v1: 20 October 2023

Review Article

Costs of Full Endoscopic Spine Surgery: A Narrative Review

Peer-approved: 20 October 2023

Qeios, Vol. 5 (2023)
ISSN: 2632-3834

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Purpose
The purpose of this narrative review was to summarize the current literature reporting costs of full endoscopic spine surgery (FESS).
Methods
Studies assessing costs in FESS written in English were included. PubMed and Embase databases were screened by the authors. Data regarding costs were extracted and reported in the current review.
Results
Nine studies were included. Seven studies were retrospective comparative, and 2 were randomized-controlled trials. The studies included treatment of lumbar disc herniation (LDH), lumbar spinal stenosis (LSS), and cervical disc herniation (CDH). Eight studies reported a comparison of FESS to open microscopic surgery. Four of them reported lower total costs in FESS. The methodologies used for cost analysis exhibited heterogeneity in terms of both the data source and accounting methodology. Length of hospital stay (LOS) and type of anesthesia consistently affected total costs.
Conclusion
Included studies report inconsistent results regarding total costs of FESS compared to open microscopic surgery. LOS and type of anesthesia seem to be the two main cost drivers. As endoscopic surgery continues to gain popularity, further research is needed to evaluate the long-term cost-effectiveness and impact on patient outcomes; however, a standardization of the methodology of cost analysis is warranted.

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Introduction

Full endoscopic spine surgery (FESS) has gained increasing popularity in recent years, although there are notable differences in its adoption across countries. Supporters of this technique have reported promising outcomes, including faster recovery time, reduced pain, and better health-related quality of life in surgery for lumbar disc herniation (LDH) [1][2], compared to open surgery. Similarly, encouraging results have been reported for the treatment of lumbar stenosis [3][4], thoracic disc herniation [5][6] and cervical disorders [7][8].

Prior research has highlighted the increasing costs associated with spine surgery and emphasized the significance of conducting cost analyses and cost-effectiveness studies [9][10]. Despite the potential benefits of FESS, there are concerns regarding potentially higher costs compared to traditional open or microscopic spine surgery. One of the primary factors affecting the costs of FESS is the required equipment. Endoscopes and other surgical instruments used in endoscopic surgery are typically more expensive than those used in traditional open surgery [11]. However, proponents of FESS argue that the reduced hospital

 doi.org/10.32388/5KQ4XA.2

stay, faster recovery time, use of local anesthesia, and decreased postoperative pain medication usage can offset the initial costs of the equipment and training. In fact, the length of hospital stay after FESS may be shorter compared to traditional open spine surgery. Besides this, the learning curve required to gain enough familiarity with the procedures in order to deliver reproducible outcomes affects the duration of surgery and costs of FESS [12]. Several studies evaluating the costs and the effectiveness of endoscopic spinal surgery have been published. However, many studies exhibited contradicting results and highly heterogeneous data, which makes it difficult to draw a final conclusion.

Therefore, the aim of this narrative review was to summarize the current literature reporting the costs of FESS.

Methods

Search Strategy and Article Selection

The last search of the literature was performed on March 23rd, 2023, on the PubMed and Embase databases with the following string: ("spine surgery" OR "spinal surgery" OR spine OR spinal) AND ("full-endoscopic" OR "full endoscopic" OR endoscopic*) AND (cost* OR expense* OR economic*).

Studies assessing costs as a primary or secondary outcome in patients undergoing FESS were considered for inclusion. Conference abstracts and studies in a language other than English were excluded.

The initial screening of articles was conducted based on their titles and abstracts. If eligibility could not be determined from the initial screening, the full text of the articles was obtained and evaluated. Two authors (F.M. and D.C.) performed the article selection independently, and a final summary was obtained by consensus between them.

Data regarding costs were extracted while maintaining the currency denomination reported in the original study. The percentage of difference in costs between procedures was calculated if not provided by the authors.

Results

The initial search identified 859 records (Embase=609; PubMed=250). After duplicates were removed, 670 records were screened, and 26 eligible reports were assessed. Nine studies were finally included (Table 1). Seven studies were retrospective comparative, and 2 were randomized-controlled trials. Seven studies investigated outcomes in patients undergoing surgery for single-level LDH, one included patients with lumbar spinal stenosis (LSS), and one included patients with cervical disc herniation (CDH). All of the studies excluded revision surgeries, as well as patients with cauda-equina syndrome.

