Turk Neurosurg, 2024

Original Investigation

DOI: 10.5137/1019-5149.JTN.45975-23.2

Received: 25.11.2023
Accepted:19.02.2024

Published Online: 18.03.2024

The Impact of the Placement of the L5 Vertebra in Relation to the Intercrest Line on the Level of Disc Herniation

Recai ENGIN[1], Yunus Emre DURMUS[2], Fatih TOMAKIN[3], Aykan ULUS[2], Alparslan SENEL[2]

[1]Kahramanmaras Necip Fazıl City Hospital, Department of Neurosurgery, Kahramanmaras, Türkiye
[2]Ondokuz Mayıs University Faculty of Medicine, Department of Neurosurgery, Samsun, Türkiye
[3]Unye State Hospital, Department of Neurosurgery, Ordu, Türkiye

Corresponding author: Recai ENGIN ✉ r.engin5552@gmail.com

ABSTRACT

AIM: To determine whether there is a correlation between a deeply seated L5 vertebra in relation to the intercrest line (ICL) and the level of degeneration of lumbar discs.

MATERIAL and METHODS: The study included 152 patients who underwent surgery for lumbar disc herniation. After analyzing the radiographs, the patients were separated into two groups. Group 1 patients had an ICL that passed through the L4 corpus, and Group 2 patients had an ICL that passed through the L4–5 disc distance or the L5 vertebra. Group 1 patients were classified as having a deeply seated L5 vertebra, while Group 2 patients were classified as not having a deeply seated L5 vertebra.

RESULTS: The study found that male patients had a significantly higher incidence of a deeply seated L5 vertebra compared to female patients (p=0.003). Patients who underwent surgery at the L4–5 level exhibited disc heights that were notably higher than those who underwent surgery at the L5–S1 level. In Group 1, 68% of the patients had surgery at the L4–5 level, compared to only 41.7% in Group 2 (p=0.009).

CONCLUSION: When investigating the effects of the position of the L5 vertebra in relation to the ICL at the L4–5 and L5–S1 disc levels, the study found that having a deeply seated L5 vertebra protected against L5–S1 disc herniation and that L4–5 disc herniation was more common in these patients. This is believed to be due to the L5–S1 segment being less mobile when the L5 vertebra is deeply seated.

KEYWORDS: Intercrest line, Lumbar disc herniation, Deeply seated L5 vertebra, Spine surgery

ABBREVIATIONS: NP: Nucleus pulposus, **AF:** Annulus fibrosus, **ICL:** Intercrest line

INTRODUCTION

Lumbar intervertebral disc herniation entails the nucleus pulposus (NP) overrunning following the rupture of the annulus fibrosus (AF). This rupture can occur for different reasons, such as lumbar degeneration and chronic strain (26). It is noteworthy that 90%–95% of lumbar disc herniations occur in the L4–L5 or L5–S1 regions (1). This higher prevalence of disc herniation in the lower lumbar region can be attributed to the fact that these segments have more mobility and are exposed to increased axial pressure (15). Upper lumbar disc hernias located at L1–2, L2–3 and L3–4 are categorized as a distinct entity and account for approximately 5%–10% of lumbar disc herniations.

Previous studies have revealed that degenerative changes in the intervertebral disc are associated with damage to structures such as ligaments, joints, and spinal muscles

Recai ENGIN : 0000-0003-2957-9848
Yunus Emre DURMUS : 0000-0001-6331-1787
Fatih TOMAKIN : 0000-0001-8290-2216
Aykan ULUS : 0000-0001-8373-7072
Alparslan SENEL : 0000-0003-3530-5480

(3,5,16). The iliolumbar ligament plays an essential role in limiting excessive movement at the lumbosacral junction and maintaining stability by preventing the sliding of L5 over the sacrum (2). The iliolumbar ligament is a robust connective tissue band that mostly runs from the L5 transverse process to the posterior iliac crest of the ilium (2,6).

