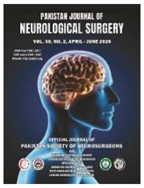

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Original Research

Comparative Analysis of Percutaneous Full Endoscopic Lumbar Discectomy and Microdiscectomy in Terms of Preservation of Paraspinal Muscle Mass: A Retrospective Analysis

Muhammad Farooq[1], Naeem-ul-Haq[2], Mumtaz Ali[3], Ali Shah Jehan[4]

[1]*Department of Endoscopic Spine Surgery, Peshawar General Hospital, Peshawar*

[2]*Department of Neurosurgery, Mardan Medical Complex, Mardan*

[3]*Ali Institute of Neurosciences, Irfan General Hospital, Peshawar*

[4]*Department of Neurosurgery, MMC General Hospital, Peshawar – Pakistan*

ABSTRACT

Aim: This study aimed to compare percutaneous full endoscopic lumbar discectomy and microdiscectomy in terms of preservation of paraspinal muscle mass.

Materials and Methods: This retrospective observational analysis was conducted at Farooq Neurospine Institute. The patient records were analyzed from 2020 to 2022, with a 1-year follow-up period. Adults aged 18-65 years diagnosed with lumbar disc herniation based on clinical and radiological findings and treated with either PEED or MD were included. Preoperative and postoperative CT and/or MRI scans were evaluated to measure the cross-sectional area (CSA) of paraspinal and iliopsoas muscles at affected and adjacent levels.

Results: Of the 480 patients analyzed, 247 underwent PFED, and 233 received MD. The PFED group outperformed the MD group in terms of improvements in muscle cross-sectional area at the one-year follow-up. In PFED, the right and left psoas muscles grew by 94.21 ± 45.0 and 59.28 ± 50.0 mm^2, but in MD, they decreased by 24.28 ± 50.0 and 41.51 ± 55.0 mm^2 ($p = 0.020$ and 0.151). PFED showed better muscle preservation, with paraspinal muscles increasing by 133.84 ± 70.0 and 126.97 ± 68.0 mm^2 compared to losses of 144.88 ± 75.0 and 112.74 ± 72.0 mm^2 in MD ($p < 0.001$).

Conclusion: Radiological findings confirmed the superior muscle-preserving capacity of PFED compared to MD. Enhanced multifidus muscle strength and smaller reoperation incisions further demonstrated its minimally invasive benefits, contributing to reduced postoperative pain, faster recovery, and improved cosmetic outcomes.

Keywords: Lumber Discectomy, Micro Discectomy, Radiological Evidence.

Corresponding Author: Muhammad Farooq
Department of Endoscopic Spine Surgery, Peshawar General Hospital, Peshawar, Pakistan
Email: farooqendospine33@gmail.com

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INTRODUCTION

In recent times, spine surgeons have become extremely concerned about approach-related iatrogenic paraspinal muscle injury. Endoscopic spine surgery (ESS) is thought to be the least invasive kind of spine surgery, aiming to reduce the paraspinal muscles' iatrogenic damage. The traditional posterior open discectomy is considered the gold standard approach for treating lumbar disc herniations. But it is linked to severe paraspinal muscular atrophy,[1] surgical-induced spinal instability,[2,] and persistent lumbar pain during long-term monitoring.[3,4] In recent times, spine surgeons have become extremely concerned about approach-related iatrogenic paraspinal muscle injury because of the chronic low back pain and spinal instability that are associated with it.[5] Several theories, including those involving heat damage, paraspinal muscular denervation, and extended retraction times linked to ischemia and reduced capillary perfusion, have been put forth to explain muscle injuries.[6,7]

Nowadays, endoscopic spine surgery (ESS) has been identified as one of the most minimally invasive approaches for spinal procedures, designed to minimize iatrogenic trauma to the paraspinal musculature.[8] Benefits of endoscopic spine surgery (ESS) include limited soft tissue retraction and damage, reduced intraoperative bleeding, decreased postoperative discomfort, and faster functional recovery through early mobilization.[9] Literature has evaluated the injury to the paraspinal muscles following open or minimally invasive spine surgery using biochemistry (creatinine phosphokinase level),[10] radiological evaluations (magnetic resonance imaging [MRI] and computed tomography [CT]), or electrophysiological tests (EMG).[11]

Numerous studies have evaluated the muscle atrophy that follows lumbar surgery and found a correlation between it and the coagulation of the posterior spinal nerve branches,[12] vascular coagulation, and prolonged retractor-induced compression of the muscles, conditions that tend to occur more frequently during extensive surgical interventions.[13,14]

This study aimed to evaluate the damage to the paraspinal muscles after percutaneous full endoscopic lumbar discectomy and microdiscectomy surgery by assessing post-operative changes on MRI in the muscle mass.