Cost analysis was the primary outcome in 4 of the included studies. The methodologies used for cost analysis exhibited heterogeneity in terms of both the data source and accounting methodology. Total hospital costs were reported in all of the studies; however, only some studies reported a more detailed description of cost entries, as well as subdivision into direct and indirect costs. Direct costs referred to those expenses that were directly related to the procedure, including the cost of medical supplies, equipment, medications, and personnel, as well as any preoperative and postoperative in-hospital care that was required. Indirect costs included the cost of time lost from work and costs associated with the societal impact of the treatment (loss of income, loss of productivity).

Studies investigating costs as the primary outcome

Gadjradj et al.[13] compared costs between transforaminal endoscopic lumbar discectomy (TELD) and microscopic discectomy (MD). The authors investigated direct and indirect costs of TELD for LDH. Direct costs included an estimation of surgical costs derived from hospital accounting records, healthcare utilization, and medication use. Surgical costs included the time in the operating room, medications during surgery, and hospital stay. Indirect costs included absenteeism, reduced work productivity, unpaid productivity, and informal care costs. Subjects undergoing TELD (n=133) were treated as outpatients in 94.2% of cases, while those undergoing MD (n=183) were usually discharged the day after surgery. 133 (TELD) vs. 183 (MD) complete cost data. Costs of surgery were 9.9% higher for TELD than for MD (TELD, 4'500.00 EUR; MD, 4'095.00 EUR). All other costs were lower in TELD. Total costs (direct and indirect) were 14.4% lower in TELD (TELD, 15'090.00 EUR; MD, 17'633.00 EUR). The authors concluded that TELD is more cost-effective compared to MD in patients treated for LDH.

Only one study investigated the costs of FESS in patients affected by LSS. Cheung et al.[14] compared 160 patients undergoing lumbar endoscopic unilateral laminotomy for bilateral decompression (LE-ULBD) with 161 patients undergoing microscopic decompression. The type of anesthesia was not

reported. Costs were retrieved from hospital data, however, without further clarification of the source. They reported an increase in costs of 8.8% in the LE-ULBD group (LE-ULBD, 33′304.00 HKD; Microscopic decompression, 30′614.00 HKD). The difference was mainly due to 2′500.00 HKD for endoscopic instruments.

Choi et al.[15] compared costs between three different full-endoscopic techniques (TELD, interlaminar endoscopic lumbar discectomy (IELD), unilateral biportal endoscopic lumbar discectomy (UBELD)) and MD in patients with single-level LDH. Direct costs were further divided into primary (operation, anesthesia, surgical equipment and material, hospital stay, physical therapy, nursing care, pain management, and other drugs) and secondary (sum of costs associated with reoperation or readmission). The source of data was not disclosed. Indirect costs consisted of work loss costs and were estimated from missed work days and average annual wages in South Korea. TELD was the only one performed under local anesthesia, and the hospital duration was the shortest (TELD, 3.6 ±5.7; IELD, 5.7 ±4.5; UBELD, 5.8 ±3.8; MD, 8.7 ±3.7), resulting in significantly lower primary costs compared to MD. IELD and UBELD were performed either under general or epidural anesthesia. Primary costs were significantly lower only in TELD compared to MD (TELD, 2′997.80 USD; IELD, 3′629.30 USD; UBED, 3′642.40 USD; MD, 3′926.20 USD). Costs of surgical equipment were similar: 1’251.70 USD for FESS and 1’179.80 USD for MD.

Wang et al.[16] investigated costs of two different endoscopic approaches, TELD and IELD, in patients undergoing surgery for LDH at the L5-S1 level. They reported direct costs (i.e., hospitalization costs, surgical expenses, cost of anesthesia, surgical equipment and material costs, drug costs, and physician costs) and indirect costs (i.e., missed time from work). The source of data was the billing/financial department. The TELD group included 50 patients, while the IELD group included 25. They found no significant difference in total costs between the two groups (TELD, 5′275.60 USD; IELD, 5′494.40 USD). Surgical equipment and material costs and the cost of anesthesia were significantly higher in the IELD group (surgical equipment: TELD, 3′354.60 USD; IELD, 3′437.90 USD; cost of anesthesia: TELD, 65.80 USD; IELD, 171.20 USD). However, the type of anesthesia was different between the two groups, preferring local or epidural in the TELD group, and epidural or general in the IELD group.