The intercristal line (ICL) is a horizontal line that is drawn across the highest points of both iliac crests on an anteroposterior lumbar radiograph (19). As we believe that the anatomical relationship between the L5 vertebra and the ICL may hold clinical significance in regard to lumbar disc herniation, we analyzed the position of the L5 vertebra in relation to the ICL. The purpose of this study is to investigate whether a deeply seated L5 vertebra in relation to the ICL affects the degree of lumbar disc degeneration.

MATERIAL and METHODS

This study was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee at our hospital (Date:14.1.2022 No: 2021/410). The study adhered to conventional structure and formatting guidelines and employed objective, value-neutral language throughout. It included patients who underwent lumbar disc herniation surgery in our department between 2020 and 2022. Patients under the age of 18 lacking clinical and radiological evidence or who had an infection, a spinal tumor, trauma-related lesions, or prior spinal surgery were excluded from the study. Also excluded were patients requiring posterior segmental instrumentation or who presented with more than two levels of disc herniation.

The study analyzed plain radiographs and categorized patients into two groups. Group 1 patients had an ICL that passed through the L4 corpus, whereas Group 2 patients had an ICL that passed through the L4–5 disc or the L5 vertebra (Figures 1, 2). Group 1 patients had a deep-seated L5 vertebra, while Group 2 patients did not (Figures 3, 4). The data were analyzed in two stages to facilitate comprehension. In stage one, we compared upper- and lower-level lumbar disc herniations, while in stage two we focused solely on lower-level lumbar disc herniations.

Statistical Analysis

The data was analyzed using the SPSS 21.0 software package. To test for conformance to a normal distribution, a Kolmogorov–Smirnov test, a Shapiro–Wilk test, and graphical evaluations were employed. A Mann–Whitney U test was used to compare non-normally distributed data between two independent groups, and a Kruskal–Wallis H test was used to compare more than two groups. A t-test for two independent samples was used to compare normally distributed data, and a one-way ANOVA was used to compare more than two groups. Pearson and Yates' chi-square tests with continuity correction were used to determine if there was an association between categorical variables. Significance was evaluated at the $p<0.05$ level.

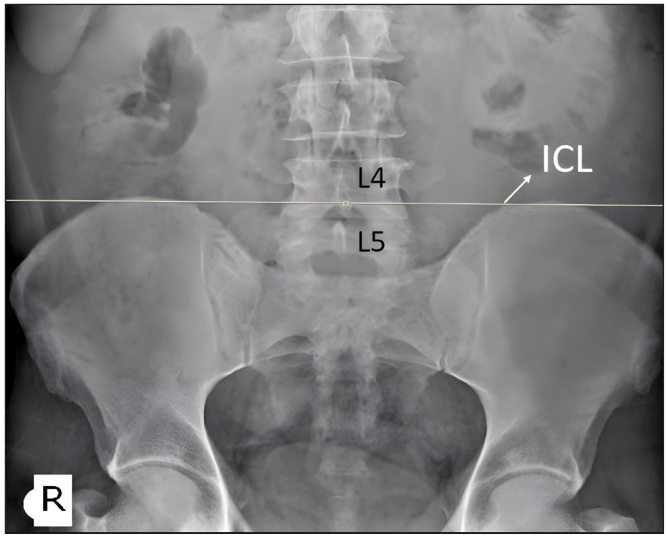

Figure 1: On the anteroposterior plain radiograph, the ICL passes through the L4 corpus (deeply seated L5 vertebra).

