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Pre-operative Disc Volume Measurement as a Predictor for Sufficient Intra-operative Excision in Lumbar Open Fenestration Discectomies

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Abstract

Background and objectives: A study was implemented by assessing pre-operative disc volume and compare it to resected disc volume intra-operatively to minimize complications. The purpose of this study is to determine whether preoperative measurement of disc volume by magnetic resonance imaging could estimate the amount of disc need to be removed intraoperatively.

Methods: This prospective cross-sectional study was conducted between 2021 and 2023, in which 44 patients were involved, the volume of the herniated disc. The height, width, and length of prolapsed disc were multiplied together and by 0.523, measured on magnetic resonance imaging machine, intraoperatively the resected disc was placed in the sterile syringe for measurement.

Results: Out of 44 patients, 23 of them were males, and 21 were females. The mean age was 41.4 years. The most common level of involvement was the L4-L5 levels. The size of the herniated disc preoperatively ranged from 0.70 cc to 3.70, among them 72.7% of patients had a measurement between 1.0 cc and 2.0. Intraoperatively, the size of resected disc ranged from 1.0 cc to 4.2, 63.6% of them had volume exceeding 2.0 cc. Our data showed that neither the volume of the herniated disc nor the volume of the resected disc has any correlation to the age, gender and the level of disc involved.

Conclusion: Preoperative measurement of lumbar disc herniation with a magnetic resonance image do not predict the disc volume that needs to be removed during surgery.

Keywords: Intraoperative lumbar disc volume, Preoperative lumbar disc volume.

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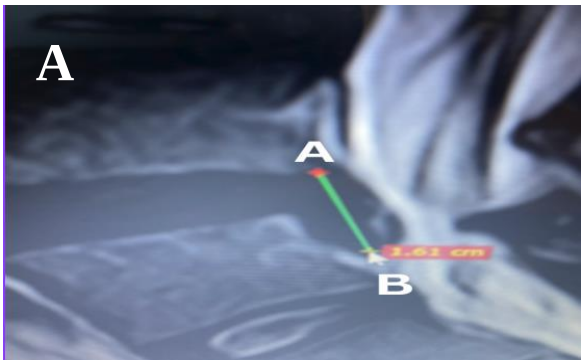
Introduction

Lumbar disc prolapse (LDP) is a localized bulge of the nucleus pulposus beyond the normal edge of the intervertebral disc space.[1] But it involves less than 25 % of the circumference.[2] It occurs in 1% to 5% of the annual population, it appears mostly during the third to the fifth decade of life, two times more common in males in comparison to females [3], and lumbar disc prolapse happens 15 times more than cervical disc prolapse.[4,5] Four stages of lumbar disc herniation have been described including: Bulging, Protrusion, Extrusion, and Sequestration.[6] The causes of pain in the lumbar disc prolapse may result from mechanical compression, ischemia, or nerve root inflammation.[7,8] Lumbar disc prolapse presents with radicular pain, weakness of the muscles, sensory impairment in the dermatome of the involved level.[9,10] However, many peoples have herniated lumbar discs without experiencing any symptoms, this found in about 25% of the general population.[11] Magnetic Resonance Imaging (MRI) is considered the diagnostic imaging procedure of choice for details of the disc abnormality.[1,12,13] Lumbar discs tend to have an elliptical and irregular shape.[14] ,and the formula for the measurement of volume in an ellipsoid-like structure is height x width x length x 0.523.[15] Surgery may be required for progressive lower extremity weakness and neurological deficits or cauda equina syndrome.[16] During surgery the amount of removed disc is measured by placing the removed disc inside sterile syringes, compressed manually, without adding normal saline, and disc volume measured by syringe indicator in cubic milliliter.[17] One cubic centimeter corresponds to a volume of one milliliter.[18] The aim of this study was to determine whether preoperative measurement of the prolapsed disc volume could estimate the number of discs that would need to be removed during surgery.

