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REVIEW ARTICLE

Transforaminal endoscopic surgery for lumbar stenosis: a systematic review

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Abstract Transforaminal endoscopic techniques have become increasingly popular in surgery of patients with lumbar stenosis. The literature has not yet been systematically reviewed. A comprehensive systematic literature review up to November 2009 to assess the effectiveness of transforaminal endoscopic surgery in patients with symptomatic lumbar stenosis was made. Two reviewers independently checked all retrieved titles and abstracts and relevant full text articles for inclusion criteria. Included articles were assessed for quality, and relevant data, including outcomes, were extracted by two reviewers independently. No randomized controlled trials were identified, but seven observational studies. The studies were of poor methodological quality and heterogeneous regarding patient selection, indications, operation techniques, follow-up period and outcome measures. Overall, 69–83% reported the outcome as satisfactory and a complication rate of 0–8.3%. The reported re-operation rate varied from 0 to 20%. At present, there is no valid evidence from randomized controlled trials on the effectiveness of transforaminal endoscopic surgery for lumbar stenosis. Randomized controlled trials comparing transforaminal endoscopic surgery with other surgical techniques are direly needed.

Keywords Lumbar · Foraminal · Lateral recess stenosis · Transforaminal · Endoscopic surgery · Minimally invasive surgery · Systematic review

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Introduction

Already in 1950, Verbiest [1] described the syndrome associated with narrowing of the lumbar spinal canal. Individuals with lumbar spinal stenosis frequently report clinical symptoms such as neurogenic claudication or sciatica with or without low back pain. Lumbar spinal stenosis may occur as a result of degenerative, developmental or congenital disorder. The degenerative type often originates due to arthritic changes of the intervertebral disc, facet joints or ligaments surrounding the vertebral canal or due to vertebral slippage (spondylolisthesis). Degenerative stenosis most often occurs in older individuals, especially in those 50–60 years of age [2–4]. Developmental spinal stenosis is a condition in which the narrow spinal canal is caused by growth disturbance of the posterior elements in the spinal canal [5]. Patients with the congenital type usually complain early in life. Their stenosis is a result of congenitally anatomic malformation

[2, 4]. Controversy exists with regard to clinical symptomatology, radiological diagnosis and choice of treatment. Patients are usually first managed with conservative therapies, such as physical therapy, education and NSAIDs [6, 7].

Also weight loss may result in relief of symptoms [8]. Failure of conservative treatment is an indication for considering surgical intervention. Open decompression laminotomy via a posterior approach is the most widely performed surgical procedure for decompression of radiculopathy caused by lumbar stenosis. This approach involves stripping of the paraspinal muscles and resection of the lamina or medial pars of the facet joint. The posterolateral endoscopic approach was originally developed for the removal of the herniated lumbar discs. Kambin and Gellmann in 1973 in the United States and Hijikata in Japan in 1975 independently developed a non visualized, posterolateral percutaneous central nucleotomy for the resection and evacuation of nuclear tissue via a posterolateral approach [9, 10]. With improvement of endoscopes with working channels for different instruments and variable angled lenses, the procedure became more refined, and consequently, other types of indications were considered for endoscopic surgery. In order to reach the posterior part of the epidural space, the superior articular process of the facet joint is usually the obstacle. Yeung and Knight used a holmium-YAG (Yttrium–Aluminium–Garnet)-laser to achieve tissue ablation of bony and soft tissue, like nuclear and annular fibres, for decompression and enhanced access [10, 11]. To improve intracanal visualization and operative access, the foraminal window is medially extended and widened towards the spinal canal. At present a systematic review evaluating the effectiveness of transforaminal endoscopic surgery for lumbar stenosis is lacking.

Methods

Objective

The objective of this systematic review was to assess the effectiveness of transforaminal endoscopic surgery for patients with symptomatic lumbar stenosis. For this systematic review we used the method guidelines as recommended by the Cochrane Back Review Group [13].

Search strategy

An experienced librarian performed a comprehensive systematic literature search. The MEDLINE and EMBASE databases were searched for relevant literature from 1973 to November 2009. The search strategy consisted of a combination of keywords concerning the technical procedure and keywords regarding the anatomical features and pathology (Table 1). These keywords were used as MESH headings and free text words. The full search strategy is available upon request.

