent: Retrospective study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: S.Ç., M.O.A., O.Ö., Concept: S.Ç., M.O.A., O.Ö., Design: S.Ç., M.O.A., Data Collection or Processing: S.Ç., M.O.A., Analysis or Interpretation: S.Ç., M.O.A., O.Ö., Literature Search: S.Ç., M.O.A., O.Ö., Writing: S.Ç., M.O.A., O.Ö.

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

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IS SPINAL GUNSHOT WOUND SURGERY REALLY NECESSARY?

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ABSTRACT

Objective: The most common causes of spinal injuries are traffic accidents and falls. The third most common cause is spinal gunshot wounds (spinal GSWs). Moreover, the treatment of spinal GSWs remains controversial. The aim of this study was to evaluate the results of treatment options and determine the best treatment for spinal GSWs.

Materials and Methods: A total of 33 spinal GSW patients treated at our institution between January 2014 and December 2019 were retrospectively assessed. Epidemiological and medical information, including age, sex, sign, the form of operation, initial examination, follow-up evaluation, and imaging data, was gathered in individuals who had neurological deficits.

Results: There were 24 males and 9 females (mean age, 31.5 years at the time of injury). The mean hospital length of stay was 14.3 days (range, 1-85 days). The mean follow-up time was 8.2 months (range, 0-13 months). Of these injuries, 27 caused neurological deficits. A total of 17 (51.5%) patients underwent spinal operations, and 16 (48.5%) had conservative management. Six (18%) patients needed intervention for spinal instability. The neurological conditions of 10 patients worsened during the follow-up period. Five patients did not show improvement in their recent neurological condition ($p>0.05$). Two patients had better outcomes during the follow-up. The surgical intervention did not significantly improve outcomes relative to those of conservative management ($p>0.05$).

Conclusion: There is an ongoing need for more extensively studied protocols specific to spinal GSWs to further improve treatment decisions and the standard of care.

Keywords: Gunshot, wound, spinal injury, surgery

INTRODUCTION

Spinal gunshot wounds (spinal GSWs) are the most frequent cause of spinal injuries after traffic accidents and falls[1] and are usually stable injuries that cause neurological deficits. Unfortunately, neurological status rarely recovers[2]. Spinal GSWs mostly occur in military battles, such as those in the Syrian civil war. Of the patients brought to our clinic for spinal GSWs, 91.1% were from the Syrian civil war.

In spinal GSW cases, the spinal cord, spinal column, and nerve roots can be injured directly or indirectly from projectiles. Bone and disc fragmentation caused by the direct impact of bullets, fragments, or pellets can, in turn, cause neurological injuries, and other indirect injuries can be caused by pressure and thermal injury. Even in radiologically normal individuals, the function may be permanently lost because of damage to the delicate cord. Following the initial damage, the neurological status may be worsened by blood flow into the spinal canal, neurological shock, hypotension (due to blood loss), and compression of the spinal cord due to foreign bodies, disc fragments, and bone fragments[3-6].

Some patients with spinal GSWs require surgical evaluation for many reasons, such as rapid neurological deterioration, radiographic evidence of spinal cord or nerve root compression, mechanical instability, cerebrospinal fluid (CSF) leakage, and infection[7-10]. Many studies have published reports on spinal GSWs that describe treatments and outcomes of spinal GSW[11-14]. Despite many studies on this topic, consensus on treatment has not been reached.

The study aimed to evaluate the results of treatment options and determine the best treatment for spinal GSWs.

MATERIALS AND METHODS

This was a retrospective study with a cohort consisting of patients ⩾18 years old admitted to a hospital clinic with spinal GSWs that had been treated between January 2014 and December 2019. Patients with spinal GSW with intracranial injuries were excluded from this study.

The medical information, including age, sex, sign, the form of operation, initial examination, follow-up evaluation, and imaging data, of 33 patients who had neurological deficits was reviewed. The Frankel grading system was used to determine the neurological status.

All patients had undergone X-ray and computed tomographic imaging at admission to specify the exact level of trauma. Each patient had been examined by a neurological surgeon.

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Routinely, the patients were administered a wide spectrum of antibiotics for ⩾7 days unless there was no evidence of another infection. Tetanus prophylaxis was routinely administered. No steroids were given to the patients because of recent research showing that steroid usage after spinal GSW provided no significant benefits[15].

The patients underwent surgical treatment for specific reasons, such as progression in neurological deficit, infection, and CSF leakage, either combined or individually with spinal instability. Our study was approved by the University of Health Sciences Turkey, Adana City Training and Research Hospital Clinical Research Ethics Committee (approval date: 30/05/2022, approval no: 1950). Written informed consent was obtained from all participants.