MATERIAL AND METHODS

Study Design/Duration and Setting

This retrospective observational analysis was carried out at the Farooq Neurospine Institute. The patient records were analyzed from 2020 to 2022, with a 1-year follow-up period for each participant. Ethical approval was granted from the institutional review board (Ref No: 357/DME/AMC/2023), informed consent was secured from all the participants, and the confidentiality of patient information was strictly maintained throughout the study.

Inclusion Criteria

The current study's inclusion criteria were adult participants aged 18 to 65 years with a validated diagnosis of lumbar disc herniation, determined through clinical evaluations and radiographic evidence. Patients going through microdiscectomy (MD) or percutaneous endoscopic lumbar discectomy (PELD) were selected. Preoperative, intraoperative, and postoperative data, along with follow-up information, were collected after obtaining informed consent from the participants.

Exclusion Criteria

Individuals with pre-existing spinal anomalies, neurological impairment not associated with lumbar disc herniation, or a previous history of lumbar disc surgery were not included. People with uncontrolled diabetes and heart disease, who could make surgery more dangerous, were also not included.

Radiological Evaluation

Computed tomography (CT), along with magnetic resonance imaging (MRI), was used to evaluate the pre- and post-operative imaging. Measurements of the cross-sectional area (CSA) of the iliopsoas and paraspinals on both sides at mid-discal level were made at several levels, concentrating on the affected as well as nearby non-affected levels.

Outcome Measures

The shift in paraspinal and iliopsoas muscle CSA following surgery served as the main outcome measure. Strength of multifidi at different levels was evaluated by the experienced physiotherapist, blinded to the surgical procedure. Other parameters, including duration of surgery, postoperative complications, and hospital stay, were evaluated as secondary outcomes. Along with that, the reoperation incision size for both procedures was also documented.

Statistical Analysis

SPSS version 26 was used for analyzing the data. Descriptive statistics such as mean and standard deviation were employed for continuous and numerical variables. while the percentages and frequencies were used to analyze the categorical data. For intergroup associations, chi-square test (for categorical variables), parametric test (independent sample t test), and the non-parametric test, such as the Mann-Whitney U test (for continuous variables), were conducted. A p-value less than 0.05 was considered statistically significant.

RESULTS

Demographics and Patient Characteristics

480 patients had lumbar discectomies; 247 were operated on for percutaneous full endoscopic lumbar discectomy (PFED), and 233 had microdiscectomies (MD). In the PFED group, there were 130 males and 117 females, whereas the MD group included 120 males and 113 females. The mean age of patients in the MD group was 41.8 ± 4.2 years, while in the PFED group it was 42.5 years. A variety of occupations were noted, with 148(60%) of patients living sedentary lifestyles, 62(25%) working in physical labor, and 15% working in offices among the PFED group. Whereas in the MD group, 128(55%) had a sedentary lifestyle, 79(34%) were manual laborers, and 26(11%) were office workers; however, the between-group difference was statistically non-significant among all demographic variables.

Table 1: *Demographic Characteristics of Study Participants.*

Characteristic	***PFED Group***	***MD Group***	***p-value***
Total Number of Patients	247	233	-
Gender Distribution (Male/Female)	130/117	120/113	0.741
Mean Age (Years)	42.5 ±4.2	41.8 ±3.7	0.186
Occupation (%):			
Sedentary	148(60%)	128(55%)	0.696
Manual Labor	62 (25%)	79(34%)	
Office work	37(15%)	26(11%)	

Radiological Outcomes of Muscle Mass between PFED and MD

The changes in muscle cross-sectional area for the psoas and paraspinal muscles on both sides from the pre-operative period to the 1-year post-operative follow-up are compared across the groups in Table 2. Each participant's change score was determined by comparing their pre-operative and post-operative measurements. The MD and PFED groups' mean change and standard deviation are presented.