Table 1 Selection of terms used in our search strategy

Technical procedure	Anatomical features/ pathology
Endoscopy	Spine
Arthroscopy	Back
Video-assisted surgery	Back pain
Surgical procedures, minimally invasive	Spinal diseases
Microsurgery	Spinal cord compression
Transforaminal	Sciatica
Percutaneous	Radiculopathy
Foraminotomy	Stenosis
Foraminoplasty	Osteophytosis
Discoscopy	Spondylarthritis
	Spondylitis
	Spondylolisthesis

Selection of the studies

The search was limited to identifying studies published in English, German and Dutch languages. As only a limited number or no randomized controlled trials were expected, also non-randomized controlled and observational studies (cohort studies, case control studies and retrospective patient series) were included. Furthermore, the following inclusion criteria were used: the population should consist of adult patients with symptomatic lumbar stenosis (at least $n = 5$); the follow-up period should be at least 6 weeks; and the intervention should be transforaminal endoscopic surgery. Two review authors independently examined all titles and abstracts yielded by the search strategy and reviewed full publications when necessary. Additionally, the reference sections of all included full text studies were inspected.

Data extraction

Two review authors independently extracted relevant data from the included studies regarding study design, study population (e.g. age, gender, duration of complaints before surgery, etc.), type of surgery, type of control intervention, follow-up period and outcomes. Primary outcomes that were considered relevant are listed in Table 2.

Methodological quality assessment

The methodological quality of the observational studies was assessed using five criteria (Tables 3, 4 describes the operationalization of the individual criteria). These criteria

Table 2 Outcome measures and instruments

Outcome measure	Measure instrument
Pain	Visual analogue score (VAS)
Functional status	Oswestry disability index (ODI)
Global perceived effect (GPE)	MacNab score
Return to work	Sick leave
Other	Patient satisfaction, complications, re-operation.

Table 3 Criteria list for quality assessment of non-controlled studies

A	Patient selection/inclusion adequately described?	Y	N	?
B	Dropout rate described?	Y	N	?
C	Independent assessor?	Y	N	?
D	Co-interventions described?	Y	N	?
E	Was the timing of the outcome assessment similar?	Y	N	?

Table 4 Operationalization of the quality criteria

A: All the basic elements of the study population are adequately described; i.e. demography, type and level of disorder, physical and radiological inclusion and exclusion criteria, pre-operative treatment and duration of disorder

B: Are the number of patients who dropped out adequately described and the reason for dropping out

C: Were outcomes assessed by an independent person who was not involved in selection and treatment of patients

D: All co-interventions in the population during and after the operation are described

E: Timing of outcome assessment should be more or less identical for all intervention groups and individuals and for all important outcome measures

are a modification of the criteria list recommended by the Cochrane Back review group [13]. Disagreements were resolved in a consensus meeting and a third review author was consulted if necessary.

Data analysis

In order to assess the effectiveness of transforaminal endoscopic surgery the results of all relevant outcome measures were extracted from the original studies. If a study reported several follow-up intervals, the outcome of the longest follow-up moment was used. Because of the heterogeneity between study populations (e.g. different indications for surgery), technical differences of the various endoscopic interventions, and differences in outcome measures, instruments and follow-up moments, statistical pooling was not performed. We present the median and range (min–max) of the results of the individual studies for each outcome measure.

Table 5 Methodological quality of the included studies

Study	A	B	C	D	E	Risk of bias
Ahn et al. [14]	0	1	0	0	0	High
Chiu [15]	1	0	0	0	0	High
Haufe et al. [16]	0	1	0	0	0	High
Kambin et al. [17]	0	1	0	1	0	High
Knight [18]	0	1	0	0	1	High
Leu and Schreiber [20] and Schreiber and Leu [19]	0	0	0	0	0	High
Savitz [21]	0	0	0	0	0	High

Results

Search and selection

2,513 references were identified. After checking titles and abstracts, a total of 123 full text articles were retrieved. Reviewing the reference lists of these articles resulted in 17 additional references. After scrutinizing all 140 full text papers, a total of seven patient cohort studies were included in this review. No randomized controlled studies were identified.

Type of studies and methodological quality

Three prospective studies and four retrospective studies were included. Table 5 presents the methodological quality of the included studies. All studies had a high risk of bias. Only one study had an adequate description of the selection criteria. None of the studies had used an independent assessor, one had an adequate description of co-interventions and one described similar timing of outcome assessment.