Statistical Analysis

The paired-sample t-test was used to compare the findings both before and after treatment. Pearson's chi-square, likelihood chi-square (for the tables when expected values in cells were less than 5), and Fisher's Exact tests were used to assess qualitative variables. A p-value <0.05 was considered statistically significant. Statistical analyses in SPSS 22.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 33 patients were enrolled in the study; 24 males and 9 females; the mean age, was 31.5±8.7 at the time of injury. The mean hospital length of stay was 14.3±12.2 days (range, 1-85 days). The mean patient follow-up was 8.2±2.4 months (range, 0-13 months). A summary of the patient's characteristics and treatment outcomes is presented in Table 1.

The levels of injuries were as follows: cervical (C1-C7), 7 (22%) patients; cervicothoracic (C7-T1), 2 (6%) patients; thoracic (T1-T10), 10 (31%) patients; thoracolumbar (T11-LI), 8 (25%) patients; lumbar (L1-L5), 6 (16%) patients; and multiple vertebral injury levels, 10 (30.3%) patients (Figure 1).

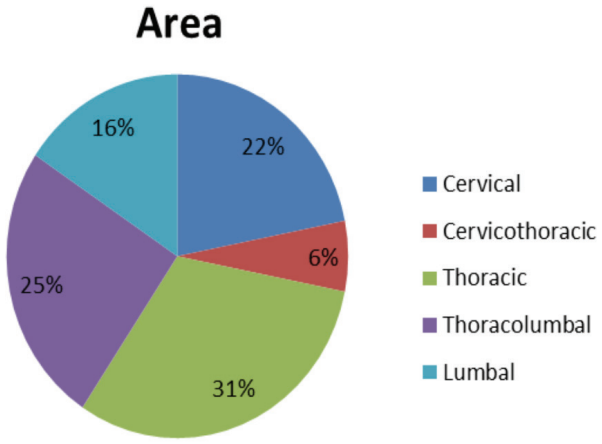


Figure 1. The areas of spinal injuries

According to the Frankel grading system, 30% of the patients had complete (Frankel A), and 70% had incomplete neurological damage (Frankel B, C, and D). No Frankel A patients showed neurological recovery. Neurological deficits were present in 82% of the patients, and 18% had no neurological deficit.

A total of 17 (51.5%) patients underwent spinal surgery, and 16 (48.5%) patients had conservative management. Six (18%) patients required intervention for spinal instability. In the case of conservative management, the patients were fitted with cervical collars, thoracolumbosacral orthoses, and halo vests. (Figures 2a-c). Because of CSF leakage, 2 of the 17 surgical fusion patients underwent additional surgery. Eight patients required surgery for CSF fistula repairment or late infection treatment. During conservative management, the neurological condition of four patients worsened during follow-up (p=0.2). Although surgery had been performed, the neurological condition of 10 patients had worsened during the follow-up period. The neurological situation did not improve in five patients (p>0.05). Two patients had better outcomes during the follow-up. The surgical intervention did not significantly improve outcomes relative to those of conservative management (p>0.05) (Figures 3a-d).

The organ injury rate of 28% is shown in the thoracic or abdominal region. During the study, 8 patients died, and 6 of them died from visceral injuries. The risk of complications or deaths was significantly associated with initial neurological injury; patients with more visceral injuries had a higher rate of complications (p=0.001). None of the patients experienced symptoms of copper or lead poisoning from bullet fragments or new neurological complications caused by intraspinal bullet fragment migration.

DISCUSSION

Management of acute spinal GSW is complicated. The recommended conservative theory supports a nonsurgical approach with careful measures involving pain management and rehabilitation[16]. Additionally, others have recommended surgical intervention with the expectation of rapid improvement in neurological symptoms. Reported cases have involved 20% cervical, 50% thoracic, and 30% lumbar injuries. Although the most lethal damage occurs in the cervical region[5,6], most injuries occur in the thoracic region. In our study, we found results consistent with the literature.

Reported spinal injuries with large vascular or visceral injury rates have been in the range of 21% to 64%. Moreover, surgery or conservative management may not significantly affect the length of hospital stay or complication rate. However, the surgery decision depends on some variables: neurologic status, spinal stability, CSF leak, and injury level along with some others. In our study, 8 patients were operated on for CSF fistula repair or because of infection. Antibiotheraphy and immobilization were provided to accelerate fistula healing after the operation. Therefore, the length of stay of

the patients was prolonged. While the mean hospital stay was 14.3±12.2 days, the mean hospital stay was 36±11.6 in 8 patients.

The internal organ injury rate is especially high in the thoracic and lumbar regions. These internal organ injuries increase the mortality rate of patients[3,9]. The indications for surgery imply that this treatment group may have more severe injuries, which could influence the outcome. In our study, the most commonly injured region was the thoracic at 30%, followed by the thoracolumbar (24%) and cervical (21%) regions. The thoracic or abdominal organ injury rate was 28%.

