Outcomes of anterior lumbar interbody fusion in low-grade isthmic spondylolisthesis in adults: A continuous series of 65 cases with an average follow-up of 6.6 years

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KEYWORDS
Spondylolisthesis; Interbody fusion; Anterior approach; ALIF

Summary
Introduction: Surgical treatment of isthmic spondylolisthesis continues to be controversial. The fusion procedure can either be instrumented using a posterior and/or anterior approach or non-instrumented. The role of associated decompression, reduction of the slippage, disc height restoration and lordosis restoration has not definitely been established. The goal of this study was to evaluate the efficacy of anterior approach for interbody fusion (ALIF) without any reduction maneuver.

Materials and methods: Sixty-five patients with isthmic spondylolisthesis were operated on, using an ALIF. The average patient age was 40 years. The preoperative maximum walking time was 20 minutes. Ten patients had radiculopathy. The average preoperative Beaujon Hospital disability index was 9/20. Standard static and dynamic X-rays were evaluated in all patients; a CT scan was performed in 33 patients 1 year after the surgery. The isthmic vertebra had slipped by an average of 12 mm. Thirty-five of the spondylolisthesis cases had abnormal vertebral motion.

Results: At an average follow-up of 6.6 years, lumbar pain and radicular pain had been reduced by 4.6 and 5 points on the visual analogue scale, respectively. Twenty-seven patients could walk for an unlimited amount of time. Three patients still had radiculopathy. The Beaujon Hospital disability index had improved by an average of 7.3 points. The fusion rate was 91%. The slippage had decreased by 30%, despite no specific reduction maneuvers at the time of surgery. The disc height had increased by 177%. On the sagittal plane, lordosis had improved by 5°, without any changes in the pelvic parameters.

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Introduction

Surgical treatment of isthmic spondylolisthesis continues to be controversial. The most common procedure consists of an instrumented fusion of the olisthetic level. This can be accomplished either through a posterior approach for posterolateral fusion (PLF) or posterolateral interbody fusion (PLIF or TLIF) or an anterior approach for interbody fusion (ALIF). In some cases, these techniques are combined to perform a circumferential fusion. Although many series have reported the results with PLF or PLIF, few results have been reported with ALIF [1,2]. In addition, the role of the slippage reduction, associated decompression (laminectomy, excision of Gill nodules) and restoration of the disc height and lumbar lordosis has not been clearly established [3–7]. Thus, it is difficult to define the ideal surgical strategy for isthmic spondylolisthesis in adults based on published data. Starting from the hypothesis that instability of the olisthetic level is the main cause of lumbar and radicular pain, we have always treated this pathology with anterior lumbar interbody fusion, without performing a reduction or direct inter-canal decompression.

We are reporting on the clinical and radiological results of a series of isthmic spondylolisthesis in adults treated with in situ anterior lumbar interbody fusion, without reduction.

Material and methods

The series

Seventy-five patients who were operated through an anterior approach in our department between 1985 and 2006 were reviewed retrospectively for this study. Ten patients who were lost to follow-up after less than 2 years were excluded from the results. For the 65 remaining patients, the test results at the last follow-up visit were taken into consideration. The study population consisted of 44 women and 21 men with an average BMI of 24.6 (range 16.3–36.3). The olisthetic level was at L5-S1 in 52 cases and L4-L5 in 13 cases. The indication for surgery was only made once conservative treatment had failed and there was radiographical evidence of listhesis.

Preoperative functional evaluation and clinical condition

Lumbar pain and radicular pain were evaluated using a visual analogue scale (VAS) with a rating of 0 to 10. The Oswestry [8] and Beaujon [9] scores were used to evaluate the preoperative and postoperative functional status of the patients.

Conclusion: In situ ALIF provides results that are comparable to those obtained with other techniques. This study confirms the essential role of fusion in achieving good functional results, given that hypermobility of the olisthetic level contributes to the symptoms generation.

Level of evidence: Level IV. Retrospective study.

