GEORGIAN MEDICAL NEWS

ISSN 1512-0112

NO 6 (363) Июнь 2025

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper formats of the Agency of Medical Information of the Georgian Association of Business Press. Published since 1994. Distributed in NIS, EU and USA.

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

GEORGIAN MEDICAL NEWS
No 6 (363) 2025

Содержание:

SPINAL CANAL SIZE IMPROVEMENT AFTER XLIF FOR LUMBAR SPINAL STENOSIS

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Abstract.

Background: To evaluate imaging outcomes of XLIF surgery for lumbar spinal stenosis

Methods: This is a cross-sectional descriptive study. There were 33 patients with 36 segments of surgery diagnosed with lumbar spinal stenosis that were surgically treated with the XLIF method. Clinical outcomes measured included VAS scores for lower back pain and leg pain, ODI, and JOA scores. Magnetic resonance imaging of the lumbar spine after surgery was used to evaluate indirect decompression. Differences were determined by independent T-test.

Results: There were 33 patients with 36 segments of surgery. They were 14 males and 19 females with an average age of 59.2±8.01. There was significant improvement in VAS for lower back pain from 7.21±1,73 to 3.15±1.70, VAS for leg pain from 6.88±2.07 to 1.18±1.76, ODI from 27.45±8.48 to 14.48±9.05, and JOA score from 7.24±2.94 to 13.91±1.94. A-P diameter increased 124% and 131%, lateral diameter increased 118% and 129%, lateral recess depth increased 168% and 181%, disc height increased 125% and 129%, foraminal height increased 118% and 117%, spinal canal area increased 125% and 141% after surgery and the last examination (respectively), segmental lordosis increased from 3.29±4.48° to 8.17±3.27°, lumbar lordosis increased from 26.69±14.66° to 34.41±12.45°. The average hospital stay was 5,88±2,9 days.

Conclusion: XLIF surgery presents a favorable option for patients with lumbar spinal stenosis. Spinal canal area improved clearly after surgery in MRI.

Key words. Clinical, imaging, lumbar stenosis, lateral approach surgery, percutaneous screws.

Abbreviations.

XLIF: eXtreme Lateral Interbody Fusion
VAS: Visual Analogue Score
ODI: Oswestry Disability Index
JOA: Japanese Orthopedic Association
MRI: Magnetic Resonance Imaging

Introduction.

Lumbar interbody fusion (LIF) has been recognized as an effective method for patients with refractory low back pain due to a variety of degenerative lumbar spinal disorders, including lumbar stenosis diseases and spondylolisthesis [1].

Extreme lateral interbody fusion (XLIF) surgery is defined as minimally invasive lateral, retroperitoneal surgery to the anterior spinal column with reduced injury to muscles and adjacent structures by manual dissection of the retroperitoneal space. We conducted initial guidance of the psoas muscle to the surface of the psoas muscle, use of the intraoperative neurophysiology monitoring when passing through the psoas muscle, extension of the retraction system and direct observation of the surgical field, placement of a large interbody instrument to open maximum intervertebral and orthopedic space expansion. XLIF is indirect decompression surgery and thus restoring disc, spinal canal size and foraminal height resulting in symptomatic relief is its main advantage over more invasive decompression and interbody fusion surgeries. Indeed, XLIF surgery can reduce post-operative pain, entry wounds, tissue trauma, operating, recovery and mobility times resulting in shorter hospital stays.

We conducted research on the topic " Spinal canal size improvement after XLIF for lumbar spinal stenosis" with the aim of: Comparing spinal canal size pre-operation and post-operation after XLIF for lumbar stenosis.

Methods.

Patient selection:

Our study recruited 33 patients with 36 segments surgery who were treated with the XLIF method from 2019 to April 2024. Ethical approval was received from the institution's review board (IRB approval number 853/GCN-HĐĐĐNCYSH-ĐHYHN)

The indications for XLIF include patients with lumbar spinal stenosis, except for patients with paralysis or severe leg pain at rest, the absence of a free disc fragment on MRI, bony lateral recess, deformities of both lower extremities, diseases that greatly affect diagnosis (spinal tuberculosis, spinal arachnoiditis, etc.), or patients were previously performed lumbar spinal surgery or patients with no clinical manifestations or enable to follow-up post-surgery.