Outcome

Table 6 includes a description of the study characteristics and outcomes.

Ahn et al. [14] ($n = 12$) described the effectiveness of posterolateral endoscopic lumbar foraminoplasty for foraminal exit stenosis with or without disc herniation of the L5–S1 level. The authors removed part of the hypertrophied superior facet, thickened ligamentum flavum and protruded disc using a bone reamer, endoscopic forceps and laser. Widening the foramen provided decompression and enhanced working space. Most patients were elderly individuals that suffered from severe osteoporosis and some could not tolerate the general anaesthesia required for decompression and fusion surgery. At the 13-month follow-up, the outcomes for general improvement were 83% satisfactory (33% excellent, 50% good), 8.3% fair and

Table 6 Study characteristics and outcome

Study	Demographic	In-exclusion	Intervention instrumentation	Follow up/outcome
Ahn et al. [14]	*n* = 12 ♀7 ♂5	*Inclusion criteria*	Posterolateral percutaneous endoscopic lumbar foraminotomy (PELF)	Follow up 13 months (range 6–20)
Retrospective	Mean 57 years range 34–88	Unilateral leg pain,	Level L5–S1	*GPE* (MacNab) 33% excellent, 50% good, 8.3% poor
		Effective nerve root block	Reamer, forceps, laser	*Complications* 0%
		Lateral exit zone stenosis with or without LDH	*Instrumentation not specified*	*Re-operation* 8.3%
		Exclusion criteria		
		Segmental instability		
		Spondylolytic spondylolisthesis		
		Painless weakness		
		Cauda equina syndrome		
Chiu [15]	*n* = 2,000 ♀990 ♂1,010	*Inclusion criteria*	Transforaminal microdecompressive endoscopic assisted discectomy (TF-MEAD)	*Follow up* 42 months (range 6–72)
Retrospective	mean 44 years range 24–92	Radiculopathy	Laser, forceps	*GPE* (not specified) 94% excellent or good, 3% poor
		Neurological deficit	*Karl Stortz instrumentation*	*Complications* 1%
		symptoms of spinal claudication,		*Re-operations* not specified
		LDH and lat stenosis and degenerative changes Spondylolytic spondylolisthesis		
		Single and multiple level		
		Exclusion criteria		
		Cauda equine syndrome, painless motor deficit, tumours		
Haufe et al. [16]	*n* = 64 ♀27 ♂37	*Inclusion criteria*	Endoscopic foraminoplasty	*Follow up* 38 months (range 24–45)
Prospective	median 62 years	Radiculopathy	Level: not specified	*GPE* (change in VAS) 66%: 75–100% improvement, 16% no improvement or worse outcome
	range 32–90	Foraminal stenosis,	Electrocautery and holmium laser, drills	
		intervertebral disc or bony compression	*Instrumentation not specified*	GPE (change in ODI) 59%: 75–100% improvement, 16% no improvement or worse outcome
		Exclusion criteria		
		Prior spinal surgery		*Complications* 3% (dural leak)
				Re-operations not specified
Kambin et al. [17]	*n* = 40 ♀15 ♂23	*Inclusion criteria*	Transforaminal arthroscopic decompression	*Follow up* 36 months (range 16–74), 5% drop out
Prospective	mean 44 years range 20–73	Radiculopathy	Level: L2–S1	*GPE* (not specified) 82% satisfactory, 18% failure
		Neurological deficit	Trephine, forceps	*Return to work* 87%
		Positive tension signs	*Kambin instrumentation*	*Complications* 7.9%
		lateral recess stenosis and LDH		*Re-operations* 5.2%
		Exclusion criteria		
		Narrowing intervertebral disc		
		facet atrophy causing foraminal stenosis		

