ABSTRACT

**Purpose.** To evaluate the outcomes, fusion rates, complications, and adjacent segment degeneration associated with transforaminal lumbar interbody fusion (TLIF).

**Methods.** 32 men and 80 women aged 15 to 85 (mean, 57) years underwent 141 fusions (84 one-level, 27 2-level, and one 3-level) and were followed up for 24 to 76 (mean, 33) months. 92% of the patients had degenerative lumbar disease, 15 of whom had had previous lumbar surgery. Radiographic and clinical outcomes were assessed at 2 years. The short-form 36 (SF-36) health survey, visual analogue scale (VAS) for pain, and the modified North American Spine Society (NASS) Low Back Pain Outcome Instrument were used.

**Results.** Of the 141 levels fused, 110 (78%) were fused with remodelling and trabeculae (grade I), and 31 (22%) had intact grafts but were not fully incorporated (grade II). No patient had pseudoarthroses (grade III or IV). For one-level fusions, poorer radiological fusion grades correlated with higher VAS scores for pain (p<0.01). All components of the SF-36, the VAS scores for pain, and the NASS scores improved significantly after TLIF (p<0.01), except for general health in the SF-36 (p=0.59). Improvement from postoperative 6 months to 2 years was not significant, except for physical function (p<0.01) and role function (physical) [p=0.01] in the SF-36. Two years after TLIF, 50% of the patients reported returning to full function, whereas 72% were satisfied. 26 (23%) of the patients had adjacent segment degeneration, but only 4 of them were symptomatic.

**Conclusion.** TLIF is a safe and effective treatment for degenerative lumbar diseases.

**Key words:** spinal fusion; treatment outcome

INTRODUCTION

Transforaminal lumbar interbody fusion (TLIF) is an increasingly popular treatment for degenerative lumbar conditions. Its unilateral posterior approach enables anterior column stabilisation and 360°...
fusion, while reducing the morbidity associated with posterior and anterior lumbar interbody fusion (PLIF and ALIF). We evaluated the outcomes, fusion rates, complications, and adjacent segment degeneration associated with TLIFs.

MATERIALS AND METHODS

From August 2001 to January 2005, 137 consecutive patients who underwent TLIF were prospectively studied. 9 men and 16 women (mean age, 51 years) were lost to follow-up, 8 of whom were from overseas and had returned to their home countries. The remaining 32 men and 80 women aged 15 to 85 (mean, 57) years underwent 141 fusions (84 one-level, 27 2-level, and one 3-level) and were followed up for 24 to 76 (mean, 33) months. They had failed a trial of conservative therapy of at least 3 months; 14 of them had had previous epidural or facet blocks, and 15 had undergone previous lumbar surgery (12 had a laminectomy and/or discectomy and 3 had a fusion). 92% of the patients had degenerative lumbar disease (Table 1).

The bilateral, posterior pedicle screw-rod instrumentation was performed by 3 different spine surgeons using a consistent surgical technique. The patient was placed in a prone position. A midline incision was made, and the posterior elements down to the tips of the transverse processes were exposed subperiosteally. Pedicle screws were placed bilaterally under fluoroscopy. The inferior facet of the cranial vertebra and the superior facet of the caudal vertebra were resected unilaterally to expose the disc. The disc and the cartilaginous endplates of the adjacent vertebra were removed. Two small or one oblique/banana cage filled with autogenous bone graft were placed in the disc space. 94% of cases entailed local bone grafts; 7 cases were augmented with posterior iliac crest grafts. The rods were measured, cut, and inserted. The locking mechanism was then applied, and tightened under compression. The wound was then closed over a drain. Physiotherapy was started the next day; ambulation with a corset was encouraged as long as the pain was tolerable. The drain was removed about 48 hours after surgery. Patients were discharged when independently ambulant, and capable of self-care.

Pre- and post-operative (at 6 months and 2 years) anteroposterior, lateral, and flexion-extension radiographs were assessed by an independent observer. Anterior fusion was assessed using a 4-point grading system (grade I: fused with remodelling and trabeculae [Fig. 1]; grade II: graft intact, not fully remodelled and incorporated, but no lucency present; grade III: graft intact, potential lucency present at top and bottom of graft; grade IV: fusion absent with collapse/resorption of graft).