Sidhu et al.[2] reported that they found no difference in the improvement between patients treated with and without surgery. Surgical treatment of spinal GSWs has failed to improve neurological outcomes relative to those of nonsurgical treatment and is associated with higher complication rates. Aarabi et al.[17] gathered 185 spinal GSW patients and decompressed 101 of those patients, but they found no difference in neurological recovery between the patients treated with and without surgery. Kahraman et al.[9] reported an analysis of 106 patients, with 60% having undergone surgery. They reported similar results between the surgical and conservative groups. In contrast, some studies have reported surgical benefits in patients with

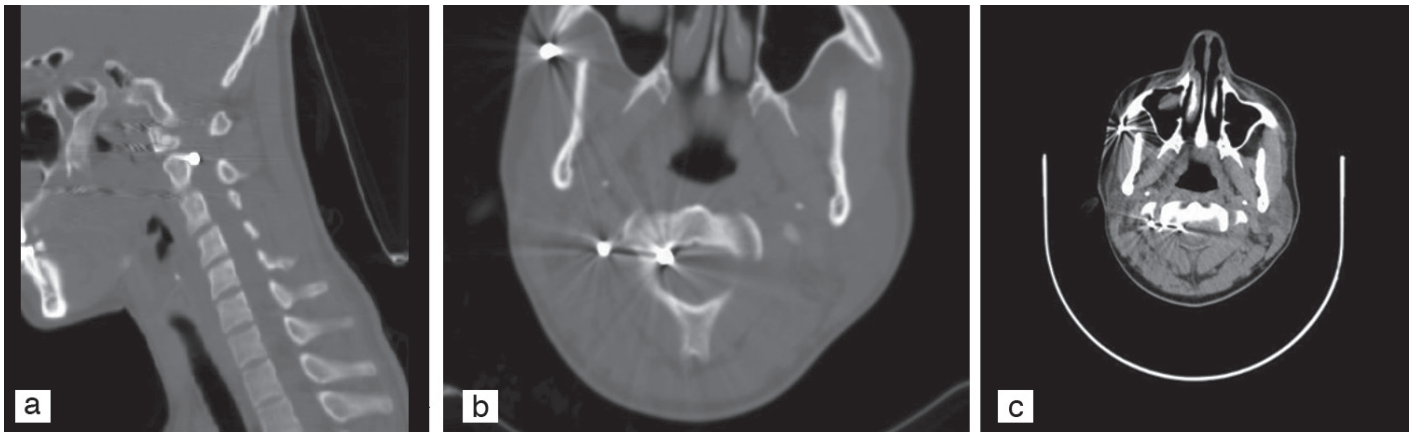
Table 1. Patient summary

Patient	Age/sex	Area	Frankel grade	Treatment	Visceral damage	Complication	Mortality	Control
1	18/M	C	D	Conservative				Same
2	26/M	C	B	Surgery				Worse (A)
3	22/M	C	A	Conservative	+	Infection	+	EXITUS
4	31/M	C	A	Surgery		Infection		Same
5	32/F	C	B	Surgery				Better (C)
6	36/M	C	C	Surgery		CSF		Worse (B)
7	29/F	C	D	Conservative				Same
8	31/M	CT	A	Conservative	+		+	EXITUS
9	22/F	CT	A	Surgery		Infection + CSF	+	EXITUS
10	29/M	T	E	Conservative	+			Same
11	22/M	T	C	Conservative				Better (D)
12	27/M	T	C	Surgery		Infection + CSF		Worse (B)
13	39/M	T	A	Surgery	+			Same
14	29/M	T	D	Conservative				Better (E)
15	50/F	T	B	Surgery				Same
16	43/M	T	A	Surgery	+	CSF	+	EXITUS
17	28/M	T	E	Conservative				Same
18	25/M	T	C	Conservative				Better (D)
19	30/F	T	A	Surgery	+			Same
20	27/M	TL	D	Surgery		CSF		Worse (B)
21	43/M	TL	C	Surgery				Same
22	33/M	TL	B	Conservative		Infection		Worse (A)
23	21/M	TL	E	Conservative				Same
24	25/M	TL	C	Surgery	+	Infection + CSF	+	EXITUS
25	32/F	TL	A	Conservative				Same
26	43/F	TL	B	Surgery				Better (C)
27	39/M	TL	E	Conservative				Same
28	35/M	L	C	Surgery		CSF	+	EXITUS
29	53/M	L	A	Surgery	+	Infection + CSF	+	EXITUS
30	38/F	L	E	Conservative				Same
31	41/F	L	E	Conservative				Same
32	19/M	L	B	Surgery				Worse (A)
33	24/M	L	A	Conservative	+		+	EXITUS