The independent sample t-test was used to examine differences in change scores across groups. When compared to the MD group, the PFED group showed considerably larger increases in paraspinal muscle cross-sectional area on both the left and right sides ($p < 0.001$). The right psoas muscle also showed a significant between-group difference, with the PFED group showing more improvement ($p = 0.038$).

Table 2: *Between-Group Comparison of Change in Muscle Cross-Sectional Area from Pre-Operative to 1-Year Post-Operative Follow-up (Independent Simple T Test).*

Muscle	Side	MD Change (Mean ± SD)	PFED Change (Mean ± SD)	t-value	P value
Psoas	Right	−24.28 ± 51.9	+94.21 ± 45.3	2.07	0.038
	Left	−41.51 ± 58.7	+59.28 ± 48.6	1.20	0.23
Paraspinal	Right	−144.88 ± 76.4	+133.84 ± 69.2	3.30	0.001
	Left	−112.74 ± 72.9	+126.97 ± 63.5	3.09	0.002

Strength of Multifidi Comparison between PFED and MD Evaluated through MMT

Table 3: *Multifidi Muscle Strength Comparison (MMT Score).*

Lumbar Level	PFED Group (Mean MMT Score)	MD Group (Mean MMT Score)	P value	Mann-Whitney U Test
L3-L4	4.8	3.9	0.012	10450
L4-L5	5.2	4.2	0.004	9820
L5-S1	4.5	3.8	0.025	10830

An analysis of multifidus muscle strength at various lumbar spine levels revealed that PFED was associated with stronger results than MD. The muscle strength was measured through Manual Muscle testing. There is a statistically significant difference between the mean muscle strength scores ($p<0.05$) at each assessed level that favors PFED, as evident in Table 3.

Table 4: *Incision Size after Reoperation Comparison.*

Reoperation Incision Size (cm)	PFED Group	MD Group	P value	Mann-Whitney U test
Mean Size	8mm	3cm	<0.001	8400

Amount of Incision Required After Reoperation: Comparison Between PFED and MD

A more minimally invasive and tissue-preserving strategy is suggested by the examination of incision size following reoperation, which shows a substantial reduction in incision size in the PFED group compared to MD. The mean Reoperation Incision Size reported for the PFED group was 8mm, as compared to the MD group (3cm) (Table 4).

DISCUSSION

Our study's primary objective was to determine whether percutaneous full endoscopic lumbar discectomy (PFED) or microdiscectomy (MD) is superior in terms of radiologically evident muscle sparring. Our results showed the different benefits of PFED as compared to MD, such as the preservation of paraspinal muscle mass, the strength of multifidi muscles, and a reduction in the size of the incision.

Analysis of the present study exposed that the PFED and MD groups showed different variations in the change in muscle cross-sectional area from pre-operative to a year post-operative follow-up. The right psoas muscle strengthened significantly in the PFED group (+94.21) and declined in the MD group (-24.28), with a substantial difference of $p=0.038$ across the groups. The left-sided psoas muscle weakened in the MD group (-41.51) and improved in the PFED group (+59.28); however, the result was not statistically significant ($p = 0.23$), indicating specific side variability. The substantial effects were detected in the paraspinal muscles, with PFED causing considerable increases on the right (+133.84) and left (+126.97) sides, whereas the MD group showed major decreases. The differences were significant (p = 0.001). These data show that during one year, PFED is more successful at preserving or increasing psoas and paraspinal muscle mass, with paraspinal musculature gaining the most. Clinically, greater spinal support, decreased pain after surgery, and more rapid physical recovery may result from better stability of these muscles, indicating the significance of muscle-sparing surgical methods for long-term results.