Research Methods:

We conducted a cross-sectional descriptive study during the mentioned period time. The demographic and clinical data were retrieved from medical chart reviews. Clinical presentations and imaging investigation were collected before, during and after surgery.

During the operation, we collected several indexes including intraoperative monitoring of surgery time, and amount of blood loss. Treatment outcomes were evaluated after surgery, the last examination from 1 month to 6 months after the surgery. The outcome measures included the VAS for lower leg pain and back pain, the ODI for disability, and the JOA scores for functional recovery after 1 month. All patients had plain anteroposterior (AP) and lateral x-rays, dynamic flexion-extension lateral x-rays before the surgery and after surgery to evaluate segmental lordosis and lumbar lordosis. Patients had a lumbar spine magnetic resonance imaging study before the surgery, after surgery and the last examination. We measure

the anterior and posterior diameter of the spinal canal, lateral diameter, lateral recess depth, spinal canal area, disc height, foraminal height pre-operation and post-operation on PACS software [2].

Paired T-tests were used to compare the continuous variables between groups. Chi-square test was used to compare categorical variables between groups. A p-value of < 0.05 was considered statistically significant. The data was processed using SPSS 20.0 software.

Results.

This study included 14 males and 19 females with an average age of 59.2 years (range 36–74 years). These patients received 36 segments of XLIF, including 1-segment fusion in 30 patients, 2-segment fusion in 3 patients. L4–5 was the most frequently involved level, followed by L3–4, and L2–3. The average hospital stay was 5.88 days (range, 3–14 days). No patient required a blood transfusion. After surgery, the VAS for lower back pain had improved from 7,21±1,73 to 3,15±1,70, and VAS for leg pain improved from 6,88±2,07 to 1,18±1,76. After 1 month ODI had improved from 27,45±8,48 to 14,48±9,05. The JOA score had improved from 7,24±2,94 to 13,91±1,94. All these improvements were statistically significant from baseline with p < 0.001. The demographic data and clinical outcomes were summarized in (Tables 1 and 2).

27 segments of surgery underwent MRI after surgery to evaluate the size of the spinal canal (Table 3). In those 27 segments of surgery, the anterior and posterior diameter increased from 7.24±1.91 mm to 8.91±2.58 mm, 124% of pre-operation , the lateral diameter increased from 11.72±3.53 mm to 13.92±4.06 mm, 118% of pre-operation lateral recess depth increased from 1.69±1.32 mm to 2.84±0.99 mm, 168% of pre-operation, spinal canal area increased from 71.95±32.82 mm2 to 90.09±41.62 mm2, 125% of pre-operation, disc height increased from 8.78±2.29 mm to 10.96±2.12 mm, 125% of pre-operation, foraminal height increased from 16.99±3.38 mm to 20.07±2.53 mm, 118% of pre-operation.

Table 1. *Demographic data.*

Variable	Value
Sex	
Male	14 (42.4%)
Female	19 (57.6%)
Age (years)	59.2±8.01
Segments of XLIF 1-segment 2-segment	 30 (90.9%) 3 (9.1%)
Level distribution (n=21) L23 L34 L45	 1 (2.8%) 6 (16.7%) 29 (80.6%)
Blood loss (ml)	43.03±85.34 (10-500)
Time surgery (minutes)	120.91±34.76
Length of hospital stay (days)	5.88±2.9

Values are presented as a number (%) or mean (range).