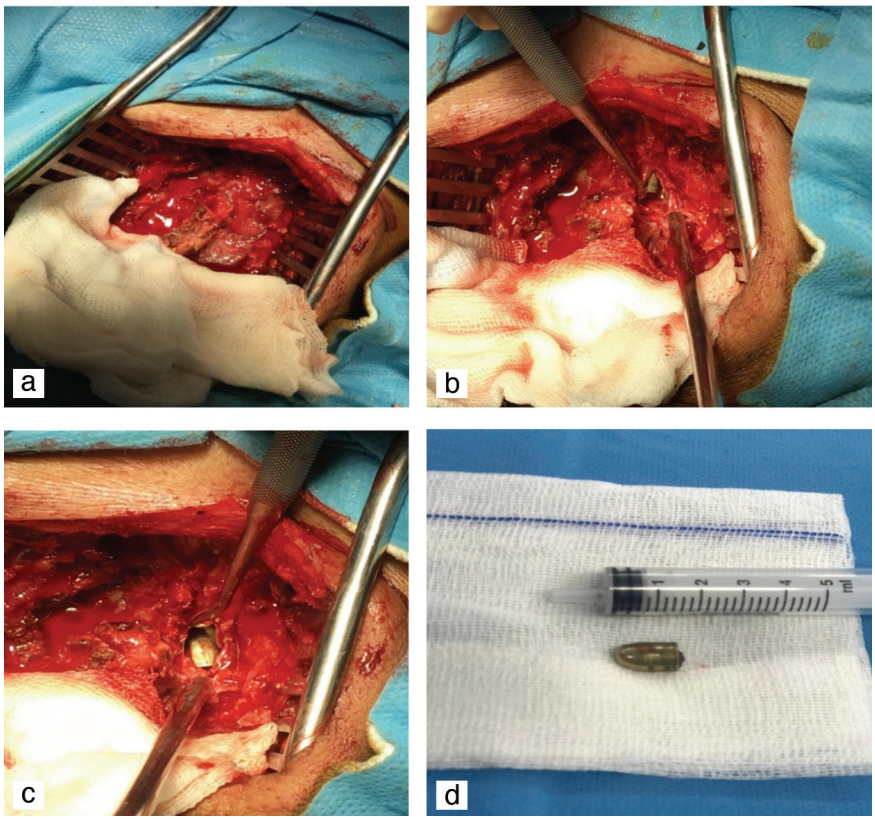
C: Cervical, CT: Cervicothoracic, T: Thoracic, TL: Thoracolumbal, L: Lumbal, CSF: Cerebrospinal fluid leak

progressive neurological deficits and incomplete cord injuries or cord compression[18]. Waters and Adkins [19] 90 patients with intracanal bullet fragments, and 32 of those patients had been treated with decompression surgery. They found that the neurological benefit of surgical decompression was significantly important only for injuries between the T12 and L4 levels, which suggested that decompression of the conus medullaris and cauda equina areas may have some benefit. In our intervention or neurosurgical consultation. This data was consistent with those in other modern large series reports[11] study, 18% of the patients presented without neurological deficits and did not require.

Lead toxicity (plumbism) related to GSWs has been reported[20]. However, the incidence of lead toxicity is very rare. Scuderi et al.[21] reviewed 238 spinal gunshot injuries that occurred over 24 years. They found 12 cases involving patients with bullets in disc spaces during that period. However, clinical signs of lead toxicity only developed in one of these 12 patients. They advised that it was more important to monitor for lead toxicity after injury instead of immediately removing the bullet. In



Figures 2a-c. The cervical spine shows a retained bullet in the cervical intradural space. Figures 2a, 2b, and 2c are images of the same patient. Left hemiparesis was observed. Patients had conservative management



Figures 3a-d. Perioperative same patient images of the cervical spine showing a bullet. The patient's neurological status worsened. Painful stimuli elicited purposeful movements of the right arm and leg. Further, examination revealed left hemiplegia. Therefore, we decided to remove the migrating bullet after the patient's neurological status improved.

our study, none of the patients experienced symptoms of lead toxicity. The short study period may be the reason why lead toxicity was not detected.

Moreover, in the management of spinal GSW patients, transvisceral injuries should be carefully examined because of possible infection of the spine. Kumar et al.[22] followed up with 31 patients treated with antibiotics for 2 to 43 days. Thirteen of these 31 patients had transcolonic injuries. None of those cases developed vertebral osteitis.

Kihtir et al.[23] studied 21 patients with transperitoneal gunshot injuries, five of whom had transcolonic injuries. There were no vertebral infections. Roffi et al.[24] studied 42 patients with 51 visceral perforations. Including 14 colonic and 15 small-bowel injuries. They used antibiotic treatment and reported three spinal infections. Additionally, that study concluded that early bullet removal did not seem to be helpful. This study illustrated the importance of conservative treatment of the spine and support our study.