Patients and methods

This study was achieved in the High-quality Hospital and Shar Teaching Hospital in Sulaymaniyah city, Kurdistan Region / Iraq, from October 2021 to August 2023, in which 44 patients were involved; their age ranges were between 21-68, male and female participants were 23 and 21, respectively. They were complaining of low back pain radiating to lower limb. Inclusion criteria included patients with lumbar disc herniation (L2-L3, L3-L4, L4-L5, and L5-S1), all single-level. Patients with spinal stenosis due to disc degeneration and ligamentum flavum hypertrophy, instability, or infection were excluded from the study. This prospective cross-sectional study was conducted in 44 patients with lower back pain, after evaluation of patients with history and clinical examination, lumbosacral MRI scan was performed to measure the volume of herniated disc. All MR images were acquired on a 1.5 T scanner (MRI HDXt, GE Medical Systems, manufacture in U.S.A, software version: 2009). The MR examination protocols was the same for all patients and examined by the same radiologist, in 4 mm thick layers. In sagittal view, the height of the disc craniocaudally (line A-B) was measured, in T2-weighted axial view we measured 2 dimensions, mediolateral (line C-D) and anteroposterior (line E-F). The three measures were multiplied by one another and then by 0.523, while final measurement was in the unit of cubic milliliter Figure (1).



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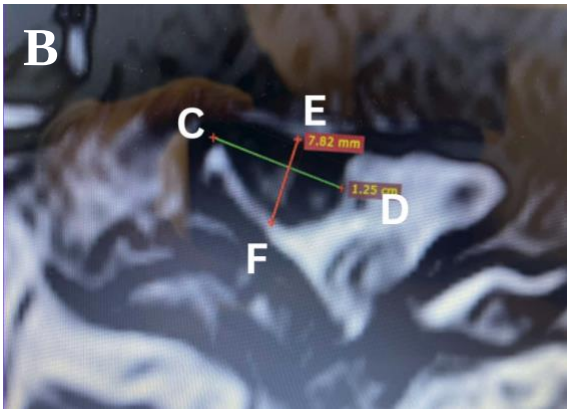

Figure (1): A. Sagittal view of lumbar spine shows measurement of prolapsed disc height line A-B. B. Axial view of lumbar spine measuring the anteroposterior line E-F and mediolateral dimension line C-D of the prolapsed disc.

Operation performed with the patient placed in knee-chest position under general anesthesia. After marking the level, a posterior midline incision was used, and the lumbar fascia was opened in line with it, paraspinal muscles separated from the spinous process, ligamentum flavum was removed, the proposed nerve root was identified, retracted and protected. Then fragile, degenerative, and abnormal disc were all removed. Immediately inside the operation, the disc material was placed inside the sterile syringe, it was compressed manually, and normal saline was not added to the syringe. The volume of the disc material was measured in cubic milliliters, Figure (2).

Figure (2): Manually compressing the disc material into disposable syringes, and the volume of content was measured in cubic milliliter.

The collected data was revised, coded, tabulated and introduced to a PC using the statistical procedure that was applied to determine the results and it includes: Descriptive statistics such as (frequency, percentage, mean, and stander deviation). Inferential data analysis: (Chi-Square Test and Parried samples T-Test.)**.** There are criteria of the probability level of determining the significance of the test: p value as: High significance (P< 0.001); Significant (P< 0.05); Non-significant (P> 0.05); Very highly significant (P< 0.000). The Scientific and Ethical Committees at the College of Medicine, University of Sulaimani, Sulaymaniyah, Iraq, approved the study protocol. Written informed consent was taken from all patients, and they felt free to leave the study anytime.

Results

According to our data, 23 out of 44 of the participants were males, representing 52.3%, while 21 out of 44 were females, representing 47.7%. Age of the patients ranged from 21 to 68 years old (the mean was 41.4). Three groups of patients were assigned according to their age: 11.4% (5 out 44) were under 30 years, 45.5% (20 out 44) of the patients were between 30 and 40 years old, and 43.2% (19 out 44) were over 40 years, Table (1).

