Efficacy of less invasive posterior lumbar interbody fusion as revision surgery for patients with recurrent symptoms after discectomy

Recurrence of back or leg pain after discectomy is a well-recognised problem with an incidence of up to 28%. Once conservative measures have failed, several surgical options are available and have been tried with varying degrees of success. In this study, 42 patients with recurrent symptoms after discectomy underwent less invasive posterior lumbar interbody fusion (LI-PLIF). Clinical outcome was measured using the Oswestry Disability Index (ODI), Short Form 36 (SF-36) questionnaires and visual analogue scales for back (VAS-BP) and leg pain (VAS-LP). There was a statistically significant improvement in all outcome measures ($p < 0.001$). The debate around which procedure is the most effective for these patients remains controversial.

Our results show that LI-PLIF is as effective as any other surgical procedure. However, given that it is less invasive, we feel that it should be considered as the preferred option.

In this paper we describe the use of less invasive posterior lumbar interbody fusion (LI-PLIF) in revision surgery for patients with recurrent symptoms. To our knowledge, the salient technical aspects of LI-PLIF that facilitate revision surgery have not been previously reported. We hope to challenge the practice and beliefs of those who believe that no further surgical treatment is possible for this condition and rely on pain management.

Patients and Methods
Between January 2002 and December 2008, 42 patients underwent LI-PLIF for recurrent symptoms after a primary discectomy in our unit. This was a prospective observational study including all patients with recurrent severe low back and/or leg pain after a single- or multiple-level discectomy who failed to respond to conservative treatment of at least six months’ duration. Patients with a previous history of infection or malignancy at the affected segment were excluded. Conservative treatment consisted of analgesics, non-steroidal anti-inflammatory drugs (NSAIDs), opiates, muscle relaxants, physiotherapy, a spinal rehabilitation programme and epidural or facet joint steroid injections.

The pre-operative demographics are shown in Table I. The study group consisted of 42 patients (21 men, 21 women) whose mean age at the time of operation was 47 years (32 to 76). The mean follow-up was 32.8 months (5.2 to 73.5). Five patients had a follow-up of...
Table I. Patient demographic factors

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean duration of pre-operative symptoms (mths) (range)</th>
<th>Predominant symptoms (n, %)</th>
<th>Smoking history (n, %)</th>
<th>Working status (n, %)</th>
<th>Others (retired, homemakers etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>96.43 (8 to 420)</td>
<td>Back pain 17 (40.5)</td>
<td>Smoker 12 (28.6)</td>
<td>Working 20 (42.6)</td>
<td>4 (9.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leg pain 6 (14.3)</td>
<td>Ex-smoker 13 (31.0)</td>
<td>Not working + paid leave 18 (42.9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Back and leg pain 19 (45.2)</td>
<td>Non-smoker 17 (40.5)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>History of anxiety/depression (n, %) 13 (31.0)</td>
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less than one year, and when these were excluded the mean duration of follow-up in the remaining 37 patients was 36.4 months (12.0 to 73.5). Eight patients (19.1%) had undergone discectomy on two previous occasions and the rest (n = 34, 80.95%) had one previous operation. We recorded pre-operative smoking and employment status and any previous history of anxiety and depression.

Ethical approval for the study was obtained and all operations were performed by the two senior authors (MK, CB). Each patient underwent a detailed clinical examination and an extensive pre-operative radiological assessment, including plain radiographs and gadolinium-enhanced MRI scans. A CT scan was undertaken for patients in whom MRI was contraindicated. Provocative discography was performed in 11 cases to confirm the level of symptoms.

Once the diagnosis had been confirmed, all patients underwent LI-PLIF surgery at the symptomatic level. The less invasive PLIF technique developed by the senior author (MK) has been previously described and differs from the standard PLIF. A limited posterior midline approach is used. Pedicle screws are inserted under direct vision using the mammillary processes and accessory tubercles as guides before undertaking the decompression. In some cases a percutaneous stab incision is made to allow the screws to be inserted at the correct angle. This allows the main incision to be kept to a minimum. All the posterior midline structures, such as spinous process, supra- and interspinous ligaments, and parts of the lamina and pars, are retained. The disc is exposed by bilateral facetectomies and by removing part of the lamina to expose the pedicle above and below, which allows adequate exploration and decompression of the nerve root. The bone chips obtained in this way are used as graft, as well as bone marrow aspirate from the iliac crest and hydroxyapatite granules in some cases. After a thorough discectomy, the lateral part of the annulus is incised with an osteotome just above the lower pedicle and the most lateral part of the disc mass is removed. This helps to create a triangular window, allowing easy access to the disc space well lateral to the traversing nerve, thereby minimising the need for dural retraction and neural injury. Cutting the tether of the lateral annulus allows sequential distraction of the disc without damaging the endplate. We believe that preserving the endplate is crucial to a successful outcome, as is the placement of the cages in the lateral part of the disc, where the endplates are thickest. This step is essential in revision surgery as it reduces the need to interfere with the midline scar tissue, minimising the risk of damage to dura and nerve. Appropriately sized cages packed with autologous bone graft are inserted on each side, taking care to protect the neural structures (Fig. 1).