Zipnick et al.[25] reported that neurogenic shock is so rare in patients with spinal GSWs secondary to GSWs and that neurogenic shock is less common after GSWs than after spinal GSWs by blunt traumas. This rarity is probably because the mechanism and clinical behavior of spinal GSWs secondary to GSWs are different from those of blunt trauma. In our study, none of the patients experienced symptoms of neurogenic shock. But the mechanisms of these two injury types should be elucidated to determine the most appropriate treatment for each.

One further major finding in our study was that patients treated with surgery had higher rates of complications (29% infection, 47% CSF leak). These results were similar to those found in three previous studies[15,17,26]. However, in the case of radiographic evidence of compression in the spinal cord, surgery should be an option.

Study Limitations

A limitation of the current study was that it was conducted at a single center and limited to the low number of patients. Therefore, all patients at follow-up do not allow for an exact analysis of those responses. Our conclusions would need to be confirmed by a larger prospective randomized controlled study.

CONCLUSION

In this study, we found that surgical intervention did not significantly improve neurological deficits after spinal GSW. We believe that surgical intervention may have some neurological benefits in patients with progressive incomplete lesions and radiographic evidence of compression. However, a consideration is that complication rates were greater in the operated patients.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, Adana City Training and Research Hospital Clinical Research Ethics Committee (approval date: 30/05/2022, approval no: 1950).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: C.S., M.U., Concept: C.S., M.U., Design: M.U., Data Collection or Processing: C.S., M.U., Analysis or Interpretation: C.S., M.U., Literature Search: C.S., M.U., Writing: C.S.

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

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CASE REPORT
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INTRADURAL DISC HERNIATION MIMICKING A SPINAL TUMOR, CASE PRESENTATION AND REVIEW OF THE LITERATURE

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ABSTRACT

Intradural disc herniation is rare. In elderly patients, particularly in cases with degeneration, as well as in cases with congenital or acquired anterior dural adhesion. 90% of them are located at the lumbar L4/5 level.

Lumbar intradural disc herniation was first reported in 1942 and to our current knowledge, 123 cases have been reported to date. We have reported an elderly patient with lumbar intradural disc herniation, as well as reviewed the literature order to explain its potential pathogenesis, natural course, differential diagnosis and treatment.

Keywords: Lumbar adhesion, intradural disc, the posterior longitudinal ligament, annulus fibrosus, intradural disc herniation

INTRODUCTION

Rupture of intervertebral disc (IVD) material into the intradural space is known to be rare[1,2]. Intradural disc herniation (IDDH) occurs in 0.04% of all IVD cases, whereas 90% of them are located at the lumbar (L4/5) level[1,3]. The extruded material of nucleus pulposus (NP) may be herniated bellow the degenerated annulus fibrosus (AF), the posterior longitudinal ligament (PLL) or the anterior wall of the dura, and may migrate intrathecally[2,4]. Dandy reported two cases of cauda equina syndrome due to chordoma in 1929. Barr definitely demonstrated that these chordomas were fragments of degenerated disc in 1934 [2,5-7]. Lumbar IDDH was first reported at 1942 and to our current knowledge, 123 cases are reported until today[8]. Lumbar IDDH may cause signs and symtoms similar to transverse lesion of the cauda equina and can be mistaken as an intraspinal neoplasm[1,6,8]. We have presented an elderly patient with lumbar IDDH, as well as reviewed the literature in order to explain its potential pathogenesis, natural course, differential diagnosis and treatment[1].

CASE REPORT

Seventy six years old male patient has been admitted to our clinic with lumboischialgia in L5 dermatome at 2020. Left leg knee extension and ankle dorsiflexion was found to be weak. Lumbar magnetic resonance imaging (MRI) scan revealed spinal stenosis at the level of L3/4, L4/5 and extruded IVD at the L4/5 level. We performed decompression of both levels and nucleotomy at L4/5 level. Weakness has resolved and the patient has been discharged from the hospital on the 5th postoperative day. At the one month follow up examination, there were no neurological deficits. Pathological examination revealed a degenerated yellow-white cartilage tissue of elastic consistence. He has been re-admitted to our clinic in 18/02/2022 again with ischialgia in L5 dermatom, as well as hypesthesia and ankle dorsiflexion weakness of his left foot. Lumbar MRI scan revealed inferiorly migrating extruded disc fragment at the L4/5 level (Figure 1).

We extended the hemilaminectomy using the old postoperative incision scar, cleared epidural scar tissue and performed re-nucleotomy at L4/5 level. Intraoperative removed disc material and MRI scans were inconsistent.