Table 2. *Summary of clinical outcomes.*

Variable (n=33)	Preoperative	Posoperative	P-value
VAS for back pain	7.21±1.73	3.15±1.70	p<0.001
VAS for leg pain	6.88±2.07	1.18±1.76	p<0.001
ODI	27.45±8.48	14.48±9.05	p<0.001
JOA score	7.24±2.94	13.91±1.94	p<0.001

Values are presented as mean± standard deviation or a number (%) VAS: Visual Analogue Scale; ODI: Oswestry Disability Index; JOA: Japanese Othopedic Association.

Table 3. *Spinal canal area pre-operation and post-operation.*

n=27	Pre-operation	Post-operation	p-value
Anterior-posterior diameter (mm)	7.24±1.91	8.91±2.58	p<0.001
Lateral diameter (mm)	11.72±3.53	13.92±4.06	p<0.001
Spinal canal Area (mm^2)	71.95±32.82	90.09±41.62	p<0.001
Lateral recess depth (mm)	1.69±1.32	2.84±0.99	p<0.001
Disc height (mm)	8.78±2.29	10.96±2.12	p<0.001
Foramen diameter(mm)	16.99±3.38	20.07±2.53	p<0.001

Table 4. *Spinal canal area pre-operation and the last examination.*

n=22	Pre-operation	Post-operation	p-value
Anterior-posterior diameter (mm)	7.48±1.96	9.78±2.41	p<0.001
Lateral diameter (mm)	11.52±3.54	14.81±4.26	p<0.001
Spinal canal Area (mm^2)	73.04±34.05	103.31±44.89	p<0.001
Lateral recess depth (mm)	1.75±1.38	3.16±1.04	p<0.001
Disc height (mm)	8.74±2.42	11.21±3.19	p<0.05
Foramen diameter(mm)	17.12±3.07	19.98±2.58	p<0.001
Segmental lordosis	3.29±4.48	8.17±3.27	p<0.001
Lumbar lordosis	26.69±14.66	34.41±12.45	P <0.05

22 segments of surgery underwent MRI at last examination from 1 month to 6 months after surgery to evaluate the size of the spinal canal (Table 4). In those 22 segments of surgery, the anterior and posterior diameter increased from 7.48±1.96 mm to 9.78±2.41 mm, 131% of pre-operation , the lateral diameter increased from 11.52±3.54 mm to 14.81±4.26 mm, 129% of pre-operation, lateral recess depth increased from 1.75±1.38 mm to 3.16±1.04 mm, 181% of pre-operation, spinal canal area increased from 73.04±34.05 mm2 to 103.31±44.89 mm2, 141% of pre-operation, disc height increased from 8.74±2.42 mm to 11.21±3.19 mm, 129% of pre-operation, foraminal height increased from 17.12±3.07 mm to 19.98±2.58 mm, 117% of pre-operation. Segmental lordosis increased from 3.29±4.48° to 8.17±3.27°. Lumbar lordosis increased from 26.69±14.66° to 34.41±12.45°.

Discussion.

Indirect decompression through eXtreme Lateral Lumbar Interbody Fusion has been shown to achieve similar or better outcomes with regards to pain and disability relief compared to direct approaches [3].

In our research group, there were 33 cases of lumbar spinal stenosis (Table 1). There were 30 cases of 1-segment XLIF surgery, 3 cases of 2-segments XLIF surgery (Table 1). The average surgery time was 120.91±34.76 minutes, the average blood loss was 43.03±85.34 ml, there was 1 case of 500ml blood loss due to damage to the iliac vein. There were no

cases requiring blood transfusion during or after surgery, the average hospital stay was 5.88±2.9 days (Table 1). According to research of Yingsakmongkol et al. [4], the hospital stays of patients undergoing XLIF surgery is shorter than MIS TLIF (XLIF: 3.6±0.62 days, MIS TLIF 4.33±0.61 days). There was 1 segment at L23, 6 segments at L34, 29 segments at L45.