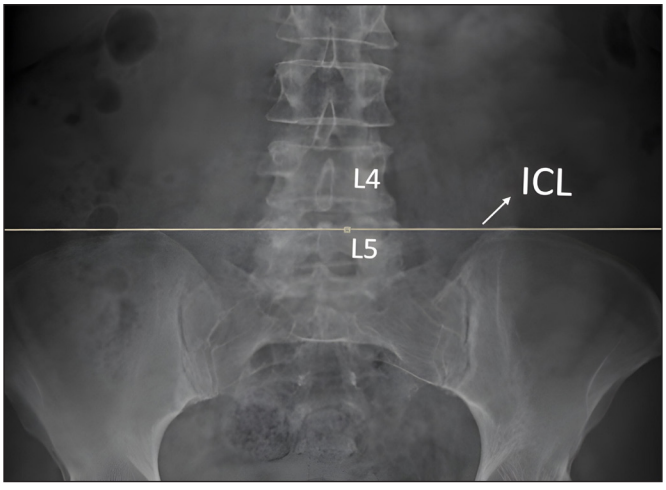

Figure 2: On the anteroposterior plain radiograph, the ICL passes through the L5 corpus (non-deeply seated L5 vertebra).

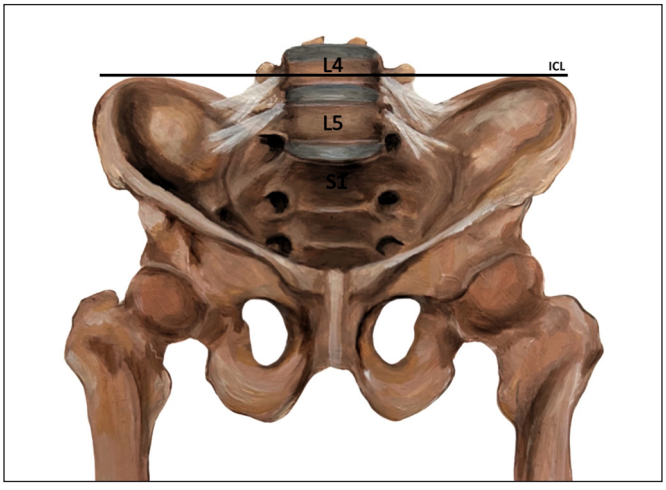

Figure 3: Deeply seated L5 vertebra.

RESULTS

We conducted an analysis of 248 patients who underwent surgery for lumbar disc herniation at our clinic. After applying the exclusion criteria, we scrutinized the data of 152 patients. These patients were aged 20–80, with a mean age of 50.46 years. Females constituted 40.8% of the patients and males constituted 59.2%. Regarding the ICL, 86 patients had a deep-seated L5 vertebra, and 66 did not. The disc heights of the patients who underwent surgery ranged between 4 mm and 14 mm, and the mean disc height was 8.78 mm (Table I).

1. First stage: comparison of upper- and lower-level lumbar disc herniations

Of the patients, 17 underwent surgery for upper-level lumbar disc herniation, and 135 underwent surgery for lower-level lumbar disc herniation. The mean age of the patients who underwent surgery for upper-level disc herniation was 59.59, and that of the patients who underwent surgery for lower-level disc herniation was 49.32. It was found that patients who underwent surgery for upper-level disc herniation were significantly older (Table II). No significant difference was observed (p=0.148) when comparing intervertebral disc heights between upper-level and lower-level lumbar disc hernias. Additionally, no statistically significant correlation was found (p=0.767) between gender and the level of surgery.

Of the patients who had surgery for disc herniation at the upper level, 64.7% were categorized in Group 1, and 55.6% of patients who had surgery for lumbar disc herniation at the lower level were also in Group 1. Our analysis found no statistically significant correlation between the position of the L5 vertebra in relation to the ICL and the location of the lumbar disc herniation at the upper or lower level (p=0.647) (Table III).

The average age of patients in Group 1 with a deep-seated L5 vertebra was 52.48 and patients in Group 2 was 47.83, which was statistically significant (p=0.027). Group 1 consisted of 60 males and 26 females, while Group 2 consisted of 30 males and 36 females. It was found that male patients had a significantly higher incidence of a deeply seated L5 vertebra compared to female patients (p=0.003) (Table III).