A cohort analysis confirms our findings that PFED improves muscle mass [15]. Percutaneous full endoscopic lumbar discectomy (PFED) is thought to be a more muscle-saving procedure than standard microdiscectomy (MD). To preserve the surrounding tissues, PFED makes small incisions and uses minimally invasive techniques.[16] Furthermore, a muscle-sparing approach is frequently used in PFED to protect muscle integrity and reduce muscle atrophy after surgery.[17] Patients who receive PFED experience less postoperative discomfort and an immediate recovery.[18] Furthermore, by decreasing tissue disturbance, PFED maintains spinal stability and enhances maintenance of paraspinal muscle function.[19]

Furthermore, a recent examination of multifidus strength of muscles via Manual Muscle Testing (MMT) revealed frequently and statistically significantly greater strength measurements in the PEED cohort at all evaluated lumbar levels [L3-L4 (4.8 vs.3.9, p=0.012), L4-L5 (5.2 vs.4.2, p=0.004), and L5-S1 (4.5 vs. 3.8, p=0.025)]. This is consistent with the results of Kim DY, who also reported better results in terms of muscle strength after PFED as opposed to MD.[20] Furthermore, as indicated by a previous comparative study, the biomechanical benefits of this technique in maintaining spine stability and function are supported by the observed increase in multifidus muscle strength with PFED.[21] These results were consistent with one of the previous findings which reported that patients who underwent the open surgical method experienced an average decrease of 5.4% in paraspinal muscle CSA (SD = 10.6%; range, -24.5% to +7.7%), whereas those treated with minimally invasive endoscopic discectomy (MEDS) showed an average increase of 9.9% (SD = 14.4%; range, -9.8% to +33.1%) (P = 0.02).[22,23] This is because the multifidi muscles are the primary stabilizers for the spine that maintain biomechanical stability, and due to various reasons, they can be credited with describing the upgrading of the strength of muscles following PFED. PFED's minimally invasive nature allows for accurate targeting of the injured disc while minimizing disruption to surrounding muscles, particularly the multifidus muscle.[24]

After the evaluation of the amount of incision needed following reoperation between microdiscectomy (MD) and percutaneous full endoscopic lumbar discectomy (PFED), our research showed that the PFED group had a significantly smaller incision than the MD group. The present study showed that a smaller incision size was required in the PDED group as compared to patients undergoing MD. The mean operation incision size for PEED was 8mm (0.8cm), compared to 3cm for MD (p<0.001), accentuating that the minimally invasive benefits of PEED spread predominantly to any consequent technique. These findings are in accordance with the earlier studies investigating the same outcome.[25,26] Decreased tissue stress and smaller incision size are reported in several studies supporting our findings further.[27,28,29] The decreased incision size is linked to greater clinical importance, including decreased discomfort following surgery, quicker healing, and decreased risk of complications, including tissue damage and infections. Additionally, cosmetic results and patient satisfaction are some other benefits associated with decreased incision size.[30]

The retrospective design of our study, along with a smaller sample size, which may cause potential selection bias, reducing the generalizability of findings, is one of the limitations of the study.

CONCLUSION

Radiological findings confirmed the superior. muscle-preserving capacity of PFED compared to MD. Enhanced multifidus muscle strength and smaller reoperation incisions further demonstrated its minimally invasive benefits, contributing to less surgical pain, faster recovery, and better cosmetic results.

RECOMMENDATIONS

Studies incorporating a prospective study design along with a larger sample size and extended follow-up durations are needed to confirm the hypothesis. Furthermore, research that includes other outcome measures such as pain, functional improvement, and patient subjective satisfaction following PFED and MD would help us better understand the subject.

Disclosure Statement

The investigators of the current study stated that no financial assistance or other supplementary support was obtained for the research and article production.