Clinical outcomes were measured independently by physiotherapists, using the short-form 36 (SF-36) health survey, visual analogue scale (VAS) for back pain and lower-limb pain, and the modified North American Spine Society (NASS) Low Back Pain Outcome Instrument. The NASS questionnaire is modified from the Oswentry Disability Index, which evaluates functional impairment in activities of daily living and physical activities in terms of back pain disability and neurogenic symptom scores. The NASS scores range from 0 to 100; higher scores indicate better outcome. Items relating to patient

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. (%) of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spondylolisthesis</td>
<td>74 (66)</td>
</tr>
<tr>
<td>Degenerative</td>
<td>65 (58)</td>
</tr>
<tr>
<td>Isthmic</td>
<td>7 (6)</td>
</tr>
<tr>
<td>Dysplastic</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Spondylosis</td>
<td>24 (21)</td>
</tr>
<tr>
<td>Degenerative disc disease alone</td>
<td>8 (7)</td>
</tr>
<tr>
<td>With spinal stenosis</td>
<td>16 (14)</td>
</tr>
<tr>
<td>Recurrent prolapsed intervertebral disc</td>
<td>9 (8)</td>
</tr>
<tr>
<td>Degenerative scoliosis</td>
<td>5 (5)</td>
</tr>
</tbody>
</table>

Table 1  Diagnoses of the patients (n=112)

Figure  Grade-I fusion 2 years after transforminal lumbar interbody fusion.
satisfaction (return to full function and treatment meeting expectations) were also explored.

Adjacent segment degeneration was evaluated radiographically and clinically. Preoperative and postoperative 2-year radiographs were compared. Anteroposterior translation, intervertebral disc height, and the degenerative grade at each lumbar segment were recorded. The degree of intervertebral space degeneration was determined qualitatively using the University of California at Los Angeles grading scale, based on the presence of disc-space narrowing, osteophytes, and endplate sclerosis. Any back or lower limb symptoms were also recorded, and magnetic resonance imaging (MRI) was performed for these patients. Radiologically, adjacent segment degeneration was defined as the presence of (1) progression of arthritic grade more apparent in the segments adjacent to the fused segment than that of other segments, or (2) instability in the adjacent segments (defined as spondylolisthesis of >4 mm translation, or segmental kyphosis of >10° on lateral flexion and extension radiographs). Clinically, adjacent segment degeneration was defined as the presence of new symptoms (back pain or lower limb pain), which were confirmed by MRI when radiographic evidence was absent.

Continuous variables were of normal distribution after examining the frequency histograms, skewness and kurtosis. Clinical outcome measures between groups were compared using two-tailed t-tests. A p value of <0.05 was considered statistically significant.

RESULTS

The mean operating time for one-, 2-, and 3-level fusions was 179 (range, 90–375), 228 (range, 155–330), and 255 minutes, respectively. The mean time to ambulation was 3.7 (range, 1–6) days, and the mean length of hospital stay was 7 (range, 3–21) days.

Of the 141 levels fused, 110 (78%) achieved grade-I fusion, and 31 (22%) achieved grade-II fusion. No patient had pseudoarthroses (grade III or IV). Analysing one-level fusion alone, poorer radiological fusion grades correlated with higher VAS scores for pain (p<0.01). Respectively in grade-I and grade-II fusions, the mean VAS scores were 1.2 and 2.7 for back pain and 1.1 and 2.6 for lower limb pain. However, radiological fusion grades were not correlated with NASS scores (p>0.05).

All components of the SF-36, the VAS scores for pain, and the NASS scores improved significantly 6 months and 2 years after TLIF (p<0.01, Table 2), except for SF-36 general health (p=0.59). Improvement from postoperative 6 months to 2 years was not significant, except for physical function (p<0.01) and role function (physical) [p=0.01] in the SF-36. At postoperative 2 years, 59% and 62% of the patients improved >4 points in VAS scores for back pain and lower limb pain, respectively. In NASS scores, 70% and 42% of the patients improved by at least 15% and 30%, respectively.

