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Review

Transforaminal endoscopic spinal surgery: The future 'gold standard' for discectomy? – A review

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ABSTRACT

Background: Lumbar disc prolapse is common and the primary method of care in most centres is still open discectomy facilitated by microscope or loupe magnification and illumination. Hospitalisation may be less than 24 h, but post-operative pain usually requires an overnight stay. This review describes transforaminal endoscopic spinal surgery (TESS) using HD-video technology, that is generally performed as a day case procedure under sedation or light general anaesthesia, and collates the evidence comparing the technique to microdiscectomy.

Methods: The method of TESS is described and an electronic literature search performed to identify papers reporting clinical outcomes. International data were translated where necessary and proceedings' abstracts included. In addition, papers held by the authors and colleagues in personal libraries were carefully cross-referenced to the obtained database.

Results: Analysis of the data supports the use of a transforaminal endoscopic approach to the lumbar intervertebral disc and suggests that outcomes following surgery are at least equivalent to those following microdiscectomy. Significant cost-savings in terms of in-patient stay may be generated. In addition, there is also some evidence supporting endoscopic surgery for relief of foraminal stenosis.

Conclusion: Based on current evidence there are good arguments supporting a more widespread adoption of transforaminal endoscopic surgery for the treatment of lumbar disc prolapse with or without foraminal stenosis.

Introduction

Lumbar disc herniation, with a reported prevalence of 1–3%[1] is the commonest pathological process leading to spinal surgery. However, despite dramatic advancements in minimally invasive surgery in other fields, the treatment of disc prolapse in many centres has made only small advances since the initial description of the pathology in the early 1930s.[2,3] This is a recognition of the fact that laminotomy and discectomy produce good to excellent results in up to 90% of patients, even without use of an operating microscope.[4] However, whether a ten percent failure rate from an

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invasive procedure, producing significant epidural scarring, is acceptable in the 21st Century is a matter for debate. This is especially the case if newer methods are associated with a shorter hospital stay and lower cost base.

The first attempt to improve matters was in the 1960's, when chymopapain injection was introduced as an alternative to lumbar discectomy. There was evidence of a satisfactory outcome in approximately 75% of treated patients but strong evidence from randomized controlled trials suggested that although more effective than placebo, chemonucleolysis was less effective than discectomy.[5] These facts, combined with concerns regarding an allergic response to chymopapain limited sales from the pharmaceutical companies leading eventually to cessation of compound production.

In the 1970s, similar 75% rates of success were reported following percutaneous dorso-lateral nucleotomy,[6] leading to the availability of a plethora of mechanical devices in the 1980's that would core out the centre of the disc relieving pressure on the exiting root. Outcomes never unfortunately reach those of standard discectomy.[1–9] and even advanced techniques using laser to vaporize the nucleus and lay open the foramen (endoscopic laser foraminoplasty) have not been widely adopted.[10–12] These methods did however lay a base for the current revolution in care that results from access through the safe extraforaminal working zone,[6] improved arthroscopic equipment and high definition video.[13–15]

Surgical approach and technique for transforaminal endoscopic spinal surgery

Operating technique

The operation is possible with the patient lying laterally or prone. Optimal positioning of the patient is essential. The authors prefer the lateral position for the following reasons. Firstly, a pillow under the waist will open up the foramen and allow the dura to fall down to the contra-lateral side avoiding damage on introduction of the cannula. Secondly, the reduced intra-abdominal pressure will decrease bleeding. This is especially important in larger patients. Thirdly, and perhaps of greatest importance, it is easier for the surgeon to maintain verbal contact with the patient (Fig. 1).

We generally advise that the procedure is performed under sedation and local anaesthesia rather than general anaesthesia. The patient is then able to warn the surgeon if instrumentation impinges on a nerve root. It is essential to have orthogonal bi-planar imaging (AP and Lateral) with an image intensifier and confirmation of the position of any annular tear, protrusion and/or sequestrated disc material may be obtained by intra-operative discography.