Studies investigating costs as a secondary outcome

Ünsal et al.[17] performed a retrospective study including 40 patients undergoing lumbar discectomy for LDH between 2017 and 2019. Surgeries were performed in a private hospital setting. Patients were subgrouped as follows: 10 underwent IELD in local anesthesia, 10 IELD in general anesthesia, 10 MD in spinal anesthesia, and 10 MD under general anesthesia. MD in general anesthesia was the most expensive procedure (total direct costs: 1′249.50 USD in IELD local anesthesia, 1′741.50 USD in IELD general anesthesia, 2’015.60 USD in MD spinal anesthesia, 2’348.70 USD in MD general anesthesia). The surgeon's cost impacted the most (IELD, 814.60 USD; MD, 1’037.00 USD), representing 47-65% of total costs of IELD and 44-51% of MD. Surgical equipment costs were 57% lower in IELD (IELD, 56.90 USD; MD, 133.20 USD). However, their cost analysis did not account for expensive disposables, such as radiofrequency electrodes, nor other specific endoscopic instruments. Additionally, the analysis did not consider the depreciation of equipment, such as microscopes, endoscopes, or radiofrequency/shaver systems. This resulted in costs of equipment of only 3-4% of total costs in IELD and 6-7% in MD. Patients undergoing MD in general anesthesia had the highest mean hospital fee (462.20 USD), which was 3.6 times higher than IELD in local anesthesia (129.50 USD) and 2.4 times higher than IELD in general anesthesia. The mean operative time was shorter in IELD groups; however, this did not affect the costs significantly.

Wang et al.[18] compared 45 patients undergoing TELD to 25 patients undergoing MD. TELD was performed under local anesthesia, while MD was performed under general anesthesia. They reported hospitalization costs, but the source of data was not specified. Mean operative time and hospital stay were significantly shorter in TELD, as well as lower bleeding. Hospitalization costs were 23.4% lower in TELD (TELD, 8′319.20 CNY; MD, 10′855.80 CNY).

In a 12-month randomized controlled trial (RCT), Chen et al.[19] also investigated surgical costs and total hospitalization costs by comparing TELD in local anesthesia (80 patients) to tubular MD under spinal/epidural anesthesia (73 patients) in subjects with single-level LDH. However, neither the authors reported details regarding what surgical costs and total hospitalization costs included, nor was the source of data disclosed. Surgical costs were 2.94 times and total hospitalization costs 1.65 times higher in TELD. It is worth noting the long length of stay reported in both

groups. The mean length of stay in the TELD group was 8.1 ±4.2 days, and 11.2 ±3.8 days in the MD group.

Liu et al.[20] conducted a retrospective comparative study investigating differences between TELD and MD (each group consisting of 60 patients). No details regarding the source of data for costs were outlined. TELD was performed under local anesthesia combined with sedation, while MD was performed under general anesthesia. Total costs related to TELD were 25.9% higher than MD (TELD, 22863.87 CNY; MD, 18152.75 CNY). As pointed out when discussing the study by Chen et al., the duration of hospital stay was pretty long in both groups and significantly shorter in the TELD group (TELD, 5.42 days ±5.08; MD, 10.58 days ±3.69).

Only one study by Wang et al.[21] reported on costs of endoscopic surgery of the cervical spine. They compared unilateral biportal endoscopic cervical discectomy (UBECD) to microendoscopic-assisted discectomy (MED) for the treatment of foraminal cervical disc herniation. Total hospitalization costs were 29.4% higher in the UBECD group (UBECD, 24'090.00 CNY; MED, 18'620.00 CNY).

Discussion

Since its introduction, FESS has undergone relevant improvements and gained much popularity, though its acceptance and spreading have disparities across countries[22]. FESS appears to be at least non-inferior to open, mini-open, and microscopic surgical treatments for common spinal pathologies in terms of clinical outcomes. [1][2][23]. This narrative review aimed to summarize the literature regarding costs in FESS.

Comparing FESS to open microscopic surgery, 4 studies reported lower total costs in FESS[13][15][17][18], and 4 studies the opposite[14],[19]-[21]. However, the heterogeneity in cost analysis across the studies should be strongly highlighted. In fact, the methodology was often unclear and inconsistent. In a previous systematic review published in 2014, Alvin et al. emphasized the lack of standardization in collecting data regarding expenses in spinal surgery, resulting in inaccuracies when comparing cost-effectiveness across different procedures.

A critical evaluation of cost analysis across the included studies showed that the length of hospital stay had the greatest impact on overall costs, without affecting clinical outcomes. Most patients undergoing FESS had a shorter hospital stay than controls and were often discharged on the day of surgery. Although MD is feasible as day surgery [24][25], none of the authors managed cases undergoing MD as outpatients, generating a bias that affects the comparison to FESS. Length of stay and cost of the surgical procedure were significantly affected by the type of anesthesia performed. This is well highlighted by the study by Choi et al. reporting on three different full-endoscopic techniques (TELD, IELD, UBELD) and MD. TELD was the only one performed under local anesthesia, and the hospital duration was the shortest. As a result, TELD was the only one significantly less expensive than MD, much rather due to the influence of anesthesia costs rather than the costs of the surgery itself. Although previous studies have shown the feasibility of performing MD under local anesthesia [26], general anesthesia is commonly adopted in most centers. Besides the type of anesthesia, length of stay is often affected by other factors that hinder an objective assessment, such as the socio-economic background of patients, regional habits, surgeon biases, and preferences. Furthermore, in order for hospitals to receive full payment from the health-care system (government or insurances), a minimum length of stay is required by reimbursement systems like the Diagnosis Related Group (DRG).