Table 6 continued

Study	Demographic	In-exclusion	Intervention instrumentation	Follow up/outcome
Knight [18] Prospective	$n = 24$ ♀12 ♂12 mean 42 years range 22–72	*Inclusion criteria* Gr 1–3 istmic listhesis Back/buttock/leg pain *Exclusion criteria* Spinal abnormality, congenital kyphosis, osteoporosis, postsurgical, posttraumatic, pathological listhesis, infection, degenerative listhesis	Endoscopic laser foraminoplasty (ELF) Level L4–S1 Laser *YESS, Richard Wolf instrumentation*	*Follow up* 34 months (range 24–46) 0% drop out *Pain leg* (VAS) pre-op 54, follow up 17, difference 37 = 69% *Pain back* (VAS) pre-op 64, follow up 25, difference 39 = 61% *Pain buttock* (VAS) pre-op 60, follow up 18, difference 42 = 70% *GPE* (VAS + ODI > 50%) 79% *Functional disability* (ODI) pre-op 69, follow up 21, difference 48 = 70% *Complications* 8.3% *Re-operation* 13%
Leu and Schreiber [20] and Schreiber and Leu [19] Retrospective	$n = 82$ Described as a subgroup of $n = 174$ ♀68 ♂106 mean 39 years range 16–81	*Inclusion criteria* Radiculopathy Neurological deficit Narrow spinal canal Spondylolysis Olisthesis Previous same level open surgery *Exclusion criteria* Free sequestrations Segmental instability	Percutaneous nucleotomy with discoscopy Level L4–S1 *Modified Hijikata instrumentation*	*Follow up mean* 28 months *GPE* (Balgrist-nucleotomy score) 69% excellent or good *Complications* not specified *Re-operation* 20%
Savitz [21] Retrospective	$n = 20$ ♀6 ♂14 60–82 years	*Inclusion criteria* Radiculitis and radiculopathy + stenotic canal. No numbness, weakness, pain while walking LDH + canal stenosis *Exclusion criteria* Not specified	Percutaneous endoscopic discectomy $n = 8$ Microsurgical discectomy $n = 12$ Level L3–S1 single *Forceps, laser* *Kambin instrumentation*	*Follow up* >24 months *Complications* 0% *Re-operations* 0%

8.3% poor. No complications were reported. The re-operation rate was 8.3%.

Chiu [15] ($n = 2{,}000$) described transforaminal endoscopic laser decompression for a wide variety of indications (i.e. lumbar disc herniations, epidural scarring, lateral recess and foraminal stenosis, and advanced degenerative changes like spondylolytic spondylolisthesis). Outcomes were not reported separately for the various indications. At 42 months of follow-up the results for general improvement were 94% satisfactory outcome ('excellent' and 'good' were not reported separately). The reported complication rate was 1%. No information was reported on the number of re-operations.

Haufe et al. [16] described the results of 64 patients who underwent endoscopic laminoforaminoplasty for refractory foraminal stenosis. Patients with stenosis due to either intervertebral disc or bony compression were included and were treated with an identical operative procedure to decompress the foraminal canal. At a median follow-up of 42 months, 59% of patients had at least 75% improvement in Oswestry Disability Index and 66% had at least 75% improvement in VAS scores. Dural leaks occurred in two patients, which were repaired intraoperatively. No other adverse events occurred.

Kambin [17] ($n = 40$) described the effectiveness of endoscopic decompression for lateral recess stenosis. At 36 months of follow-up the results for general improvement showed that 82% had a satisfactory outcome and 18% was considered a failure, but it was unclear how this was defined. Furthermore, at 3-year follow-up 87% had returned to work. The complication rate was 7.9 and 5.2% re-operations were reported.

Knight [18] ($n = 24$) included patients with chronic complaints due to symptomatic isthmic spondylolitis: grade I ($n = 14$), grade II ($n = 9$) and grade III ($n = 1$). They were operated by posterolateral endoscopic foraminal decompression with laser-assisted bone and soft tissue ablation. Elements causing distortion, compression, traction or irritation of the nerve were ablated confirmed by immediate pain relief by the wakeful patient. At 34 months of follow-up the mean improvements in pain (VAS) were 69% leg, 61% back and 70% buttock. The outcome of functional disability (ODI) improved on average by 70%. The 13% who failed to improve after posterolateral endoscopic foraminal decompression responded sufficiently to open decompression.

Schreiber and Leu [19, 20] ($n = 174$) assessed the effectiveness of percutaneous nucleotomy with discoscopy. Results were separately presented for patients with an isolated lumbar disc herniation ($n = 92$) and patients with concomitant lumbar pathology ($n = 82$) (e.g. spondylolysthesis/olisthesis, narrow spinal canal or former open low back surgery). In the group with concomitant lumbar pathology, the outcomes on global perceived effect was 69% satisfactory ('excellent' and 'good' were not reported separately) after a mean follow-up of 28 months.