Assessing the VAS score 1 month after surgery, the back VAS score decreased from 7.21±1.73 to 3.15±1.70 after surgery (P<0.001) (Table 2). The leg VAS decreased from 6.88±2.07 to 1.18±1.76 1 month after surgery (p<0.001) (Table 2). Rogers et al. [5] studied XLIF surgery for 63 patients with grade II spondylolisthesis, with an average follow-up period of 12 months. The results showed that the most common surgical level was L4-5 (97%), 84% of patients were female, average age was 66. The majority of patients (71%) had undergone previous lumbar spine surgery. The average amount of blood loss decreased by 1.4g (after surgery compared to before surgery), the average hospital stay was 1.2 days. 2 cases (3.4%) of complications were: 1 case of intestinal obstruction after surgery, 1 case of screw fracture 14 months after a traffic accident. There was no nerve damage or infection. VAS score improved 75% (8.7 to 2.2), disc height increased 96% (4.6mm to 9.0mm), slippage improvement was 11.1mm to 3.6mm. Most patients had complete bone union with an improved Lenke score of 1.1 after 12 months. 89% of patients described being satisfied or very satisfied with the results.

In our research group, 27 segments of surgery underwent MRI after surgery to evaluate the size of the spinal canal. In those 27 segments of surgery, the anterior and posterior diameter increased from 7.24±1.91 mm to 8.91±2.58 mm, 124% of pre-operation , the lateral diameter increased from 11.72±3.53 mm to 13.92±4.06 mm, 118% of pre-operation, lateral recess depth increased from 1.69±1.32 mm to 2.84±0.99 mm, 168% of pre-operation, spinal canal area increased from 71.95±32.82 mm^2 to 90.09±41.62 mm^2, 125% of pre-operation, disc height increased from 8.78±2.29 mm to 10.96±2.12 mm, 125% of pre-operation, foraminal height increased from 16.99±3.38 mm to 20.07±2.53 mm, 118% of pre-operation.

22 segments of surgery underwent MRI at last examination from 1 month to 6 months after surgery to evaluate the size of the spinal canal. In those 22 segments of surgery, the anterior and posterior diameter increased from 7.48±1.96 mm to 9.78±2.41 mm, 131% of pre-operation , the lateral diameter increased from 11.52±3.54 mm to 14.81±4.26 mm, 129% of pre-operation, lateral recess depth increased from 1.75±1.38 mm to 3.16±1.04 mm, 181% of pre-operation, spinal canal area increased from 73.04±34.05 mm^2 to 103.31±44.89 mm^2, 141% of pre-operation, disc height increased from 8.74±2.42 mm to 11.21±3.19 mm, 129% of pre-operation, foraminal height increased from 17.12±3.07 mm to 19.98±2.58 mm, 117% of pre-operation (Figures 1 and 2). Segmental lordosis increased from 3.29±4.48° to 8.17±3.27°. Lumbar lordosis increased from 26.69±14.66° to 34.41±12.45° (Figure 3). In Hiroaki Nakashima's study the thecal sac increased 189% [6]

In the study by Hiyama et al. [7], the mean preoperative disc heights in both groups were similar at baseline (5.3 mm and 7.9 mm for the 2-position group and the 1-position group), with