Table (1): Age of patients.

Age (Years)	Frequency		%	Rank
< 30	5		11.4	3
30 – 40	20		45.5	1
More than 40	19		43.2	2
Mean ± S. D		41.43 ~ 41 ± 11.62		
Total	44		100.0	

According to the level of affection, L4-L5 level was the most common level of affection, which represents 61.36% of patients (27 out of 44 patients), followed by

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L5-S1 level which represent 31.82% of patients (14 out of 44). The third most common level in our study was L3L4 level, which represents 4.54% of patients (2 out of 44). Only one patient (2.27 %) had disc herniation at L2L3, Table (2).

Table (2): Level of disc prolapse among participants.

Level	Frequency	%	Rank
L4L5	27	61.4	1
L5S1	14	31.8	2
L3L4	2	4.5	3
L2L3	1	2.3	4
Total	44	100.0	

According to MRI measurements, patients were grouped into three categories: those with measurements less than 1.0 cc made up 11.4% (5 out of 44), those with measurements between 1.0 and 2.0 cc made up 72.7% (32 out of 44), those with measurements over 2.0 cc made up 15.9% (7 out of 44), Table (3).

Table (3): Measurements preoperative disc volume with MRI.

Preoperative disc volume	Frequency	%	Rank
< 1.0 cc	5	11.4	3
1.0– 2.0 cc	32	72.7	1
More than 2.0 cc	7	15.9	2
Mean ± S. D	1.62 ± 0.74		
Total	44	100.0	

Regarding intraoperative measurements by syringe: there was no any resected disc volume below 1.0 cc, 36.4% (16 out 44) had a value between 1.0 and 2.0 cc, while 63.6% (28 out 44) had a value greater than 2.0 cc., Table (4).

Table (4): Intraoperative disc volume measurements.

Intraoperative disc volume	Frequency	%	Rank
< 1.0 cc	0	0.0	3
1.0– 2.0 cc	16	36.4	2
More than 2.0 cc	28	63.6	1
Mean ± S. D	2.52 ± 0.94		
Total	44	100.0	

Table (5): Compare mean between preoperative disc volume & intraoperative disc volume.

Items	Mean	S. D	T-test	p-value
Preoperative volume (MRI)	1.6175	0.73810	-9.249	0.000
Intraoperative volume (Syringe)	2.5205	0.94021		

Based on the information provided, in 5 patients their preoperative disc prolapses volumes were less than 1.0 cc, intraoperatively the resected disc volume in 4 of them became 1.0-2.0 cc and one patient exceeding 2 cc. In 32 patients, preoperative disc prolapse volumes ranged from 1.0 to 2.0 cc, 12 of them maintained volumes within the same range during the intraoperative period, while 20 patients had volumes that exceeded 2.0 cc. Additionally, there were 7 patients who had both preoperative and intraoperative volumes exceeding 2.0 cc, Table (6).

Table (6): Association between preoperative disc volume and resected disc volume.

			Intraoperative disc volume		Total
			1.0– 2.0 cc	More than 2.0 cc	
Preoperative disc volume	< 1.0 cc	Count	4	1	5
		% of Total	9.1%	2.3%	11.4%
	1.0– 2.0 cc	Count	12	20	32
		% of Total	27.3%	45.5%	72.7%

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	More than 2.0 cc	Count	0	7	7
		% of Total	0.0%	15.9%	15.9%
	Total	Count	16	28	44
		% of Total	36.4%	63.6%	100.0%
	Significant Test: Chi-Square Test		8.132	P-value	0.017

In terms of preoperative disc prolapse volume measurements, there were 5 patients under 30 years of age, the disc prolapse volume in one of them was less than 1.0 cc, and 4 of them were between 1.0 cc - 2.0 cc. Among 20 patients aged 30–40, the disc prolapse volume in 3 of them was less than 1.0 cc, while in 14 of them were between 1.0–2.0 cc and 3 patients exceed 2.0 cc. There were 19 patients who were older than 40 years, disc prolapse volume in one of them was less than 1.0 cc, in 14 of them were between 1.0 and 2.0 cc, in 4 of them over 2.0 cc.In terms of gender, the disc prolapse volume among 23 males reveals (3 males were < 1 cc, 15 males were between 1.0 and 2.0 cc, 4 males were over 2.0 cc), while the disc prolapse volume among 21 females reveals (2 females were < 1 cc, 17 females were between 1.0 and 2.0 cc, 3 females were over 2.0 cc), Table (7).