The position of the iliac crest is marked and a line is drawn along the spinous processes. With X-ray guidance, a line is then drawn on the skin in line with the isthmus of the lamina to the upper backside of the lower vertebral body. Local anaesthesia is administered and an 18 guage needle then introduced between 10 and 15 cm from the midline of the spine, to the disc herniation, passing over the anterior side of the isthmus. One should aim at a position a few millimetres medial of the medial interpedicular line through the caudal part of the foramen (as low through the foramen as possible). The position of the needle is checked in two planes during its introduction with the image intensifier. After the tip of the needle has reached the correct position, a discogram may be performed, if required, to further delineate the pathology and a guide wire introduced (Figs. 2,3).

A small skin incision of 8 mm is then made and the needle removed leaving the guide-wire in situ. A 2 mm conical rod is introduced over the guiding wire, and then sequentially the first, second and third sleeves (guiding tubes) dilating the soft tissues to 6.5 mm. At the levels L4/L5 and L5/S1 the procedure is usually carried out close to the iliac crest. Passing the iliac crest may be painful and it is recommended that extra anaesthetic is placed down to the iliac crest at this stage.

The second and third sleeves are then removed and over the first sleeve, the first of sequentially larger reamers introduced anti clockwise, to avoid damage to the spinal muscles as shown in Fig. 4. The patient is told to alert the surgeon if he or she experiences pain. In the case of L4/5 and L5/S1 herniations this is usually localised under the knee. Occasionally, pain is felt in the trochanteric region during reaming or in the proximal upper lateral leg, although more commonly the patient is comfortable and can talk to a member of the team.

Continuously checking with the image intensifier the lamina may then be reamed (cutting clockwise) and the reamer advanced safely to 1 or 2 mm inside the medial pedicular line. The procedure is repeated with each of the sequentially larger rods, tubes and reamers. The working cannula can be introduced over the third conical rod. Its tip should be located on the herniated disc (Fig. 5).

The endoscope may now be introduced and the hernia removed (Fig. 6). Sometimes a large sequestered disc can be removed immediately, but in most cases the disc fragments have to be taken out with small forceps. The patient should be asked to confirm that no pain is being experienced on leg movements. After removing the hernia the working cannula is also removed and the skin is closed with a subcutaneous suture and a steristrip. Two hours following surgery the patient can mobilise and be discharged home.

Figure 1 – Theatre set-up.

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Figure 2 – Guide wire placement.

Current literature

Methods of review

A systematic literature review of Pubmed, Google scholar, Cinahl and Cochrane library databases was performed for articles, including randomized trials (RCTs), controlled clinical trials (CCTs) and reviews, up to and including December 2011

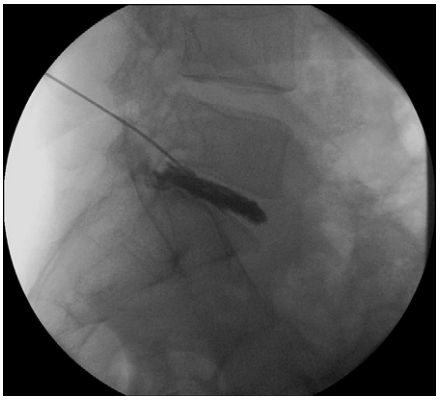

Figure 3 – Discogram showing lateral disc prolapse.

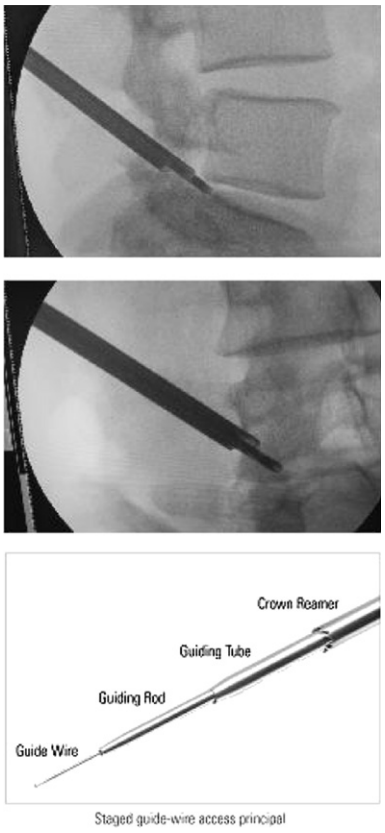

Figure 4 – Spine radiograph showing placement of conical rod, sleeve and reamer.