REFERENCES

1. Soares RO, Astur N, Rabello de Oliveira L, Kanas M, Wajchenberg M, Martins DE. Qualitative Evaluation of Paraspinal Musculature After Minimally Invasive Lumbar Decompression: A Prospective Study. International journal of spine surgery. 2024;18(4):448-54. Doi: 10.14444/8631
2. Tabaraee E, Ahn J, Bohl DD, Phillips FM, Singh KJIjoss. Quantification of multifidus atrophy and fatty infiltration following a minimally invasive microdiscectomy. 2015;9. Doi: 10.14444/2025
3. Taylor HP, Richards SW, Khan N, McGregor AH, Al-Aghband-Zadeh J, Hughes SP. The impact of self-retaining retractors on the paraspinal muscles during posterior spinal surgery. In Orthopaedic Proceedings 2002 (Vol. 84, No. SUPP_II, pp. 143-144). Bone & Joint. Doi: 10.1097/01.BRS.0000035728.24284.6D
4. Mayer TG, Vanharanta H, Gatchel RJ, et al. Comparison of CT scan muscle measurements and isokinetic trunk strength in postoperative patients. Spine. 1989;14(1):33–36. Doi: 10.1097/00007632- 198901000-00006.
5. Han G, Wu H, Dai J, Li X, Yue L, Fan Z, et al. Does paraspinal muscle morphometry predict functional status and re-operation after lumbar spinal surgery? A systematic review and meta-analysis. 2023;33(8):5269-81. Doi: 10.1007/s00330-023-09548-6
6. An JW, Kim HS, Raorane HD, Hung WP, Jang IT. Postoperative paraspinal muscles assessment after endoscopic stenosis lumbar decompression: magnetic resonance imaging study. International Journal of Spine Surgery. 2022 ;16(2):353-60. Doi: 10.14444/8217.
7. Kumar M, Baklanov A, Chopin D. Correlation between sagittal plane changes and adjacent segment degeneration following lumbar spine fusion. European spine journal. 2001;10(4):314-9. Doi: 10.1007/s005860000239.
8. Kim M, Kim HS, Oh SW, Adsul NM, Singh R, Kashlan ON, Noh JH, Jang IT, Oh SH. Evolution of spinal endoscopic surgery. Neurospine. 2019 ;16(1):6. Doi: 10.14245/ns.1836322.161
9. Kim M, Lee S, Kim HS, Park S, Shim SY, Lim DJ. A comparison of percutaneous endoscopic lumbar discectomy and open lumbar microdiscectomy for lumbar disc herniation in the Korean: a meta-analysis. BioMed research international. 2018 ;2018. Doi: 10.1155/2018/9073460.
10. Ayaz SB, Matee S, Gill ZA, Khan AA. The diagnostic dilemma of progressive muscular atrophy. Journal of the College of Physicians and Surgeons Pakistan. 2015 ;25(2):149-50. PMID: 25703763
11. Pang D, Yang J, Hai Y, Fan Z, Gao H, Yin PJFiS. Changes in paraspinal muscles and facet joints after percutaneous endoscopic transforaminal lumbar interbody fusion for the treatment of lumbar spinal stenosis: A 3-year follow-up. 2022;9:1041105. Doi: 10.3389/fsurg.2022.1041105
12. Kawaguchi, Yoshiharu MD; Matsui, Hisao MD; Tsuji, Haruo MD. Back Muscle Injury After Posterior Lumbar Spine Surgery: Part 2. SPINE 19(22):p 2598-2602,1994. Doi: 10.1097/00007632-199411001-00018
13. Aly TJASJ. Back muscles injury during posterior

