INTRODUCTION

Posterior lumbar interbody fusion (PLIF) is a widely performed surgical procedure for the management of pain and spinal instability resulting from spondylolisthesis. Posterior instrumentation is frequently used to augment interbody fusion, and pedicle screws with rods are commonly employed for this purpose. However, traditional open PLIF for instrument implantation requires a large midline skin incision and extensive dissection of the paraspinal muscles that can increase the risk of complications over both the short and long term. Furthermore, it is known that medially-oriented pedicle screw placement is necessary to obtain a secure anchor to the sacrum for screw fixation at the L5-S1 level. However, for the conventional midline approach for screw fixation at the L5-S1 level, forceful retraction of the paraspinal muscles is required to achieve the proper lateral-to-medial screw trajectory due to coronal plane angle increase of pedicle. In contrast, both screw fixation via the paraspinal muscle sparing approach and percutaneous screw fixation are known to significantly diminish the risk for complications such as iatrogenic muscle injury and postoperative back pain. Compared to conventional open PLIF, these techniques can reduce intraoperative blood loss, decrease postoperative elevation of pro-inflammatory cytokine levels, and
postoperative back pain. So far, no study has yet addressed the best surgical approach to reduce LBP for L5-S1 spondylolisthesis, which is the less invasive technique. The purpose of this prospective and comparative study was to investigate the safety and efficacy of less invasive techniques for screw fixation, namely the paraspinal muscle sparing approach and percutaneous screw fixation technique, for treating spondylolisthesis at the L5-S1 level.

**MATERIALS AND METHODS**

A total of 20 patients who underwent single level PLIF to treat L5-S1 spondylolisthesis were studied. Patients with chronic illness, or a history of malignancy or infectious disease were excluded from this study. Twenty patients were classified into two groups. Group I consisted of 10 patients (three males and seven females) treated by PLIF using interbody cages and the paraspinal muscle sparing approach for screw fixation. A clear plane was identified between the multifidus medially and the longissimus laterally for placement of pedicle screws. Group II consisted of 10 patients (four males and six females) treated by PLIF using interbody cages and percutaneous screw fixation. Patient outcomes before surgery and 7 days, 1 month, 3 months, and 6 months following the operation, were assessed and radiographs were obtained. Outcomes were measured according to the Low Back Outcome Score (LBOS) normalized to 75 (Table 1). LBP and leg pain were measured separately using a self-assessment 10-point VAS. In addition, modified MacNab's grading criteria were used to assess the subjective patient outcomes 6 months after surgery. Perioperative parameters and complications of each group were analyzed. Radiographs included upright anteroposterior, lateral, and flexion-extension images. Angulation of less than 4° on flexion-extension radiographs and absence of radiolucency were considered to be evidence of fusion course. All patients were instructed to wear a thoraco-lumbo-sacral orthosis (TLSO) when out of bed until 3 months post-surgery.

**Statistical analysis**

Differences in demographic and preoperative data of mean value (MV) and standard deviations (SD) were assessed by analysis of variance for continuous variables and Fisher’s exact test for categorical variables. Differences in continuous outcome measurements between the two groups were evaluated using the analysis of covariance with the preoperative score as the covariate. For assessing the statistical significance of postoperative

| Parameter         | Finding                      | Points | Parameter         | Finding                      | Points |
|-------------------|------------------------------|--------|-------------------|------------------------------|--------|
| Current pain      | 7 to 10 cm VAS               | 0      | Sex life          | Severely affected impossible | 0      |
|                   | 5 to 6 cm VAS                | 3      | Moderately affected difficult | 2      |
|                   | 3 to 4 cm VAS                | 6      | Mildly affected   | 4      |
|                   | 0 to 2 cm VAS                | 9      | Unaffected        | 6      |
| Employment        | Unemployed because of back pain | 0    | Sleeping          | Severely affected impossible | 0      |
|                   | Part time                    | 3      | Moderately affected difficult | 1      |
|                   | Full time lighter            | 6      | Mildly affected   | 2      |
|                   | Full time original           | 9      | Unaffected        | 3      |
| Domestic chores   | None                         | 0      | Walking           | Severely affected impossible | 0      |
| odd jobs          | A few but not many           | 3      | Moderately affected difficult | 1      |
|                   | Most or all but more slowly  | 6      | Mildly affected   | 2      |
|                   | Normally                     | 9      | Unaffected        | 3      |
| Sport or active   | None                         | 0      | Sitting           | Severely affected impossible | 0      |
| social activities | Some but much less than before | 3    | Moderately affected difficult | 1      |
|                   | Back to previous level       | 9      | Mildly affected   | 2      |
| Resting           | Resting more than half the day | 0    | Unaffected        | 3      |
|                   | Little rest needed occasional | 4    | Travelling        | Severely affected impossible | 0      |
|                   | No need rest                 | 6      | Moderately affected difficult | 1      |
| Treatment or consultation | More than once per month     | 0      | Mildly affected   | 2      |
| consultation      | About once per month         | 2      | Unaffected        | 3      |
|                   | Rarely                       | 4      | Dressing          | Severely affected impossible | 0      |
|                   | Never                        | 6      | Moderately affected difficult | 1      |
| Analgesia         | Several times each day       | 0      | Mildly affected   | 2      |
|                   | Almost every day             | 2      | Unaffected        | 3      |
|                   | Occasionally                 | 4      | Total             | 75     |

Table 1. The low back outcome scale of Greenough and Fraser
improvement in outcome scores from the preoperative status within each treatment group, a paired Student's t-test was used. For comparing event rates, Fisher’s exact test was used. Two-sided p values were reported for comparing differences between the two groups. p-value of less than 0.05 was considered to be statistically significant.