with the following search terms: endoscopic discectomy, microdiscectomy, transforaminal discectomy, lumbar discectomy, percutaneous discectomy; combinations of the preceding interventions. Proceeding's abstracts were

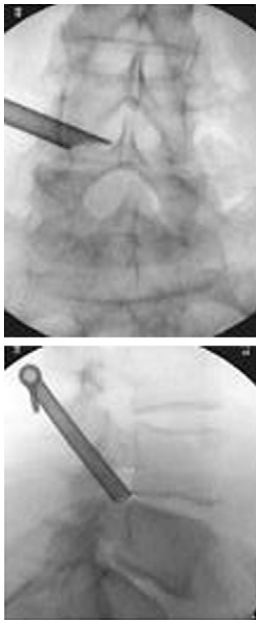

Figure 5 – Placement of working cannula.

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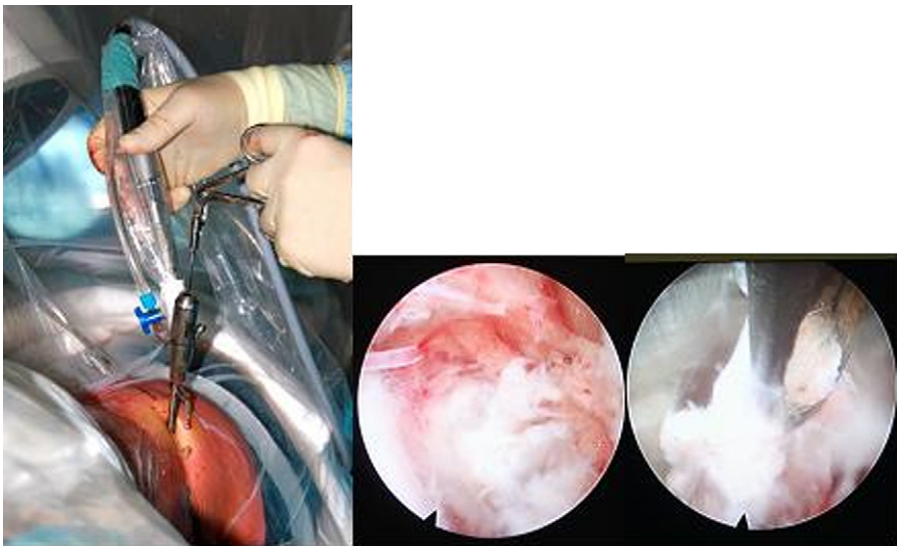

Figure 6 – Endoscopic view.

included. Reference lists from the sourced articles were scanned for other relevant publications. The authors' personal papers and communications were also reviewed and cross-referenced against the main database.

Results

We identified three review articles that covered transforaminal endoscopic spinal surgery as part of their remit. Gotfryd and Avanzi[16] looked at the safety and effectiveness of different discectomy techniques for the treatment of herniated lumbar discs. Karnezis[17] looked at all minimally invasive interventions in the spine, touching on transforaminal endoscopic discectomy as part of a larger review. Nellensteijn and colleagues[18] were the first group to specifically review the literature regarding transforaminal endoscopic discectomy for symptomatic lumbar disc herniations.

We identified seven publications directly comparing the outcomes of traditional microdiscectomy and TESS. Mayer,[19] Hermantin,[20] Krappel[21] and Ruetten[22] carried out randomized or quasi-randomized controlled trials (allocation by a method that was not strictly random: alternation of participants[21,22]) comparing endoscopic and microdiscectomy. These trials had small numbers and only Hermantin's study had a low risk of bias as per the criteria of the Cochrane Back Review group (Table 1).[23] All the trials found benefits in endoscopic surgery over micro discectomy but no statistically significant changes in satisfaction outcomes. Mayer used a direct approach to the disc and showed that patients following percutaneous endoscopic discectomy were more likely to return to work (95% vs 72.2%). After TESS, Hermantin showed a shorter duration of post-operative disability with less need for analgesia and Ruetten showed shorter operating times, more rapid rehabilitation (25 days vs 49 days), lower costs of care and reduced trauma. Krappel suggested that there was less scarring after endoscopic surgery.