lumbar spine surgeries: minimally invasive versus open approaches—a review of the literature. 2022;41(2):61-72.
Doi: 10.57055/2314-8969.1259
14. Flores AP, Feijoo PG, Guerrero AI. Paraspinal muscle atrophy after posterior lumbar surgery with and without pedicle screw fixation with the classic technique. Neurocirugía (English Edition). 2019;30(2):69-76. Doi: 10.1016
15. Kim HS, Wu PH. Comparative cohort study of paraspinal muscle volume change between uniportal full endoscopic and mini open posterolateral transforaminal lumbar interbody fusion. InSeminars in Spine Surgery 2024(p. 101081). WB Saunders.
Doi: 10.21203/rs.3.rs-1943082/v1
16. Jang JW, Lee DG, Park CK. Rationale and advantages of endoscopic spine surgery. International Journal of Spine Surgery. 2021;15(suppl. 3):S11-20.
Doi: 10.14444/8160
17. Giordan E, Drago G, Zanata R, Marton E, Del Verme JJIJoSS. The correlation between paraspinal muscular morphology, spinopelvic parameters, and back pain: a comparative cohort study. 2023;17(5):627-37. Doi: 10.14444/8531
18. Gengyu H, Jinyue D, Chunjie G, Bo Z, Yu J, Jiaming L, et al. The predictive value of preoperative paraspinal muscle morphometry on complications after lumbar surgery: a systematic review. 2022;31(2):364-79.
Doi: 10.1007/s00586-021-07052-3
19. Choi DJ, Kim JE. Efficacy of biportal endoscopic spine surgery for lumbar spinal stenosis. Clinics in orthopedic surgery. 2019;11(1):82-8.
Doi: 10.4055/cios.2019.11.1.82
20. Hasan S, Hofstetter CP. Endoscopic spine surgery: Past, present, and future. Bulletin of the NYU Hospital for Joint Diseases. 2019;77(1):75-84.
PMID: 30865869
21. Kim DY, Lee SH, Chung SK, Lee HY. Comparison of multifidus muscle atrophy and trunk extension muscle strength: Percutaneous: Versus: Open pedicle screw fixation. Spine. 2005;30(1):123-9.
PMID: 15626992
22. Fan S, Hu Z, Zhao F, Zhao X, Huang Y, Fang X. Multifidus muscle changes and clinical effects of one-level posterior lumbar interbody fusion: minimally invasive procedure versus conventional open approach. European spine journal. 2010;19:316-24. Doi: 10.1007/s00586-009-1191-6.
23. Sun K, Qin R, Wang W, Jiao G, Sun G, Chen G, et al. Multifidus fat infiltration negatively influences the postoperative outcomes in lumbar disc herniation following transforaminal approach percutaneous endoscopic lumbar discectomy. 2025;30(1):47.
Doi: 10.1186/s40001-025-02283-2
24. He W, He D, Sun Y, Xing Y, Liu M, Wen J, et al. Quantitative analysis of paraspinal muscle atrophy after oblique lateral interbody fusion alone vs. combined with percutaneous pedicle screw fixation in patients with spondylolisthesis. 2020;21(1):30.
Doi: 10.1186/s12891-020-3051-9
25. Bresnahan LE, Smith JS, Ogden AT, Quinn S, Cybulski GR, Simonian N, Natarajan RN, Fessler RD, Fessler RG. Assessment of paraspinal muscle cross-sectional area after lumbar decompression. Clinical spine surgery. 2017;30(3):E162-8.
Doi: 10.1097/BSD.0000000000000038.
26. Kim HS, Wu PH, Jang IT. Current and future of endoscopic spine surgery: what are the common procedures we have now and what lies ahead? World Neurosurgery. 2020 ;140:642-53.
Doi: 10.1016/j.wneu.2020.03.111.
27. Ahn Y. Current techniques of endoscopic decompression in spine surgery. Annals of Translational Medicine. 2019;7(Suppl 5).
Doi: 10.21037/atm.2019.07.98.
28. Gadjradj PS, Depauw PR, Schutte PJ, Vreeling AW, Harhangi BS. Body image and cosmesis after percutaneous transforaminal endoscopic discectomy versus conventional open microdiscectomy for sciatica. Global Spine Journal. 2022:21925682221105271.
Doi: 10.1177/21925682221105271.
29. Choi KC, Kim JS, Lee DC, Park CK. Percutaneous endoscopic lumbar discectomy: minimally invasive technique for multiple episodes of lumbar disc herniation. BMC musculoskeletal disorders. 2017;18(1):329. Doi: 10.1186/s12891-017-1697-8
30. Çelik M, Karaoğlu A, Çekinmez M, Karataş G. Investigation Of The Role Of Multifidus Muscles In The Development of Recurrent Lumbar Disc Herniation. Europeanatolia Health Sciences Journal. 2025;3(1):8-16. Doi: 10.5281/zenodo.15183996

Additional Information

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AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to the Paper in Terms of
1.	Muhammad Farooq	1. Study design, methodology, and Literature review and referencing.
2.	Naeem ul Haq	2. Paper write-up, editing, and quality assurance.
3.	M. Farooq & Mumtaz Ali	3. Data collection & calculations, analysis of data & interpretation of results.
4.	Ali Shah Jehan	4. Editing and referencing.