Savitz [21] ($n = 20$) assessed the effectiveness of percutaneous endoscopic discectomy ($n = 8$) and open microdiscectomy ($n = 12$) retrospectively for symptomatic lumbar disc herniations in the presence of a stenotic spinal canal. After 1-year follow-up only the re-operation rates were reported; none of the 20 patients required additional decompression.

Other studies [22–24] that were found describing foraminal stenosis as an inclusion criterion did not report the results such that enabled extracting data specifically for patients with lumbar stenosis.

Discussion

In the current review, the available evidence regarding the effectiveness of transforaminal endoscopic surgery for lumbar stenosis was systematically identified and summarized. No randomized controlled trial, but only seven observational studies were identified that had a high risk of bias. Consequently, there is no valid evidence on the effectiveness of transforaminal endoscopic surgery for lumbar stenosis.

There are a number of issues that need to be considered. The included studies in this review were heterogeneous with regard to the selection of patients, the indications for surgery, the surgical techniques used and the duration of follow up. Furthermore, the sample sizes of most studies were small and different outcome measures were used.

Central stenosis

Central lumbar stenosis can be managed by decompression laminotomy or laminectomy. A fusion procedure with or without instrumentation may be performed at the same time to prevent instability [25]. In a review by Postacchini, satisfactory outcomes of 52–67%, leg pain improvement of 82% and back pain improvement of 71% were reported after decompressive surgery with or without fusion techniques. In the current review, three studies [15, 20, 21] included patients with a narrow spinal canal, but outcomes were not reported separately for this subgroup. Therefore, the results of the current review cannot be compared with the outcomes as reported for the decompression laminotomy or laminectomy.

Lateral stenosis

Pure osteoligamentous lateral stenosis is a fairly uncommon condition. Lateral stenosis is commonly seen in

association with global bulging of intervertebral discs, osteophytosis of the vertebral bodies and articular processes, narrowing of the intervertebral disc height, calcification of the posterior ligament and its foraminal expansion. Developmental conditions such as short pedicles and spondylolisthesis can also cause lateral recess stenosis [17]. Lateral lumbar stenosis is mostly surgically managed by decompression of the nerve root emerging from the thecal sac along its entire course in the radicular canal by means of unilateral laminotomy with or without medial facetectomy [25]. Postacchini [25] reported satisfactory results from several studies of patients with lateral stenosis after laminotomy of 79–93%. In the current review, we found satisfactory outcomes of 83% after transforaminal endoscopic surgery in patients with lateral stenosis [14, 17].

The possible advantages of transforaminal endoscopic surgery are described in many articles. The procedure can be performed in an outpatient or day-surgery setting. Because of the small incision and minimal internal tissue damage, the rehabilitation period is supposed to be shorter and scar tissue fewer. The procedure can be performed in wakeful patients under local anaesthesia and conscious sedation, thereby avoiding the risk of general anaesthesia especially for elderly and infirm individuals [26, 27]. Despite these potential advantages, disadvantages are also reported. Transforaminal endoscopic surgery has a steep learning curve that requires patience and experience, especially for those unfamiliar with percutaneous techniques. Some patients may experience local anaesthesia as a disadvantage. The current study seems to suggest that after transforaminal endoscopic surgery 69–83% of the patients experience a satisfactory outcome.

Unfortunately, no randomized controlled studies directly comparing the transforaminal endoscopic surgery with the most appropriate alternative were indentified. It would be timely to perform high-quality randomized controlled trials comparing transforaminal endoscopic surgery for lumbar stenosis with other surgical techniques, with an adequate duration of follow-up that is at least 2 years. For future trials, we strongly recommend following the CONSORT statement [28] and the use of well validated and reliable outcome measurement tools and cut-off values [29, 30].

Conclusion

This systematic review assessed the effectiveness of transforaminal endoscopic surgery for patients with lumbar stenosis. Seven observational studies were found. The studies were of low methodological quality and heterogeneous regarding patient selection, indications, operation techniques, follow-up period and outcome measures. No randomized controlled trial was identified. Consequently, there is no valid evidence on the effectiveness of transforaminal endoscopic surgery for lumbar stenosis.

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