A small matched cohort series by Lee et al.[24] showed very successful clinical outcomes in both groups (96.7% in the percutaneous endoscopic discectomy group vs 93.3% in the

Table 1 – Risk of bias of Randomised Studies.[23]

	Mayer 1993	Hermantin 1999	Krappel 2001	Ruetten 2008
Patient number	40	60	40	200
Random sequence generation (selection bias)	U	L	H	H
Allocation concealment (selection bias)	U	L	H	H
Outcome assessment – functional outcomes, pain, clinical outcomes, complications (perfomance bias and detection bias):	L	L	L	L
Outcome assessment – death, re-operation (perfomance bias and detection bias)	L	L	L	L
Incomplete outcome data (attrition bias): death, re-operation	L	L	L	L
Selective reporting (reporting bias)	L	L	L	L
Balance in baseline characteristics	L	L	L	U

Risk of Bias: L = Low, H = High and U = Unclear.

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open microdiscectomy group, $n = 60$) but statistically significant differences in only the radiological parameters. Retrospective comparative studies were published by Kim[25] who compared 295 TESS patients with 607 patients that had a micro discectomy at one institution, and by Iprenburg[26] who compared 255 TESS patients with microdiscectomy patients from the Swedish national spine register. Kim showed similar clinical outcomes from the two techniques. Iprenburg showed the VAS scores for back and leg pain, walking distance and patient satisfaction in the TESS group were significantly better than in the micro discectomy group.

Forty-nine case series which included over 6000 patients who have had TESS were reviewed. These reported a multitude of outcomes including visual analogue scores, Oswestry disability index (ODI), global perceived effects (McNab score), patient satisfaction and quality of life scores. Complications such as recurrence, dural tears and nerve root injuries were monitored. Duration before return to work, rehabilitation required and overall costs were also studied.

Chiu[27] reviewed 2000 patients who underwent transforaminal endoscopic surgery for herniated discs. 94% of the patients had good or excellent results and the morbidity rate was less than 1%. It is not clear what percentage of these patients had percutaneous surgery or open endoscopic surgery.

A number of studies have shown that there is a learning curve with TESS. Wang[28] and Lee[29] have both shown that the complication rate and the requirement for conversion to open techniques vastly decreases after the first twenty cases.

The recurrence rate following TESS at approximately 8% is comparable with the 5% recurrence rate quoted for microdiscectomy.[30] However, recent publications are also now showing improved outcomes in revision surgery in patients that have had recurrence after endoscopic surgery in comparison to those that have recurrence after microdiscectomy.[18–20] This is thought to be due to reduced scarring present after TESS. The risk of dural tear or nerve root injury at 1.1%[31] and 2%[16] respectively also compare favourably to traditionally quoted values for microdiscectomy.

Peng et al.[32,33] have shown that there are significant improvements in quality of life scores (SF-36) and that these improvements correlated with improvements in The North American Spine Society (NASS) score. Allen and Garfin[34] reviewed the literature with regard to the cost effectiveness of minimally invasive spinal surgery in general. They concluded that minimally invasive surgery has the potential to be cost effective provided that the improved clinical outcomes noted in the short term are maintained.

Entry to the spine by the transforaminal approach allows widening of the foramen to relieve foraminal exit stenosis, access to the lateral recess with decompression and soft tissue ablation in patients with spondylolytic defects. Seven observational studies of patients with stenosis were reported by Nellensteijn[35] showing satisfactory outcomes in 69–83% of patients, although no randomised controlled trials were found.

Preliminary results from the Edinburgh RCT

In 2006, a RCT was set up to compare the outcomes of TESS and microdiscectomy at the Royal Infirmary of Edinburgh. The trial was approved by the Regional Ethics Committee and patients randomized to treatment by computer. Patients aged 25–55 years with single level disease, clinical and radiological evidence of nerve root compression and failure of conservative management (including physiotherapy) for six weeks were included. Excluded were those patients of excess weight (>100 kg), with a disc prolapsed above the level of L3/4 or with sequestered fragments >2 cm length, and those with previous disc surgery.