Table (7): Association between the preoperative disc volume and sociodemographic of patients.

Socio demographic		Preoperative disc volume						p-value
		< 1.0		1.0– 2.0		More than 2.0		
		Fr.	%	Fr.	%	Fr.	%	
Age	< 30	1	20.00	4	12.50	0	0	0.669
	30 – 40	3	60.00	14	43.75	3	42.86	
	More than 40	1	20.00	14	43.75	4	57.14	
Gender	Male	4	80.00	15	46.88	4	57.14	0.791
	Female	1	20.00	17	53.13	3	42.86	
Total		5	100.0	32	100.0	7	100.0	

The Test is used: Chi-square test

The preoperative disc prolapse volume divided to three groups and based on the level of involvement as shown in Table (8), the provided data reveals that there was no statistically significant difference between preoperative disc prolapse volume in related to level of affection.

Table (8): Association between the preoperative disc volume and Level of affection.

Level	Preoperative disc volume						p-value
	< 1.0		1.0– 2.0		More than 2.0		
	Fr.	%	Fr.	%	Fr.	%	
L2L3	0	0.0	1	3.1	0	0.0	0.923
L3L4	0	0.0	2	6.3	0	0.0	
L4L5	4	80.0	18	56.3	5	71.4	
L5S1	1	20.0	11	34.4	2	28.6	
Total	5	100.0	32	100.0	7	100.0	

The Test is used: Chi-square test

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Based on the provided information, under 30 years old: we had 5 patients (4 of them had a measurement greater than 2.0 cc, 1 of them had a measurement between 1.0-2.0 cc.). Between 30-40 years old: we had 20 patients (11 of them had a measurement between 1.0-2.0 cc, 9 of them had a measurement greater than 2.0 cc.). Over 40 years old: we had 19 patients (4 of them had a measurement between 1.0-2.0 cc, 15 of them had a measurement greater than 2.0 cc. We had 22 males, and their disc volume intraoperatively was (7 of them: 1.0-2.0 cc, 15 of them: more than 2.0 cc). We had 22 females and their disc volume intraoperatively was (9 of them 1.0-2.0 cc and 13 of them more than 2.0 cc). Results show that there was no statistically significant difference between preoperative disc prolapse volume in related to socio-demographic of the patient. This was explained in, Table (9).

Table (9): Association between the resected disc volume and patients sociodemographic.

Socio demographic		Intraoperative disc volume				p-value
		1.0– 2.0		More than 2.0		
		Fr.	%	Fr.	%	
Age	< 30	1	6.25	4	14.29	0.064
	30 – 40	11	68.75	9	32.14	
	More than 40	4	25.00	15	53.57	
Gender	Male	8	50.00	15	53.57	0.531
	Female	8	50.00	13	46.43	
Total		16	100.0	28	100.0	

The Test is used: Chi-square test

The intraoperative resected disc volume divided into three categories, as shown in Table (10), the provided data reveals that there was no statistically significant difference between intraoperative volume and level of affection.

Table (10): Association between the intraoperative disc volume and level of affection.