Considering the studies that reported a breakdown of costs, it is still challenging to determine the differences in expenses for surgical equipment alone. This is again due to the lack of standardization and missing details regarding what the term "surgical equipment" entails. Furthermore, costs of equipment may also be affected by agreements with device companies as well as by their market policy in different countries. It should also be emphasized that none of the studies reported any amortization of expensive instruments, such as a microscope or radiofrequency generator, as well as the depreciation of these instruments and other reusable items. Although we acknowledge the complexity of such analysis, this should also be considered when comparing full-endoscopic to microscopic surgery.

Further limitations should be pointed out. Most of the included studies were retrospective. Apart from one study assessing full-endoscopic decompression in LSS and one assessing cervical posterior discectomy, all other studies included only patients affected by LDH. As previously stated, methodology was inconsistent among the different studies, and details regarding the source of data were often omitted. Moreover, in most studies, it was unclear whether the costs reported were based on fixed rates or actual expenses.

This review highlighted significant heterogeneity in methodology. Hence, FESS cannot be considered less expensive than microscopic surgery, yet it seems that

FESS can reduce the LOS, thus lowering the total hospital costs. In light of the insights of this narrative review, a standardization of cost analysis is warranted to promote comparison of expenses and cost-effectiveness across different studies.

Conclusion

The costs of FESS may exhibit insignificant cost differences regarding the surgical intervention when compared to microscopic surgery. However, considering the cost reduction of anesthesia and LOS, which seem to represent the two main cost drivers, the overall cost of FESS may be lower when compared to microscopic surgery. Current results, however, are limited by the methodology of cost analysis, which is too heterogeneous and results, therefore, inconsistent. Studies featuring high-quality data with a direct cost-effectiveness analysis across several countries will be needed to give a definitive answer to this question.anesthesia

doi.org/10.32388/5KQ4XA.2

Author (year)	Country	Journal	Study design	Spinal disorder	Groups	Results
Gadjradj et al.[14] 2021	Netherlands	British Journal of Sports Medicine	RCT	LDH	TELD, MD	TELD less expensive
Cheung et al.[15] 2020	Hong Kong	Journal of Spine Surgery	Retrospective comparative	LSS	LE-ULBD, Microdecompression	LE-ULBD more expensive
Choi et al.[16] 2019	South Korea	The Spine Journal	Retrospective comparative	LDH	TELD, IELD, UBELD, MD	Only TELD significantly less expensive than MD
Wang et al.[17] 2019	China	Spine	Retrospective comparative	LDH	TELD, IELD	No difference in total costs
Ünsal et al.[18] 2021	Turkey	Clinical Neuroscience	Retrospective comparative	LDH	IELD, MD	IELD less expensive
Wang et al.[19] 2022	China	Orthopaedic Surgery	Retrospective comparative	LDH	TELD, MD	TELD less expensive
Chen et al.[20] 2018	China	Journal of Neurosurgery: Spine	RCT	LDH	TELD, MD	TELD more expensive
Liu et al.[21] 2021	China	Orthopaedic Surgery	Retrospective comparative	LDH	TELD, MD	TELD more expensive
Wang et al.[22] 2023	China	Medicina	Retrospective comparative	CDH	UBECD, MED	UBECD more expensive

Table 1. Overview of included studies. RCT: randomized controlled trial; LDH: lumbar disc herniation; TELD: transforaminal endoscopic lumbar discectomy; MD: microscopic discectomy; IELD: interlaminar endoscopic lumbar discectomy; LE-ULBD: lumbar endoscopic unilateral laminotomy for bilateral decompression; UBELD: unilateral biportal endoscopic lumbar discectomy; LSS: lumbar spinal stenosis; CDH: cervical disc herniation; MED: microendoscopic-assisted discectomy.

Statements and Declarations

The authors declare that they have no conflict of interest.

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Supplementary data: available at https://doi.org/10.32388/5KQ4XA.2

Declarations

Funding: No specific funding was received for this work.
Potential competing interests: No potential competing interests to declare.