Results from the initial 48 patients have been reported.[36] Three months following surgery leg pain scores had decreased by 55 and 65% in the two groups. Patient satisfaction ratings were equal. ODI had decreased 15 points in both groups by 1 year and this improvement was maintained to 2 years (final scores: 7 ± 3 TESS versus 14 ± 13 Microdiscectomy: means $\pm$ SD; difference at $p < 0.05$: Student's t-test). In-patient stay was lower in the TESS patients with the majority of the later cases being treated as day cases (0.8 ± 0.5 days TESS versus 1.8 ± 1.4 days Micro: means $\pm$ SD). One revision was reported at 12 months (TESS) and one at 18 months (Micro). Two patients presented with a disc prolapse at a different level and side (both TESS).

In the 101 currently recruited patients (Gibson et al. unpublished results: 52 TESS, 49 Micro; 62% L5/S1 level) complications have been rare. Two endoscopy patients complained of excessive pain thought probably due to failure to anaesthetize the iliac wing periosteum that is richly innervated. Greater care was subsequently taken to observe the prescribed anaesthetic protocol[37] and there have been no further complaints in 40 trial and non-trial consecutive surgeries. Five patients (3 TESS, 2 Micro) suffered dysaesthesia persisting for greater than one week after surgery, but in each instance resolving within four weeks. There have been no infections and no patient has had a CSF leak. Four further patients have required revision surgery (1 micro 3 TESS), three of whom chose secondary endoscopy.

Discussion

Our data and other reviews of the medical literature reveal that TESS has short to medium term follow up benefits in comparison to microdiscectomy. This is borne out in good clinical outcomes, high patient satisfaction rate and improvements in quality of life. Patients have less surgical scarring, shorter hospital stay and generally are able to return to work sooner.

Early results from the Edinburgh RCT are very much in line with those reported elsewhere. Improvements in ODI and Physical Function are marked. A higher rate of revision following TESS may be a reflection of the learning curve related to the procedure. Reported rates of revision in the Dutch series[26] have been 5% lower in the second hundred patients treated. In a commentary in the Spine Journal, Benzel and Orr[38] noted that in reference to endoscopic interlaminar discectomy, that the learning curve for the procedure was 'shallow' (the graphical representation showing that the rate of improvement in performing a task as a function of time) rather than steep as suggested by Wang.[28] This is clearly also the case in TESS. The transforaminal approach does pass adjacent to the

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exiting spinal nerve root and it would be expected that a nerve root injury could occur. However, the rate of recorded complications including dysaesthesias (5–10%), persistent sensory deficits (1%) and dural tears (0.3%)[39–41] are certainly no greater than those after open surgery.[3]

In the last five years the quality of the equipment available has dramatically improved, particularly in respect to the arthroscopic instrumentation systems that are now coupled to high definition TV monitors. The development of angled instruments, arthroscopic osteotomes and reamers have all facilitated surgical access. This improves the ability to teach the technique and reduces the exposure of multiple patients to surgeons learning these skills. Access through the transforaminal approach also allows widening of the foramen to ensure that the exiting and traversing nerve roots are free. Although evidence supporting decompression for stenosis in isolation is currently sparse,[35,42] quality endoscopic burrs and shavers will undoubtedly increase the spectrum of conditions routinely treated.

Conclusion

There are now a substantial number of reports supporting the use of the transforaminal endoscopic discectomy. Although still relatively scarce, RCT evidence including our own, suggests that outcomes at least equate and are probably better than those from microdiscectomy in selected patients. The majority of patients are treated in day care facilities leading to cost savings. Minimization of scarring makes secondary surgery easier and is thought to lead to less long term low back pain. We would recommend that surgeons start performing the procedure under experienced guidance, after attending cadaveric workshops.

In East Asia up to 30% of all spinal surgery is now performed by endoscopic techniques. We believe that it is only a matter of time before there is a similar radical shift in the United Kingdom and Ireland.

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Conflict of interest

JNAG and MI have received payments for teaching from Joimax, GmbH, Germany.

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