67% of patients reported returning to full function at 6 months, but this decreased significantly to 50% at 2 years (p=0.01). 76% and 72% of patients were

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Preop</th>
<th>Postop 6 months</th>
<th>Postop 2 years</th>
<th>Improvement from preop to postop 2 years*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean visual analogue score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back pain</td>
<td>7.2</td>
<td>2.3</td>
<td>2.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Lower limb pain</td>
<td>7.8</td>
<td>1.7</td>
<td>2.3</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Mean North American Spine Society score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back pain and disability</td>
<td>52.8</td>
<td>78.0</td>
<td>79.8</td>
<td>27.0</td>
</tr>
<tr>
<td>Neurogenic symptoms</td>
<td>51.8</td>
<td>83.3</td>
<td>80.3</td>
<td>28.5</td>
</tr>
<tr>
<td><strong>Mean Short-Form 36 score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical functioning</td>
<td>40.8</td>
<td>65.5</td>
<td>70.1</td>
<td>29.3</td>
</tr>
<tr>
<td>Role functioning (physical)</td>
<td>23.6</td>
<td>51.7</td>
<td>64.6</td>
<td>41.0</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>31.5</td>
<td>62.2</td>
<td>65.2</td>
<td>33.7</td>
</tr>
<tr>
<td>General health</td>
<td>66.3</td>
<td>70.1</td>
<td>67.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Vitality</td>
<td>54.3</td>
<td>60.0</td>
<td>67.7</td>
<td>13.4</td>
</tr>
<tr>
<td>Social functioning</td>
<td>51.9</td>
<td>80.1</td>
<td>81.7</td>
<td>29.8</td>
</tr>
<tr>
<td>Role functioning (emotional)</td>
<td>57.0</td>
<td>79.5</td>
<td>81.2</td>
<td>24.2</td>
</tr>
<tr>
<td>Mental health</td>
<td>66.1</td>
<td>74.7</td>
<td>81.2</td>
<td>15.1</td>
</tr>
</tbody>
</table>

* p<0.01 in all except for general health in Short Form 36 (p=0.59)
satisfied at 6 months and 2 years, respectively. Three patients had residual debilitating back pain, and 10 patients had residual radiculopathy at the operated levels. Most of these symptoms resolved with time (range, 3–27 months); one patient received epidural steroid injection.

One patient developed a postoperative haematoma within 4 hours of surgery, and developed acute cauda equina syndrome. The clot was evacuated immediately, and the patient made full neurological recovery. There were no other major complications (pseudoarthrosis, implant failure, permanent neurological deficit, acute cardiac event, stroke, pulmonary embolism, or death). The minor complication rate was 14.3% (Table 3). One patient had acute cholecystitis, which resolved after antibiotic therapy. The patient had known gallstones and had an uneventful laparoscopic cholecystectomy one month later. One asthmatic patient had bronchospasm for which intubation was carried out for one day. Three patients had incidental durotomies and underwent primary repair; 2 of whom resolved with bed rest, and one developed cerebrospinal fluid collection, which was treated by surgical drainage and reinforcement with a patch. All 3 patients made a full neurological recovery. Two patients had deep wound infections that were treated with intravenous antibiotics for 4 weeks.

At postoperative 2 years, 26 (23%) of the patients developed adjacent segment degeneration (22 radiographically, 3 clinically [also confirmed by MRI], and one by both). Of the latter 4 patients, 3 had lower limb symptoms and one had mechanical low back pain. Radiographic evidence appeared over 6 to 24 months, whereas clinical symptoms appeared over 18 to 23 months. Adjacent segment degeneration occurred proximally in 18 patients, distally in 4, and both in 4. Of the 30 affected levels, the most commonly affected level was L3/4 (53%), followed by L5/S1 (27%), L2/3 (13%), and L4/5 (7%). The mean NASS neurogenic symptom score was worse in patients with radiographic evidence than in those without (79 vs. 84, p=0.04). However, the 2 groups did not differ in terms of SF-36, NASS back pain disability, and VAS scores for pain (p=0.05). Three of the symptomatic patients received epidural steroid injections. None underwent surgical decompression.

**DISCUSSION**

Biomechanically, TLIF provides anterior column support and a posterior tension band. It can be safely performed via a unilateral posterior approach at any vertebral level. Revision can be through the undisturbed contralateral foramem. TLIF provides adequate surface area for solid anterior fusion. It requires less manipulation of the dura, and therefore is at lower risk of neurological injury and perioperative complications than PLIF. TLIF is also associated with lower surgical morbidity, blood loss, operating time, and costs than ALIF.