2. Second stage: comparison of lower-level lumbar disc herniations

Of the 135 patients who underwent surgery for lumbar disc herniation at the lower level, 76 (56.3%) had an L4–5 herniation, 40 (29.63%) had an L5–S1 herniation, and 19 (14.07%) had herniation affecting both L4–5 and L5–S1. Of the patients, 81 were male and 54 were female, resulting in a male-to-female ratio of 3 to 2. Of the patients who underwent surgery for lower-level lumbar disc herniation, 75 (55.56%) belonged to Group 1 (with a deeply seated L5 vertebra) and 60 (44.44%) belonged to Group 2 (with an L5 vertebra that was not deeply seated).

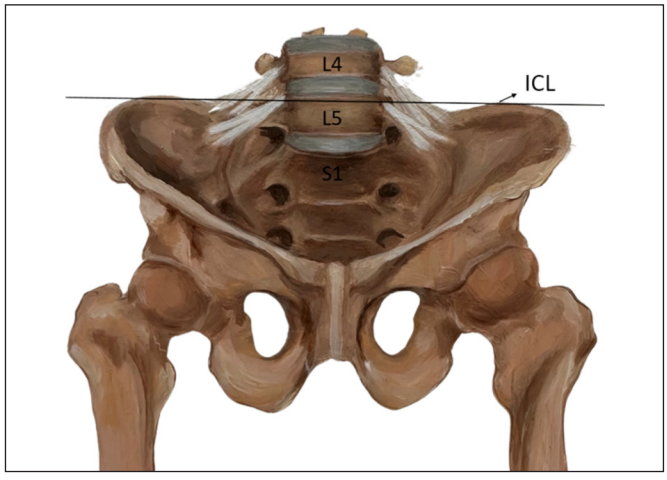

Figure 4: Non-deeply seated L5 vertebra.

Table I: Descriptive Statistics for the Lumbar Disc Hernia Surgeries

Variable	Mean ± SD	Median (Min-Max)	n
Age	50.46 ± 12.86	50 (20-80)	152
Disc Height	8.78 ± 2.63	9 (4-14)	152
Gender		**Frequency (%)**	
Female		62 (40.8)	152
Male		90 (59.2)	
Operation Level			
Upper level		17 (11.2)	152
Lower level		135 (88.8)	
To the ICL according to L5 Status			
Group 1 (L4)		86 (56.6)	152
Group 2 (Below L4)		66 (43.4)	

ICL: *Intercrest line.*

A statistically significant difference in disc heights was found between the patients who had surgery at different levels (p=0.021). Patients operated on at the L4–5 level had disc heights that were statistically significantly higher than those operated on at the L5–S1 level (Table IV). No statistically significant difference was found in the ages and disc heights of patients with and without deeply seated L5 vertebra (p>0.05).

A Pearson $\chi^{\wedge 2}$ test indicated a statistically significant correlation between the level of surgery and L5 location (p=0.009) (Table V). The results of the column ratio comparisons performed with Bonferroni correction revealed a significant difference between Group 1 and Group 2 in terms the of L4–5 surgery level. In Group 1, 68% of patients underwent surgery at the L4–5 level, whereas in Group 2, only 41.7% had surgery

Table II: Comparison of Upper-Level and Lower-Level Disc Status

Variable	Operation Level				p-value
	Upper level (n=17)		Lower level (n=135)		
	Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)	
Age	59.59 ± 12.33	62 (23-79)	49.32 ± 12.51	49 (20-80)	**0.001**[a]
Disc Height (mm)	8.06 ± 1.82	8 (5-12)	8.87 ± 2.3	9 (4-14)	0.148[a]
Gender	Frequency (%)		Frequency (%)		
Female	8 (47.1)		54 (40)		0.767[b]
Male	9 (52.9)		81 (60)		-
To the ICL according to L5 status					
Group 1 (L4)	11 (64.7)		75 (55.6)		0.647[b]
Group 2 (Below L4)	6 (35.3)		60 (44.4)		-

a: *Mann-Whitney U Test,* ***b:*** *Yates Continuity Correction Chi-Square Test.*