RESULTS

There were no significant differences between Group I and Group II with respect to age, gender, or type of spondylolisthesis. The mean operative time from skin incision to complete wound closure was 208.4 minutes (range, 178-230 minutes) in Group I and 151.7 minutes (range, 125-187 minutes) in Group II (p=0.083). The amount of intraoperative blood loss, postoperative blood transfusion and midline skin incision were also higher in Group I than Group II, even though these differences were not statistically significant (Table 2). All patients in both groups were found to have excellent or good results according to modified MacNab's criteria. The average LBOS for Group I and Group II improved significantly from preoperative scores of 31.6 and 30.5 to 60.2 and 58.4 at 6 months, respectively (p<0.001). Both groups showed similar improvements over all time intervals (Fig. 1) with no statistically significant differences in their 6 month average LBOS (p=0.622). Back pain score (VAS) in both groups showed statistically significant improvement based on comparison to preoperative scores (p<0.001). However, 7 days and 1 month after surgery, patients in Group II had significantly low back pain scores compared to Group I (Fig. 2). After 3 months, no statistically significant differences were noted between the groups. Leg pain score (VAS) after surgery in both Group I and Group II showed an improvement in a similar manner over all time intervals (Fig. 3). The average leg pain scores for the two groups improved from 6.17 and 6.08 to 1.55 and 1.32 at 6 months, respectively (p<0.001). In both groups, there were no evidence of fusion failure such as angulation of more than 4° on flexion and extension radiographs and radiolucency at the 6-month follow-up. Moreover, no patient experienced neurological sequelae as a result of misplaced pedicle screws.

DISCUSSION

Traditional procedures for symptomatic spondylolisthesis involve spinal decompression and fusion with supplemental instrumentation7. PLIF has been associated with improvement of the fusion rate while restoring disc height and maintaining vertebral alignment. However, despite the advantage of a satisfactory rate of fusion, PLIF itself has some drawbacks. Due to the massive skin incision, the risk for intraoperative blood loss and

### Table 2. Patients demographics and backgrounds

|                        | Group I (Paraspinal approach) | Group II (Percutaneous screw fixation) | p     |
|------------------------|-------------------------------|----------------------------------------|-------|
| Age(yr)                | 65.1±15.8                     | 63.5±18.2                              | 0.624 |
| Male : Female (%male)  | 3 : 7 (30%)                   | 4 : 6 (40%)                            | 0.873 |
| Spondylolisthesis      |                               |                                        |       |
| Degenerative           | 7                              | 7                                      |       |
| Spondylolytic          | 3                              | 3                                      |       |
| Time for operation (min)| 208.4 (178-230)               | 151.7 (125-187)                        | 0.083 |
| Intraoperative blood loss (mL) | 448.5 (381-608) | 302.3 (278-396)                            | 0.162 |
| Transfusion (pint)     | 1.3 (0-2)                      | 0.4 (0-2)                              | 0.172 |
| Midline skin incision (cm) | 10.0 (8.5-12.4)           | 7.8 (6.8-9.0)                          | 0.355 |

Fig. 1. Mean Low Back Outcome Score in the Group I and Group II at the different time intervals. No difference between groups is present at any time period.

Fig. 2. Mean low back pain scores in the Group I and Group II at the different time intervals. The Group II (Percutaneous screw fixation) shows lower back pain scores compared to Group I significantly on postoperative 7 days (*p=0.005) and 1 month (**p=0.037).

Fig. 3. Mean leg pain scores in the Group I and Group II at the different time intervals. No difference between groups is present at any time period.
postoperative back pain are increased. In addition, for the conventional midline approach for screw fixation at L5-S1 levels, forceful retraction of the paraspinal muscles is required to achieve the proper lateral-to-medial screw trajectory because of coronal plane angle of pedicle. Subsequent prolonged wide retraction may result in denervation of the paraspinal musculature. Self-retaining retractors cause a significant rise in intramuscular pressure in the erector spinae muscles which is maintained throughout the surgical procedure. Moreover, the procedure can potentially injure the medial branches of the dorsal ramus at adjacent levels and at the level of fusion; this is because these branches are relatively fixed as they run beneath the fibro-osseous mamilloaccessory ligament. In contrast, several authors have recently reported that the muscle paraspinal sparing approach causes less paraspinal muscle damage than the traditional midline approach, and has positive effects on postoperative trunk muscle performance. The paraspinal approach can also result in a more medially-oriented S1 pedicle screw placement than traditional midline approach, which should lead to stronger fixation. However, the results of the current study demonstrate that percutaneous screw fixation causes less LBP than screw fixation via the paraspinal muscle sparing approach. It is known that postoperative back pain is caused by muscle injury during surgery and is directly related to the operation time and external compression force from the retractor. This study demonstrated that the mean operative time and estimated blood loss seemed low in the Group II (percutaneous screw fixation group). All outcome measurements in both groups showed significant improvement at 6 months after operation. However, we observed a significant difference in the reduction of LBP between the two groups at 7 days and 1 month following the operation. At these two times, patients in Group II had significantly better LBP scores compared to patients in Group I. This may indicate that the paraspinal muscle sparing approach for placement of pedicular screws is associated with longer incisions, extensive deflection of muscle, longer operative time, and greater blood loss compared to percutaneous screw fixation. As a result, we believe that systemic inflammatory reactions are high in patients who underwent the paraspinal muscle sparing approach compared to patients who underwent percutaneous screw fixation. Although this was prospective study, it had a small patient group. Further investigations including a more rigorous selection of patients are needed in the future.

**CONCLUSION**

Although screw fixation via the paraspinal muscle sparing approach and percutaneous screw fixation are satisfactory techniques that result in reduced muscle injury, percutaneous screw fixation can reduce LBP more effectively in the early postoperative period for treatment of L5-S1 spondylolisthesis.

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