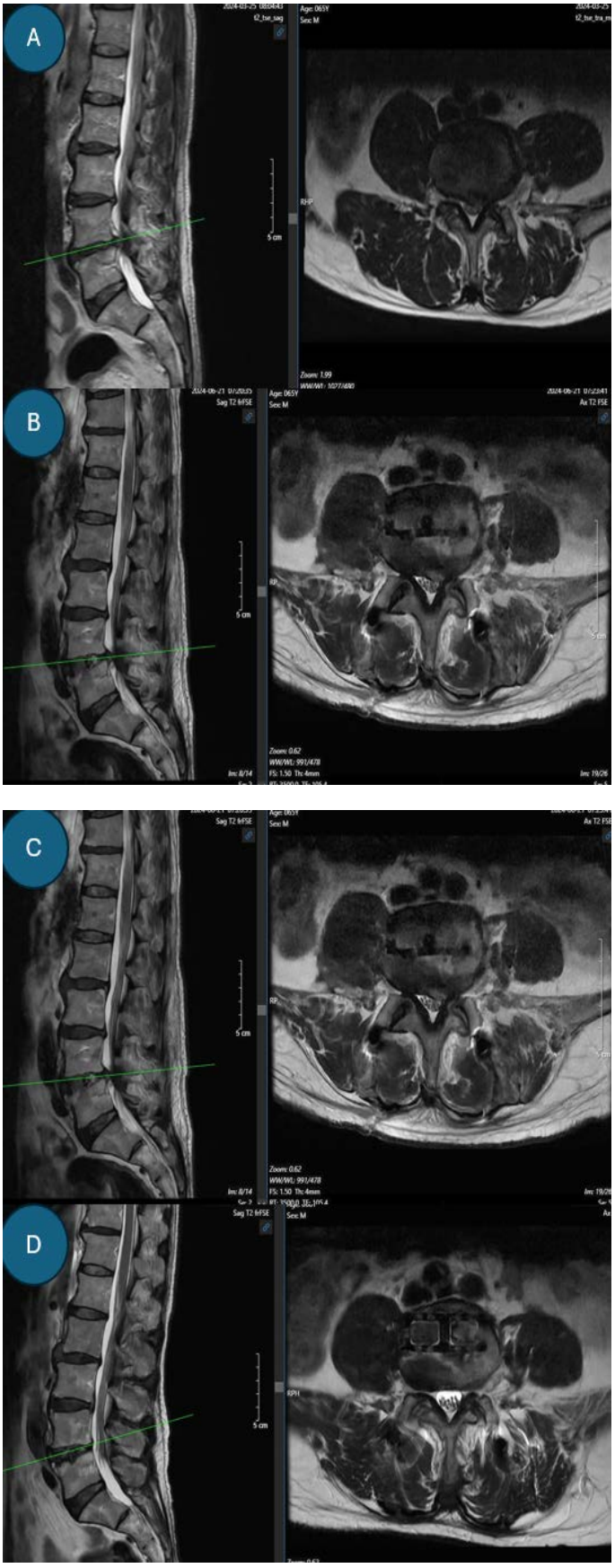

Figure 1. *Change MRI in spinal diameter before (A) and after surgery (B), 1 month after surgery (C), 6 months after surgery (D).*

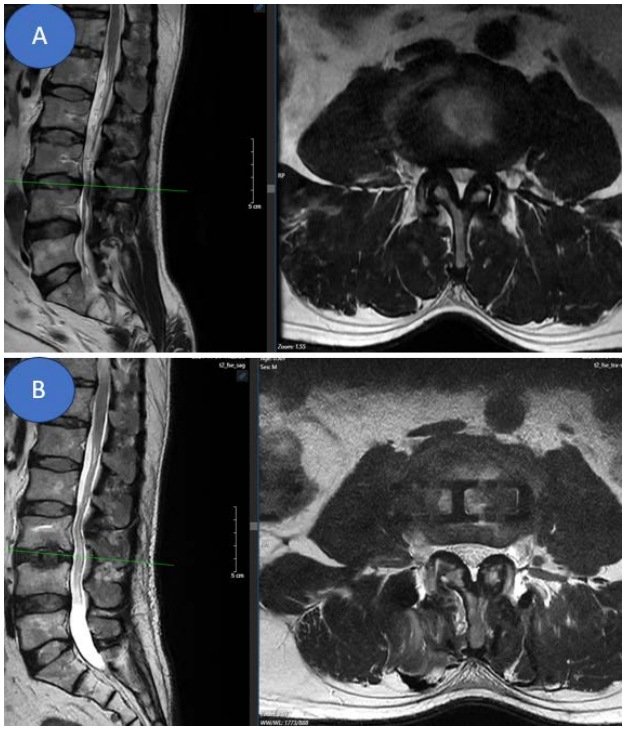

Figure 2. *Change MRI in spinal canal area pre-operation (A) and 1 month after surgery (B).*