Table III: Comparison of the ICL according to L5 Status

Variables		L5 Status		p-value*
		Group 1 (n=86)	Group 2 (n=66)	
Age	Mean ± SD	52.48 ± 13.61	47.83 ± 11.39	**0.027** [a*]
	Median (Min-Max)	54 (20-80)	46.5 (22-76)	
Disc Height (mm)	Mean ± SD	8.67 ± 1.99	8.92 ± 2.58	0.606[b]
	Median (Min-Max)	8.4 (4-13)	9 (4-14)	-
Gender	Male	60	30	**0.003** [c**]
	Female	26	36	
Operation Level	Upper	11	6	**0.647** [d]
	Lower	75	60	

**p<0.05, **p<0.01, [a] Independent t test, [b] Mann -Whitney U Test, [c] Pearson Chi-Square test, [d] Yates Continuity Correction Chi-Square Test.*

Table IV: Level of Surgery Based on Examination

Variables		Operation Level			p-value
		L4-5 (n=76)	L5-S1 (n=40)	L4-5/L5-S1 (n=19)	
Age	Mean ± SD	51.39 ± 12.69	46.45 ± 11.96	47.05 ± 11.93	0.089[a]
	Median (Min-Max)	51 (20-80)	46 (24-76)	49 (23-71)	
Disc Height (mm)	Mean ± SD	9.36 ± 2.14	8.23 ± 2.53	8.32 ± 2.08	**0.021**[a]
	Median (Min-Max)	9 (5-14)	8 (4-13)	8 (5-12)	

[a] *OneWayANOVA.*

Table V: The Relationship Between Disc Herniation Level and L5 Status according to Intercrest Line

	L5 Status	
Operation Level	**Group 1 (Deep) (n=75)**	**Group 2 (Non-deep) (n=60)**
L4-5	51 (68%)	25 (41.7%)
L5-S1	16 (21.3%)	24 (40%)
L4-5/L5-S1	8 (10.7%)	11 (18.3%)

Pearson χ^2= 9.418, p-value: 0.009.

at this level. The difference in rates between the two groups was found to be statistically significant. Additionally, there was a significant difference between the two groups in terms of the L5–S1 surgery level. In Group 1, 21.3% of patients had surgery at this level compared to 40% in Group 2. Again, this difference between the rates was found to be statistically significant. There was no significant statistical difference observed between the groups in relation to surgery at the L4–5/L5–S1 levels.

DISCUSSION

The L4–5 and L5–S1 levels exhibit the greatest mobility in the lumbar region and are the most common site for lumbar disc herniation. Compared to the upper lumbar level, the lower levels are subjected to greater axial pressure, which is the principal risk factor for intervertebral disc degeneration (15). We hypothesize that the location of the L5 vertebra in relation to the ICL influences the incidence of lumbar disc herniation. If the L5 vertebra is deeply seated in relation to the ICL, it decreases the mobility of the L5–S1 segment. This may protect against low-level disc herniations, specifically L5–S1 disc herniation.

1. First stage: comparison of upper- and lower-level lumbar disc herniations

Approximately 90%–95% of lumbar disc hernias occur at the lower lumbar level, with the remaining 5%–10% occurring at the upper lumbar level (3). This study found that low-level disc herniations made up 88.8% of the cases of lumbar disc herniation, while 11.2% of the cases were upper-level lumbar disc hernias.

Although disc herniation can happen in individuals in any age group, it is most prevalent between the third and fifth decades of life (8). Our study found that the average age of the patients was 50.47 years old, with the average age of those with upper-level disc being 59.59 years and the average age of those with lower-level lumbar disc hernias being 49.32 years. Furthermore, the average age of those with upper-level disc hernias was considerably higher compared to those with lower-level disc hernias (p=0.001). Various studies have demonstrated that as age increases, the extent of disc herniation advances from tail to head (4,10,20). Dammers and Koehler found a strong association between upper-level lumbar disc herniation and increasing age (7), which corresponds with our research.