Data were collected using the GPOS (Global Patient Outcome System) website (http://www.gpos.info), which is an internet-based database for spinal surgery patients. All patients were registered and provided with user names and passwords, which allowed them to access the website in order to complete pre-operative and follow-up questionnaires. Those without access to GPOS were provided with paper questionnaires and the data were transferred manually to GPOS. Data about the duration of surgery, blood loss, length of stay in hospital and complications were obtained from the medical records.

All patients underwent pre- and post-operative evaluation of pain and functional status using self-administered questionnaires. The intensity of back and leg pain was measured using VAS, functional outcome was assessed using the Oswestry Disability Index (ODI), and overall general health benefit with the Short-Form 36 (SF-36). The SF-36 bodily pain (SF36-BP) dimension was used in this study. Routine post-operative radiographs were performed at the
time of follow-up. However, in a few questionable cases CT scans were obtained to confirm fusion.

Illustrative pre- and post-operative radiological images are shown in Figures 2 and 3.

Statistical analysis was carried out using SPSS 16.0 for Windows (SPSS Inc., Chicago, Illinois). Where the data were skewed, the median is reported as well as the mean. Before applying parametric methods, the data were checked for normality. If there was significant deviation from normality, non-parametric tests were used. The assumptions of statistical tests were verified before use. Statistical significance was set at p < 0.05. The data were checked for normality and confirmed a non-normal distribution; hence non-parametric tests (Wilcoxon and Mann-Whitney U) were used.

Results
A total of 67 levels were fused: 20 patients had a single-level fusion (47.6%), 19 a two-level fusion (45.2%) and three a three-level fusion (7.1%). In the two-level procedures the commonest levels addressed were L4/5 and L5/S1 (17 of 19 revisions). Overall, L5/S1 (n = 34) was the most frequently fused level. The mean duration of the operation was 190 minutes (110 to 260), mean intra-operative blood loss was 456 ml (100 to 1200) and mean duration of hospital stay was 2.63 days (one to ten).

The mean ODI score was 53.5 (SD 13.9, median 56.0) pre-operatively and which had improved to 28.86 (SD 20.6, median 28.0) at final follow-up (p < 0.001). The mean VAS-BP score was 7.39 (SD 1.77, median 8.0) pre-operatively and 4.07 (SD 3.09, median 3.00) at final follow-up (p < 0.001). The mean VAS for leg pain was 6.46 (SD 2.50, median 7.00) pre-operatively and 3.73 (SD 3.07, median 3.00) at follow-up (p < 0.001). The mean SF-36 bodily pain dimension was 26.60 (SD 7.53, median 29.2) pre-operatively and 41.5 (SD 13.7, median 39.3) at follow-up (p < 0.001). A detailed analysis of the clinical outcome measures and their statistical significance is given in Table II. The outcome was not significantly related to smoking status, employment status, gender and history of anxiety/depression (Table III).

Complications occurred in six patients (14.3%); four (9.5%) had a dural tear in association with epidural fibrosis. These were treated by intra-operative repair. These patients had no further complications and were discharged within a mean of 3.75 days (1 to 10). One patient (2.4%) had a superficial infection, which resolved with oral antibiotics; another (2.4%) developed a deep wound infection which settled completely following debridement and antibiotic treatment. Two patients (4.8%) experienced severe leg pain/sciatica during the early post-operative period, which completely settled within three days; this was not classed as a complication. There were no neurological complications.

Discussion
Recurrent low back pain after discectomy may be due to many factors: progressive disc degeneration and fragmentation causing inability to cope with normal mechanical loads,8 a high concentration of inflammatory mediators in the disc space, spondylolytic changes in the intervertebral joint, and osteophyte formation around the vertebral body.8 Recurrent leg pain may be due to referred pain, foraminal stenosis, segmental micro-instability28,29 or epidural fibrosis.1,28,30 Changes can coexist in patients who have undergone discectomy and require revision surgery when conservative measures have failed.

The incidence of further lumbar surgery, which is required after discectomy increases over time, 7.4%14 within one year, 9.5% at four years,31 15% at five years32 and 25% at ten years.14,33 Osterman et al.14 in their population-based study of 35 309 patients who had undergone
discectomy, reported that the risk of having one revision is 14% (n = 4943) and of two is 2.3% (n = 803). However, the cumulative risk of multiple revisions after one re-operation is 25.1% at ten years. Furthermore, the risk of subsequent re-operations depends on the nature of the first revision procedure. This is up to 24.9% when discectomy is the first re-operation, 27.2% for spinal decompression and 37.5% for discectomy and decompression. In the same group, when compared with other procedures, fusion was considerably more successful than other procedures as first revision, with a lower re-revision rate of only 5% at ten-year follow-up. This is important when planning revision after lumbar discectomy because the success rate of revision surgery decreases with successive procedures. It is about 50% at first revision and diminishes to 30% with the second revision procedure, 15% after third and about 5% after fourth. North et al reported that the incidence of instability increases from 12.5% at first revision to 50% at the fourth. These combinations of factors have highlighted the importance of selecting a revision operation with the lowest re-revision rate.