In our study, all components of the SF-36 improved significantly after 2 years, except for general health. Most of our patients had co-morbidities, which may offset any improvement. Moreover, there may be psychological effects of poorer general health after a major spine operation. Improvement mostly occurred within the first 6 months and then plateaued until 2 years, except in the physical function and role function (physical) components. This may be due to engagement in more physical activities after improvement in symptoms. Clinical outcomes at 6 months may reflect long-term clinical states, at least up to 2 years.

In our study, the general health component of the SF-36, VAS scores for pain, and NASS neurogenic symptom scores decreased (not significantly) from postoperative 6 months to 2 years. This may be due to adjacent segment degeneration.

In our study, at postoperative 2 years, 72% of patients were satisfied, but only 50% were able to return to full function. This may be due to poor control of co-morbidities or adjacent segment degeneration. Another study reported a similar satisfaction rate of 76%.

Radiographic evaluation may underestimate fusion mass formation, particularly when instrumentation is used. Fusion results of our TLIF patients are comparable with those treated with TLIF and PLIF (89–100%), but the criteria for defining fusion may differ. In one-level fusions, poorer

<table>
<thead>
<tr>
<th>Minor complications after transforaminal lumbar interbody fusion</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>General (8.0%)</td>
<td>9</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>3</td>
</tr>
<tr>
<td>Ileus</td>
<td>2</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>1</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>1</td>
</tr>
<tr>
<td>Acute cholecystitis</td>
<td>1</td>
</tr>
<tr>
<td>Bronchospasm requiring intubation</td>
<td>1</td>
</tr>
<tr>
<td>Specific (6.3%)</td>
<td>7</td>
</tr>
<tr>
<td>Incidental durotomy</td>
<td>3</td>
</tr>
<tr>
<td>Deep wound infection</td>
<td>2</td>
</tr>
<tr>
<td>Superficial wound infection</td>
<td>1</td>
</tr>
<tr>
<td>Superficial wound dehiscence</td>
<td>1</td>
</tr>
</tbody>
</table>
fusion grades correlated with poorer VAS scores for pain (p<0.01) but not NASS scores (p>0.05). This indicated that fusion grades affect pain more than function.

Minor complications rates vary from 20 to 35.3%,,6–8 and a revision rate of 7.6% has been reported. General complications include ileus and pseudomembranous colitis. Specific complications include pseudoarthrosis, pedicle screw malposition, haematoma, symptomatic contralateral disc herniation, dural tears, wound infection, wound dehiscence, seroma formation, donor-site infection, as well as transient and persistent radiculopathy.,2,4,6–8

In our study, no patient had a life-threatening or permanent neurological complication or revision.

Adjacent segment degeneration may be caused by increased stress and hypermobility above a fused segment, in addition to the normal ageing process of the spine. This leads to premature degeneration of the facet joints, and spinal instability. Accompanying facet hypertrophy and thickening of the ligamentum flavum may result in canal or foraminal stenosis in adjacent segments.,10,17 Adjacent segment degeneration adversely affects functional outcomes, and thus long-term follow-up and/or additional surgical intervention are needed. In our study, 26 (23%) of the patients had such condition 2 years after TLIF, but only 4 (3.6%) of them were symptomatic (compared to 3.9% per year reported after posterior lumbar arthrodesis10), despite open instrumentations (as in our patients) being associated with earlier development of adjacent segment degeneration.17 70% of the cases of adjacent segment degeneration developed proximally, which is consistent with another study.18 MRI is better than radiography in picking up adjacent segment degeneration and should be conducted for patients developing new back or lower limb–related symptoms. In those with radiographic adjacent segment degeneration, only the NASS neurogenic symptom score was significantly worse. Other clinical outcomes might also deteriorate with longer follow-up.

In our study, the heterogeneous nature of our patient group was a main limitation. The diagnoses of patients were mixed. Although 8% of patients belonged to the younger isthmic and dysplastic spondylolisthesis group (resulting in better clinical outcomes9), most had degenerative lumbar conditions. Moreover, 15 patients had previous lumbar surgery before TLIF. The implants used were not standardised, owing to surgeons' preferences. 25 patients were lost to follow-up. Nonetheless, the demographics of the study population and those lost to follow-up were not significantly different. There was no control group to compare TLIF with PLIF or ALIF. However, the large number of patients and follow-up of 2 years suggested that TLIF is a safe and effective treatment for degenerative lumbar diseases.

REFERENCES