In our study, 59.2% of the patients were male and 40.8% were female. While lumbar disc herniation is twice as common in men as in women, studies with a male-to-female ratio of 3 to 2 have also been reported in the literature (12,21,22). This is consistent with our findings.

In a study by Wattanaruangkowit and Lakchayapakorn that examined 270 patients from Thailand, the position of the lumbar vertebra in relation to the ICL was investigated. The authors found that the ICL was located higher in elderly patients (24). Our findings are in line with those of Wattanaruangkowit and Lakchayapakorn. Our study found that the mean age of patients in Group 1 with a deeply seated L5 vertebra was 52.48 and that of the patients in Group 2 was 47.83. This may be attributed to the decrease in intervertebral disc height with ageing.

The position of the ICL is higher in males than in females (19). Earlier research has demonstrated that the ICL primarily traverses the L4 vertebral body in males and the L5 vertebral body in females (19,23). In our investigation, Group 1 comprised 60 male patients who had undergone surgery, and Group 2 consisted of 30 male patients who had also undergone surgery. Regarding the female patient cohort, Group 1 included 26 patients and Group 2 included 36. Our findings suggest that a deeply seated L5 vertebra was more prevalent among male patients; this may be attributed to the fact that the male pelvis is narrower and longer than the female pelvis, which is typically wider and shorter.

During this stage of the study, we evaluated the impact of the deep location of the L5 vertebra in relation to the ICL on the formation of upper- and lower-level disc herniation. As a result, we determined that the location of the L5 vertebra did not have an effect on the formation of either upper- or lower-level disc herniation.

2. Second stage: comparison of lower-level lumbar disc herniations

During the second stage of the study, lower-level lumbar disc hernias were evaluated. Of the patients, 56.3% (n=76) underwent surgery for L4–5 disc herniation, 29.63% (n=40) for L5–S1 disc herniation, and 14.07% (n=19) for L4–5 and L5–-S1 disc herniation.

Dammers and Koehler analyzed the data of 1431 patients with lumbar disc herniation and found that L5–S1 disc herniation occurs at a younger age than does L4–5 disc herniation (mean age of 44.1 and 49.5 years, respectively) (7). These results align with our research. The average age for patients who underwent surgery for L5–S1 disc herniation was 46.45 years, whereas for those who underwent surgery at the L4–5 level the mean age was 51.39 years. Numerous studies have demonstrated that the level of disc herniation typically advances from the lumbosacral level to the cranial level with increasing age. However, the underlying reasons for this pattern still remain unclear (4,10,20).

Of the patients who underwent surgery for lower-level lumbar disc herniation, 55.56% (n=75) were in Group 1 (with deeply seated L5 vertebrae) and 44.44% (n=60) were in Group 2

(with L5 vertebrae that were not deeply seated). According to a study of patients who received posterior segmental instrumentation at the L5 and S1 levels conducted by Guo et al., the L5 vertebra was found to be deeply seated in 63% of patients and not to be deeply seated in the remaining 37% (9). The authors reported that posterior segmental instrumentation proved more challenging when encountering deeply seated L5 vertebra compared to those that were not deeply seated and that the presence of iliac prominences could potentially hinder screw orbit (9). While the probability of L5–S1 disc herniation is lower in the presence of a deeply seated L5 vertebra, a deeply seated L5 vertebra does not provide complete protection against such an occurrence. It is important to note that the medial angle of the pedicle screw may be restricted by the iliac wings in cases where stabilization is needed alongside disc herniation in these patients.