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Expected big, free disc sequester was not found. Level was checked again with flouroscopy and ultrasonography (USG) was performed, where both were found to be normal. Nevertheless complaints of the patient receded rapidly during the postoperative period and he has been discharged on the 5th postoperative day. Patological examination of removed material revealed degenerated hyalinised fibrocartilage tissue.

On the 7th postoperative day the patient came again with incontinence and weakness of his left leg. We have considered that the reason might be an IDDH. Contrast enhanced lumbar MRI scan has been performed and revealed extruded fragment with dimensions of 24x18x14 mm, at the same level and was reported as peripherally contrast enhanced intradural mass (Figure 2). We performed surgery to remove the mass. Intraoperatively it was adherent to the

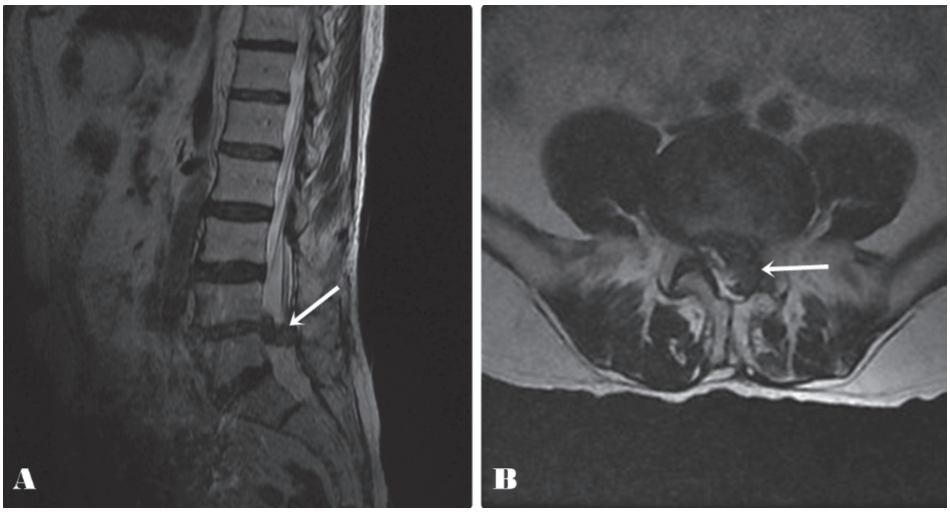

Figure 1. Inferiorly migrated disc in MRI scans
MRI: Magnetic resonance imaging

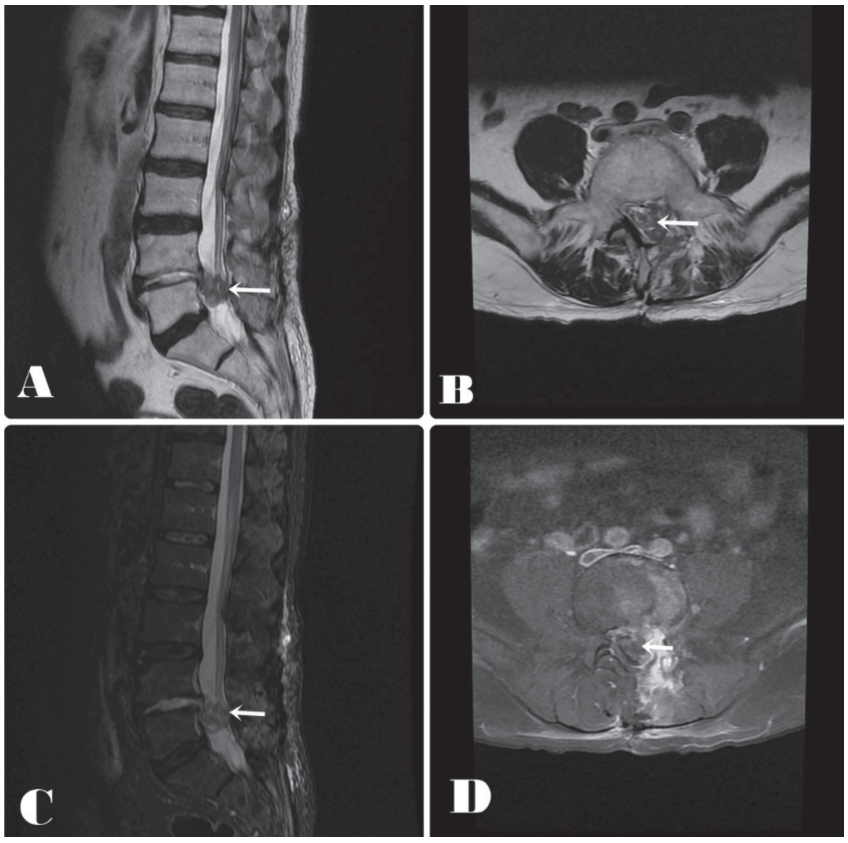

Figure 2. MRI scans showing contrast enhanced mass
MRI: Magnetic resonance imaging

adjacent nerve roots and vessels. We could remove the mass totally. A dural defect or postoperativer Lymphleckagen (PLL) tear was not detected (Figure 3). Patients complaints receded postoperatively and he was discharged on the 7th postoperative day. Pathological examination revealed a yellow beige colored cartilage tissue with degeneration, necrosis and elastic consistence. Signs of neoplasm were not observed.