Several surgical techniques have been proposed for the management of patients who have recurrent symptoms after lumbar discectomy. Niemeyer et al, in a retrospective study, reported the clinical and radiological outcomes of 18 patients who had undergone ALIF and nine who had undergone TLIF. At the final follow-up there was a statistically significant improvement in ODI and VAS pain scores, but only seven (28%) had returned to work. The mean blood loss was 1240 ml (250 to 1500) and mean operating time 275 minutes (120 to 645). Six patients (22.2%) had a complication including two who required repair of the common iliac vein, three who developed retrograde ejaculation and one deep wound infection. They concluded that successful outcome is independent of the surgical approach and correlates well with successful fusion. Skaf et al also demonstrated that a successful instrumented posterolateral lumbar fusion using transpedicular screws and bone grafts can achieve a successful outcome. Among 50 prospective patients who had failed primary surgery, those with instability (n = 14) did better with fusion than those with recurrent disc herniation (n = 11), inadequate previous surgery (n = 8) or failure due to fibrosis and adhesions (n = 17). There was no clear information was given about how many patients underwent posterolateral fusion as a revision operation. However, among their fusion patients they reported 50% improvement in symptoms among 92% of patients at one-year follow-up. No data were available for blood loss, operating time and complications.

For patients who suffer from lumbar instability after primary surgery, a successful fusion gives an excellent outcome. Badawy et al achieved an 80% success rate with posterolateral fusion and pedicle screw instrumentation in 25 such patients. All underwent either hemilaminectomy or laminectomy during the primary procedure. Four (13%)
dural tears were reported. The mean operating time was three hours (two to five), mean blood loss 950 ml (500 to 2300) and mean hospital stay eight days (five to 16). However, no objective clinical outcome measures were used. The authors noted a good success rate among patients in whom fusion was obtained.

In our series, the patients had significant improvements in all outcome measures. TheVAS-BP and LP improved by 45% (p < 0.001) and 43% (p < 0.001), respectively, and the ODI and SF-36 bodily pain scores improved by 46% (p < 0.001) and 48% (p < 0.001). A history of smoking, employment status, gender and a previous history of anxiety/depression had little influence on the outcome. The mean blood loss (450 ml) and operating time (190 min) were comparably less than in previous studies involving standard PLIF.14,36 and other revision procedures.18,19 This reduced blood loss is explained by the minimal invasiveness of LI-PLIF. It has been shown that patients often experience reduced blood loss is explained by the minimal invasiveness of LI-PLIF. By contrast, this is rare after LI-PLIF, probably because there has only been minimal retraction of the nerve roots. There were no neurological complications in our patients. The net effect of all these factors is the likely explanation for the shorter hospital stay of our patients compared to those of others.18 Furthermore, the rate of dural tear in our series is well below that quoted in other studies on revision lumbar surgery through a posterior approach.18,19 Even though this is the first study reporting on the efficacy of LI-PLIF on patients with post-discectomy syndrome, there are some limitations, which include the small sample size, the retrospective nature of the study and the lack of a comparison group. However, these are common obstacles for any review of a new surgical technique. Further prospective studies with longer follow-up are needed.

It is our view that the main cause of back pain in these patients is progressive failure of the disc on loading, segmental micro-instability, and a local concentration of inflammatory mediators in the disc space. Leg pain may be caused by a combination of disc herniation and/or foraminal stenosis. We do not believe that epidural fibrosis causes significant pain. To achieve successful clinical results the senior author (MK) believes it is necessary to decompress the neural structures, remove the disc and facets, and restore normal loading across the operated segment.

Based on the above evidence, we believe that revision decompression and/or discectomy alone might lead to further disc degeneration, segmental instability and further symptoms in these patients. In LI-PLIF the excision of the facet joints and the lateral access to the neural structures minimises the risk of neurological injury. Furthermore, this approach has the added advantage of reducing blood loss and operating time, and allows earlier discharge from hospital. The less invasive approach achieves a biomechanically stable spine, as it restores the sagittal balance. Cages packed with bone graft are strategically placed in a load-bearing position, which promotes interbody fusion while the segmental pedicle screw construct acts as a posterior tension band. Our results show that LI-PLIF is as effective as other surgical techniques and, given its added advantages, may represent a better surgical option for patients with recurrent symptoms after discectomy.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