Level	Intraoperative disc volume				p-value
	1.0– 2.0		More than 2.0		
	Fr.	%	Fr.	%	
L2L3	0	0.0	1	3.6	0.778
L3L4	1	6.3	1	3.6	
L4L5	9	56.3	18	64.3	
L5S1	6	37.4	8	28.6	
Total	16	100.0	28	100.0	

The Test is used: Chi-square test

Discussion

Reliability of preoperative disc volume measurement as predictor for intraoperative amount of prolapsed disc need to be removed was addressed by some authors, however axial and sagittal MRI image measurements and comparison with intra operative measurement is not well evaluated till now, to our knowledge. The objective of this study was to investigate whether preoperative disc volume measurement by MRI estimates the intraoperative volume of the disc to be removed, since the amount of removed prolapsed disc may affect the outcome of the

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operation. In this study, the preoperative prolapsed disc volume was measured through MRI in a way similar to that of Kreyszig, and this study preferred this method because lumbar disc herniation has irregular shape, easy applicable method, and familiar to radiologist.[15] Alternatively, some authors used different ways for measuring size of prolapsed disc, Neubert et al.[20] estimated disc volume by multiplying the sum of the disc areas in sagittal layers with the thickness of the layers.[19] In the current study, 11.4% of the patients were under 30 years old, 45.5% were between 30 and 40 years old, and 43.2% were over 40 years old. Similar findings have also been pointed out by Dammers [21], Ali [22], and further supported by Junaid [23], because repetitive activities that overload the vertebral column is most common; such as physically demanding activities that constantly requiring bending, straining, or twisting. In the present study, 23 out of 44 of the patients were males (52.3%), while 21 out of 44 were females (47.7%). This is consistent with findings from a study by Strömqvist [24], supported by another study done by Ali.[22] The explanation is that male patients participate more in jobs requiring increased bending and spine twisting, whereas also females harm their back during work and pregnancy. Regarding the level of involvement, 61.36% of patients had disc herniation at L4-L5 levels and 31.82% of patients had disc herniation at L5-S1 levels. These findings are consistent with those of the study by Daoyou.[25] Due to the fact that lower lumbar region is under excessive strain because it supports the upper body and carries the highest stress of any spinal region. In the current study, preoperative prolapsed disc volume measurements had an average of 1.61 cc (0.7-3.7), this was akin to the results obtained by Elshiekh [26], in which the mean of preoperative prolapsed disc volume was 0.95 cc. Also comparative to the study done by Negro A [27] which was 1.02 cc (0.77 – 1.35). The mean volumes of herniated discs at the initial and follow-up visits in another study by Seo were 1,30 cc.[28] The explanation of that is the size of disc herniation affected by the duration of disc herniation since the herniated disc undergo shrinkage and dehydration with time. Besides, affected by physical therapy prior the surgery. In the current study, sterile syringes to quantify intervertebral disc volume were used intraoperatively, which was comparable to Ji Han's method.[17] Since syringes remain inexpensive, readily available, sterile, and simple to use. The mean intraoperative disc volume in our study was 2.43 cc (1.0 - 4.2). In this regard, Han Heo showed a mean intraoperative disc volume of 1.01 (0.81 – 1.28).[17] Whereas Kostas N. Fountas claimed that the mean removed disc volume was 2.1 cc +/- .[29] The explanation of this variability is the fact that non prolapsed degenerated friable part needs to be removed to prevent re-prolapse later on. The data of the study showed that neither the volume of the herniated disc nor the volume of the resected disc has any correlation to the age, gender and the level of disc involved. The explanation of that is disc prolapse commonly follow degeneration of the disc material and the severity depend on the mechanical overloading and repetitive stress rather than age and gender. The results in this study shows that there is a statistically significant difference between the preoperative and intraoperative volumes of removed prolapsed disc, which are unequal; a similar finding noted in a study conducted by Elshiekh.[24] The explanation of this is that not only the prolapsed part need removal, but any friable fragment liable for later prolapse should be removed. The limitations of this study are the small sample size, single center study and it is better to measure pre and intraoperative disc volume by at least two investigators.

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Conclusion

Preoperative lumbar disc prolapse measurement by MRI machine does not predict the volume of lumbar disc prolapse inside operation.

Conflicts of interest:

The author reports no conflicts of interest.

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