DISCUSSION

Lumbal IDDH is a very rare phenomenon of a degenerative lumbar lesion in the elderly population[1].

IVD consists of shock absorbing semifluid, very elastic chorda dorsalis remnant, strong AF rich in collagene at the outer part, as well as an end plate at the adjecent vertebral body[9,10]. At the most outer part PLL is attached from C2 level up to the sacrum along the posterior aspect of the vertebral bodies[11-13]. Stability of the vertebras depend on its static and dynamic structure[12]. 55-70% of longitudinal and tortional forces on the vertebra reach to the disc, whereas 30-45% reach to the facet. The direction of these forces can be changed and can expand all to the transverse surface[10]. PLL restricts flexion, posterior herniation of the disc and transform the forces to different sides[10,12,13]. However with age, degeneration occurs and these tasks can not be performed[5,9,10].

The PLL is strongest in the midline[10]: Therefore lumbar disc herniation occur mostly at one side. A herniated disc fragment will rarely be centraly extruded, mostly herniation can be localized subligamentous, transligamentous or retroligamentous[1,5]. Migrated fragment as a term is used for a disc, settled in another area apart from intervertebral space[2,14]. Pathogenesis and natural course of IDDH is still unclear[1]. The formation of this phenomenon depends on extruded fragment of NP, and tear of AF, PLL and anterior spinal dura mater[8,15,16].

Gelatinous structure of NP transforms into fibrous cartilage, whereas water consistence reduces from 90% to 70%[5]. Also vessels at the central area of IVD obliterate and ossify with age[10]. Adhesion occurs between AF, PLL and dura[1,4]. This adhesion and degenerative changes progress with increase in age[4,9,10]. Therefore the force coming here can not be transferred to enviromental tissue and is delivered to dura mater[12]. Reduced elasticity and flexibility in this area may result with tear of dura mater[10,12,15]. In elder population spontaneous adhesions between AF, PLL and ventral spinal dura prevent lateral migration of disc fragment and facilitate penetration of the tethered

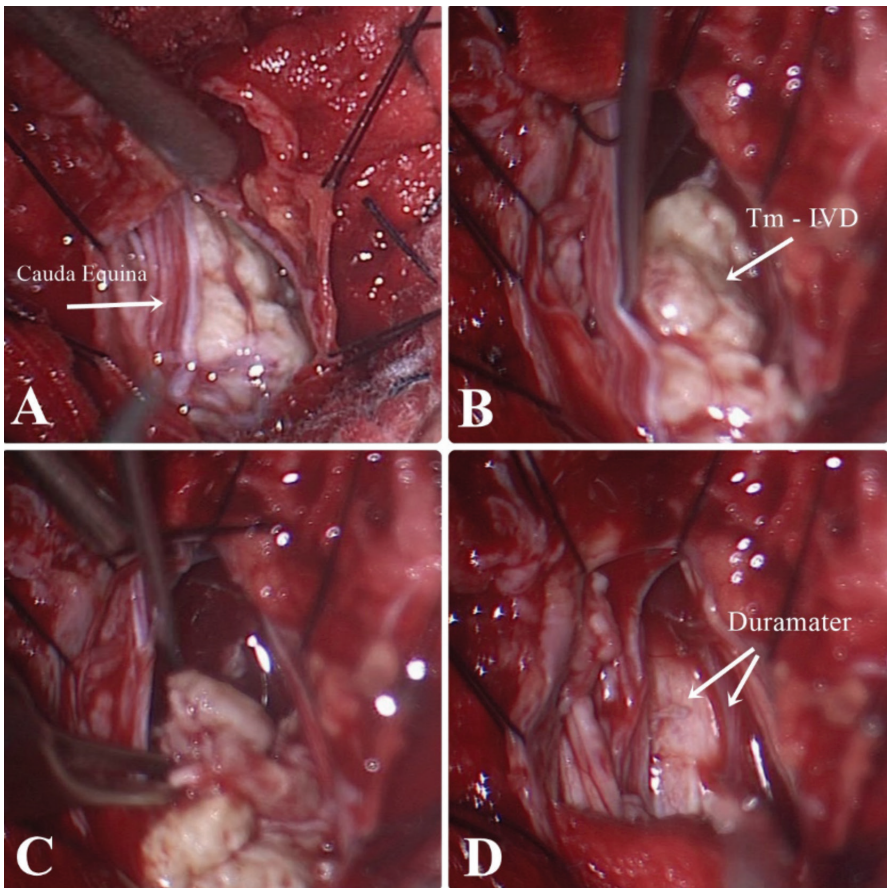

Figure 3. Intraoperative images of intradural disc herniation
IVD: Intervertebral disc