Seo et al. investigated the risk of degenerative lumbar scoliosis progression in 27 patients. They found that 29% of patients had an ICL that passed through L4, and the final scoliosis angle was significantly lower in these patients compared to the other studied group (18). Sapkas et al. (17) conducted a study of 162 patients with degenerative scoliosis and found that the ICL passing through the L5 vertebra is a risk factor linked to the development of scoliosis. Likewise, Pritchett and Bortel (14) demonstrated that an ICL at the level of the L5 vertebra is a risk factor for scoliosis angle progression. Ohashi et al. analyzed data from 56 patients who had been followed up for 25 years. These patients were among a larger group of 147 individuals with adolescent idiopathic scoliosis who had received non-surgical treatment. The results showed that the L5 vertebra, which was less deeply seated in relation to the ICL, could be considered a risk factor for curve progression (13). Of the 56 patients, 38 had a deeply seated L5 vertebra (13). When examining patients with L4–5 and L5–S1 disc herniations in our study, we found a statistically higher prevalence of L4–5 disc herniation in cases where L5 vertebrae were deeply seated in relation to the ICL. Conversely, L5–S1 disc herniation was less frequent in these cases, indicating that deeply seated L5 vertebrae protect against L5–S1 disc herniation. Our study also demonstrated a higher incidence of L4–5 disc herniation in these patients. We believe that this is attributable to the limited mobility of the L5–S1 segment when the L5 vertebra is deeply seated, with the L4–5 level serving a more pivotal role as a motion segment.

The disc heights of the patients at the level of surgery ranged between 4 mm and 14 mm, with an average of 8.87 mm. As per our findings, L4–5 disc height exceeded L5–S1 disc height, in line with the literature (25). Inoue et al. found a negative correlation between ICL height and L5–S1 disc height in their study (11). They found that L5–S1 disc height was significantly lower in patients with deeply seated L5 vertebrae. No significant correlation was discovered between the height of the disc and the position of the L5 vertebra in relation to the ICL (p=0.624) in our study.

CONCLUSION

The effect of the relationship between the ICL and the L5 vertebra on the frequency of lumbar disc herniation was investigated in patients who were operated on for lower-level disc herniation. It was found that a deeply seated L5 vertebra provides protection against L5–S1 disc herniation, whilst increasing the likelihood of L4–5 disc herniation. This is attributed to the reduced mobility of the L5–S1 segment when the L5 vertebra is deeply seated.

AUTHORSHIP CONTRIBUTION

Study conception and design: RE, AS, AU
Data collection: RE, YED, FT
Analysis and interpretation of results: RE, YED
Draft manuscript preparation: YED, FT, RE
Critical revision of the article: YED, AS, AU
Other (study supervision, fundings, materials, etc...): YED, FT
All authors (RE, YED, FT, AU, AS) reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Amin RM, Andrade NS, Neuman BJ: Lumbar disc herniation. Curr Rev Musculoskelet Med 10:507-516, 2017
2. Bogduk N, Macintosh JE, Pearcy MJ: A universal model of the lumbar back muscles in the upright position. Spine 17:897-913, 1992
3. Bosacco SJ, Berman AT, Raisis LW, Zamarin RI: High lumbar disk herniations. Case reports. Orthopedics 12:275-278, 1989
4. Butler D, Trafimow J, Andersson G, McNeill T, Huckman M: Discs degenerate before facets. Spine 15:111-113, 1990
5. Colombini A, Lombardi G, Corsi MM, Banfi G: Pathophysiology of the human intervertebral disc. Int J Biochem Cell Biol 40:837-842, 2008
6. Dąbrowski K, Ciszek B: Anatomy and morphology of iliolumbar ligament. Surg Radiol Anat 45:169-173, 2023
7. Dammers R, Koehler PJ: Lumbar disc herniation: Level increases with age. Surg Neurol 58:209-212, 2002
8. Fjeld OR, Grøvle L, Helgeland J, Småstuen MC, Solberg T, Zwart JA, Grotle M: Complications, reoperations, readmissions, and length of hospital stay in 34 639 surgical cases of lumbar disc herniation. Bone Joint J 101:470-477, 2019
9. Guo J, Guo L, Gao J, Ling Q, Yin Z, He E: Does a deep seated L5 vertebra position with respect to the iliac crests affect the accuracy of percutaneous pedicle screw placement at lumbosacral junction? BMC Musculoskelet Disord 18:1-6, 2017
10. Harmon PH, Abel MS: Correlation of multiple objective diagnostic methods in lower lumbar disk disease. Clin Orthop Relat Res 28:132-151, 1963
11. Inoue H, Ohmori K, Miyasaka K, Hosoe H: Radiographic evaluation of the lumbosacral disc height. Skeletal Radiol 28:638-643, 1999