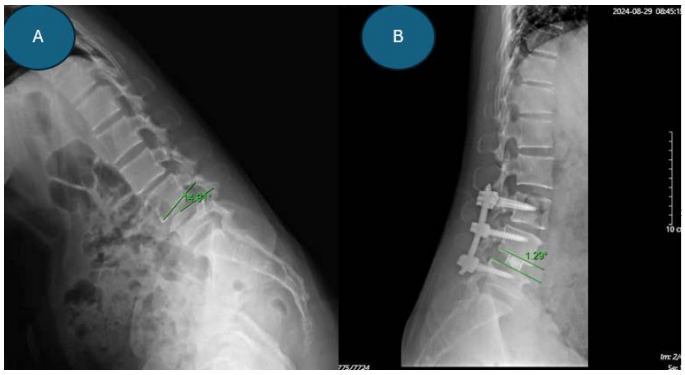

Figure 3. *X ray after surgery to evaluate segmental lordosis pre-operation (A) and post-operation (B).*

a significant adjustment immediately after surgery to 10.0 mm and 11.3 mm, respectively. There was no significant difference in the mean disc heights obtained between the two groups (4.6 mm and 3.5 mm for the 2-position group and the 1-position group).

To assess indirect decompression, the spinal canal area and diameter were measured by MRI. The results showed that the spinal canal area increased significantly after surgery in both groups (2-position group, from 55.3 to 78.4 mm2; 1-position group, from 54.7 to 77.2 mm2). The authors found a mean increase in spinal canal area (21.9 and 22.6 mm2 for the 2-position group and the 1-position group, respectively; p = 0.684), which was 42 and 41% higher than preoperative values, respectively. The central canal diameter also increased from 5.9 mm to 7.9 mm in the 2-position group and from 5.6 mm to 7.7 mm in the 1-position group. Statistically, there was no difference in the rate of improvement in spinal canal area and diameter between the two groups. In the authors' study, central canal size increased significantly in both groups after LLIF, but the change was smaller at 2 weeks after surgery. Previous studies of indirect decompression by LLIF have demonstrated that the increase in disc and foraminal height and the relaxation of ligamentous structures may indirectly decompress neural elements. However, the imaging findings of indirect decompression of central canal stenosis using LLIF are less consistent [8,9]. Oliveira et al demonstrated an increase in mean disc height (42%) and central canal diameter (33%) at 43 lumbar levels [8], and it was reported that the area of the spinal canal gradually expanded over time. Thus, Ohtori et al suggested that spinal stabilization may induce changes in the ligamentum flavum and restore spinal canal size [10]. Furthermore, Elowitz et al also found improvements in clinical outcome scores even in patients with only a slight increase in spinal canal area after LLIF [11]. In support of these data, a recent interesting prospective study reported a steady decrease in ligament thickness and disc bulge over time after fixation, with the cauda equina visible in the majority of cases 2 years after surgery [6]. The need for additional direct decompression after LLIF is a recurring theme [12,13].

In the study by Roger et al. [5] disc height increased by 96% (4.6 mm to 9.0 mm), with an improvement in slippage of 11.1 mm to 3.6 mm.

Kepler et al. [14] analyzed 29 patients with 67 XLIF levels and found a mean increase in posterior disc height of 70% and a mean increase in foraminal height of 35%.

Elowitz et al. [15] reported a study of 25 patients with MRI for 20 XLIF levels, showing an average increase in anteroposterior diameter of 54% and lateral diameter of 48%. In the study of Jun Ti et al. [16], the degree of canal stenosis affected the outcome after indirect decompression surgery. In the authors' study, there were a total of 901 surgical levels from 557 patients. The overall rate of postoperative direct decompression was 29.97%. The overall direct decompression rate was 75.21% for type D central spinal stenosis and 29.74% for type C spinal stenosis. Despite a steady decline in the annual direct decompression rate over the years, the annual direct decompression rate for type D remains very high. Logistic regression analysis showed that type D spinal stenosis was the highest risk factor for indirect decompression (OR = 17.77). The authors concluded that the degree of spinal stenosis grade D is a risk factor for failure of indirect decompression.