dura[4,5,8,13]. This adhesion becomes weaker and may also ocur following repeated minor trauma, prior to surgery, chronic inflammation, osteopathies, degenerated herniated NP (HNP), acute or chronic compression[8,16-18]. Penning and Wilmink[3] demonstrated weakness and tear at this area by myelography, Hodge et al.[19] showed it by metrizamide enhancement computed tomography (CT). Sharma et al.[16] believed that when the spine sudenly bears external force when patient sneezed, pressure in the IVD increases sharply and cause IDDH. Lee and Fairholm[15] stated that processes like osteophytes and extruded IVD cause long-term mechanic compression and result with thinner and fragile dura mater, facilitating penetration of the dural sac. Dura mater and PLL are close at the L4/5 level respectfully and IDDH is most frequently involved at this level[1,16]. Extreme strain occur at this level by flexion and extension[6]. Rathod et al.[8] observed congenital narrowing of the spinal canal with less epidural space and congenital adhesion between PLL and dura mater in 8 of 40 cadaver. Blikra[4] demonstrated firm anatomic adhesion between anterior dural wall and PLL at level L4/5.

All of these processes were present in our case in addition to deep curetage of PLL in order to remove the fragments at the middle part and to prevent recidive disc which may contribute to dural tear and penetration of the fragment. CT scans were shown to be insufficient in demonstrating IDDH[1,16], whereas contrast-enhanced MRI scans can show sequestered fragment, intradural extension and lateral restenosis[8].

Contrast enhacement MRI scans are crucial for both diagnosis and differentiation of a HNP from disc space infection and tumor[2,6,7,19]. Hodge et al.[19] demonstrated IDDH rupture at the preoperative period by metrizamide enhancement spinal CT scanning. Still it is difficult to make an exact diagnosis. Wasserstrom et al.[7] reported that IDDH mimics an intra dural tumor.

We operated on our case 2 years ago with diagnosis of left subligamentous disc herniation of the L4/5 level and spinal stenosis of the L3/4 level. Two years later, numbness and weakness started at the left leg. MRI scan revealed a disc fragment extruding to the left of L4/5 level, as well as spinal stenosis. We have extended the left laminectomy and cleared the space, however the removed disc material and the preoperative MRI was incompatible[1,8]. Intraoperative palpation of dura through laminectomy defect did not reveal rigidity. We did not detect pathology of the USG in this area[1]. His complaints receded postoperatively but we were already in doubt about the presence of IDDH. Although, jugular vein compression test (Naffziger test) was positive[6]. Because of the patients persistence, on the 5th postoperative day he has been discharged. Rathod et al.[8] reported that while treating lumbar disc disease, the possiblity of an IDDH should be kept in mind, especially because it is mostly diagnosed intraoperatively as a surprise.

Ge et al.[1] states that after the observation of an intraoperative disc fragment, if additional fragment can not be detected at the epidural area and if the observed material is not in accordance with preoperative MRI, PLL rupture, ventral dura tear and IDDH should be considered[6,8]. The patient underwent contrast enhancement MRI scan on the 7th postoperative day because of weakness of the left leg and urinary incontinence. Radiologists reported that separated epidural fragment was still at the same area but was found to be smaller. We discussed that there was no mass detected at the epidural space intraoperatively, and that it could only be an intradural mass. Therefore after revaluation of MRI scans, intradural mass was reported at the L4/5 level (Figure 2).

We opened the dura and completely removed the yellow white, fragile, bleeding, mass resembling macerated dermoid tumor which was pushed towards the right side, and attached to the nerve root, as well as the vascular structures. We did not detect a tear at the anterior wall of dura. Pathological findings revealed cartilage tissue with degenerative and necrotic tissue. No signs of malignancy were found. Wasserstrom et al.[7] also reported that his case resembled intradural tumor. Ge et al.[1] detected ruptured PLL and old tear of the ventral dura, a mass similar to NP tissue in his case with IDDH. We did not detect a tear. IDDH can enhance contrast because it is surrounded by vascular tissue rich in blood vessels, which is considered to be the most specific. Furthermore appearance of macrophage infilitration may mislead us[1,8,20].

As a result, in elderly patients with degeneration, if contrast enhanced MRI is not compatible with intraoperative findings, IDDH should be considered, even though it might not be detected by palpation or USG.

Ethics

Informed Consent: Oral informed consent from a patient, to conduct a research.

Peer-review: Externally peer-reviewed.

Authorship Contributions

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

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

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