12. Lurie JD, Tosteson TD, Tosteson ANA, Zhao W, Morgan TS, Abdu WA, Herkowitz H, Weinstein JN: Surgical versus non-operative treatment for lumbar disc herniation: Eight-year results for the Spine Patient Outcomes Research Trial (SPORT). Spine 39:3-16, 2014
13. Ohashi M, Watanabe K, Hirano T, Hasegawa K, Katsumi K, Shoji H, Mizouchi T, Endo N: Predicting factors at skeletal maturity for curve progression and low back pain in adult patients treated nonoperatively for adolescent idiopathic scoliosis with thoracolumbar/lumbar curves: A mean 25-year follow-up. Spine 43:E1403-E1411, 2018
14. Pritchett JW, Bortel DT: Degenerative symptomatic lumbar scoliosis. Spine 18:700-703, 1993
15. Rohlmann A, Zander T, Schmidt H, Wilke HJ, Bergmann G: Analysis of the influence of disc degeneration on the mechanical behaviour of a lumbar motion segment using the finite element method. J Biomech 39:2484-2490, 2006
16. Sanderson SP, Houten J, Errico T, Forshaw D, Bauman J, Cooper PR: The unique characteristics of “upper” lumbar disc herniations. Neurosurgery 55:385-389, 2004
17. Sapkas G, Efstathiou P, Badekas AT, Antoniadis A, Kyratzoulis J, Meleteas E: Radiological parameters associated with the evolution of degenerative scoliosis. Bull Hosp Jt Dis 55:40-45,1996
18. Seo JY, Ha KY, Hwang TH, Kim KW, Kim YH: Risk of progression of degenerative lumbar scoliosis. J Neurosurg Spine 15:558-566, 2011
19. Snider KT, Kribs JW, Snider EJ, Degenhardt BF, Bukowski A, Johnson JC: Reliability of Tuffier’s line as an anatomic landmark. Spine 33:E161-E165, 2008
20. Spangfort EV: The lumbar disc herniation: A computer-aided analysis of 2,504 operations. Acta Orthop Scand Suppl 142:1-95, 1972
21. Støttrup C, Andresen AK, Ernst C, Andersen MØ: Surgical treatment of lumbar disc herniation. Ugeskr Laeger 180:V05170398, 2018
22. Strömqvist F, Ahmad M, Hildingsson C, Jönsson B, Strömqvist B: Gender differences in lumbar disc herniation surgery. Acta Orthopaedica 79:643-649, 2008
23. Walsh J, Quinlan J, Butt K, Towers M, Devitt A: Variation de la position de l’espace discal L4-L5- revue de 450 radiographies et applications cliniques. Eur J Orthop Surg Traumatol 16:203-206, 2006
24. Wattanaruangkowit P, Lakchayapakorn K: The position of the lumbar vertebrae in relation to the intercrestal line. J Med Assoc Thai 93:1294-300, 2010
25. Zheng J, Shen C: Quantitative relationship between the degree of lumbar disc degeneration and intervertebral disc height in patients with low back pain. Contrast Media Mol Imaging 2022:5960317, 2022
26. Zheng K, Wen Z, Li D: The clinical diagnostic value of lumbar intervertebral disc herniation based on MRI images. J Healthc Eng 2021:5594920, 2021