Low postoperative disc height, especially less than 10 mm, was found to be associated with failure. This finding is consistent with the study by Park et al. [17], which showed that subjects requiring direct decompression after LLIF had a mean postoperative disc height of 9.4 mm. The degree of postoperative disc height had a positive effect on increasing the foraminal height and relaxing the ligaments that indirectly decompress the nerve.

The degree of disc height reduction, defined as the difference in preoperative disc height between the standing and supine positions, also affected the surgical outcome. Higher disc height achieved in the supine position was associated with successful outcomes. This may be explained by the lower stiffness of the

surgical segment, leading to a larger postoperative disc height and a higher indirect decompression effect. Furthermore, if the surgical segment is too rigid to be restored, the risk of disc graft collapse increases. The authors' results showed that when the disc height restored in the supine position was below 13%, the risk of failure increased significantly.

In Wicharn Yingsakmongkol's study [4], it was shown that in the successful group the disc height increased from 8.08 mm to 12.195 mm, in the failed patient group the disc height increased from 7.47 mm up to 9.39 mm, foraminal height in the success group increased from 17.05 mm to 19.7 mm, in the failed group increased from 16.58 mm to 18 mm.

Loss of lumbar lordosis after lumbar spinal fusion can lead to chronic back pain, sagittal imbalance with forward trunk tilt, and adjacent segment degeneration.

In the study by Kepler et al. [18], the mean preoperative lumbar lordosis was 4.1° at the surgical level compared with 7.8° postoperatively ($P < 0.01$); thus, the mean increase was 3.7° per level. The mean preoperative lordosis per level was 1.6° at L1–2, 3.8° at L2–3, 4.8° at L3–4, and 4.3° at L4–5. The mean postoperative lordosis was 6° at L1–2, 6.6° at L2–3, 7.9° at L3–4, and 10° at L4–5. The increase in lordosis at each level was significantly different ($p < 0.05$). There was no statistically significant difference in the amount of lordosis increase between levels ($p > 0.05$ for all differences). Lumbar lordosis was greatest when the disc graft was placed in the anterior part of the disc space (+7.4° of curvature per level) and less when it was placed in the middle part of the disc space (+3.8° of curvature per level). When it was placed in the posterior part of the disc space, net kyphosis was produced (−1.2° of curvature per level); these differences were statistically significant ($P = 0.017$). Analysis of disc graft tilt did not show that disc graft tilt affected postoperative lordosis, regardless of whether the data were analyzed in two groups (tilt <5° and tilt >5°, $P > 0.1$) or three groups (tilt <5°, tilt 5°–10°, and tilt >10°, $P > 0.2$). The height of the disc graft also did not affect postoperative lordosis ($P > 0.2$). Analysis of the rate of postoperative neurological symptoms (sensory or motor) showed no difference between anterior/mid-disc (rate = 22%) or posterior (rate = 33%, $P = 0.62$) placement of the disc graft. The mean preoperative global lumbar lordosis was 43.5° compared with 48.4° postoperatively ($P = 0.14$) for an increase of 3° per level.

Limitation.

The study was small in number, and the follow-up period was not long.

Conclusion.

XLIF is a minimally invasive spinal surgery that improves symptoms well. This is an indirect decompression method, comparing pre- and post-operative MRI images has proven the effectiveness of the indirect decompression method.

Ethical policy and institutional review board statement.

Ethical approval for this study was provided by the Institutional Ethical Committee/Institutional Review Board.

Authors' contributions.

Conceptualization or design of the work: NV, TMH; Data acquisition: TMH; Analysis or interpretation: TMH, Writing or manuscript revision: TMH. All authors reviewed and approved the final draft of the manuscript, and all take responsibility of the content of the publication.

Financial support and sponsorship.

Nil.

Conflicts of interest.

There are no conflicts of interest.

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