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The average preoperative EVA was 6.7 (range 2–10) in lumbar pain patients and 5.9 (range 0–10) in radicular pain patients. Fifty-eight patients presented with neurogenic claudication. The average preoperative maximum walking time was 20 minutes. The pain-free maximum walking time was 5 minutes or less in 43 patients. Eleven patients had a radiculopathy with loss of motor function. The motor deficit (based on an international scale from 0 to 5) was rated as 4 in 10 cases and 3 in one case. The average preoperative Oswestry [8] score was 55% (range 30–80). The average Beaujon score [9] was 9.2 points (range 4–14).

Preoperative radiographic evaluation and clinical condition

Standard AP, lateral and three-quarter oblique X-rays centered on the olisthetic level were sufficient to confirm the diagnosis of isthmic spondylolisthesis. The amount of slippage was quantified according to the classification proposed by Meyerding [10]. The disc height was calculated for the olisthetic levels and the levels above and below. The average was taken of the sum of the disc height measured on the anterior wall (AB) and the posterior wall (CD) and divided by the height of the anterior wall of the L5 vertebral body (EF) (Fig. 1). We also recorded parameters of sagittal equilibrium. For lumbar lordosis, this was measured between the sacral endplate and the upper L1 endplate. Dynamic X-rays of the lumbar spine in standing hyperflexion and hyperextension were used to measure the motion at the olisthetic vertebral level before and after the surgery. The motion was objectively determined by the change in slippage (in mm) parallel to the superior endplate of the vertebra below and by the change in the change in angle between the inferior endplate of the olisthetic vertebra and the superior endplate of the vertebra below on the various X-rays taken during

Figure 1 Measurement of slippage and vertebral body height.
The angle formed was revealed by a surgical approach, and the pelvic incidence was determined on a CT scan after a follow-up of 1 year.

Based on the classification described by Meyerding, Grade 1 slippage was present in 32 cases and Grade 2 in 33 cases. The olisthetic vertebra had an average slip of 12 mm (range 5–23). The average pelvic incidence was 68° (range 45–90), pelvic tilt 18° (range 2–30), pelvic slope 50° (range 33–66) and overhang 38 mm (range 5–68). All of the spondylolisthesis cases showed evidence of being mobile on the preoperative X-rays. Angular motion of 5° or more between dynamic flexion and extension X-rays was present in 44 patients; the average difference in the entire study population was 5° (range 0–16). Abnormal sagittal translation motion of 3 mm or more between dynamic flexion and extension X-rays was found in 23 patients. The motion revealed itself either by an isolated change in the interbody angle (50%) or an associated variation in the angle and the translation (50%).

**Surgical technique**

Anterior lumbar interbody fusion without reduction was performed in all cases. The approach was transperitoneal for the early L5-S1 cases or left-sided retroperitoneal for the later L5-S1 cases and all the L4-L5 cases. The operated patient was placed in dorsal decubitus on a regular surgical table that could be flexed. For the transperitoneal approach, the abdominal content was turned back toward the top with drapes. The retroperitoneal tissues (consisting of the superior hypogastric plexus) were injected with saline and then the posterior parietal peritoneum was opened vertically. Dissection was performed from right to left using a cotton-tipped applicator. The left-sided retroperitoneal approach for L5-S1 was performed with the same patient positioning. Once the linea alba was incised, the approach was performed between the peritoneum and the left rectus abdominis, then following the contour of the left psoas muscle to come into contact with the spine on the medial side of the muscle. The peritoneal sac is moved medially with the ureter always visible; then the promontory of the sacrum was approached between the left and right iliac blood vessels.

No matter which approach was used, once the abdominal wall had been breached, no electrocautery was performed. The medial presacral blood vessels were located, then ligated or clipped and cut. Once the anterior side of the L5-S1 disc had been exposed, the vena cava confluence was pushed back upwards and laterally with Steinman pins that were inserted into the L5 and S1 vertebral bodies.

To approach the L4-L5 spondylolisthesis, the incision was performed over a line joining the middle of the pubisumbilicus gap with the middle of the left costal-iliac gap. The large muscles were incised (but mainly in their aponeurosis) or dissected along the long axis of their fibers. The transversalis fascia was opened to provide access to the retroperitoneal space then the posterior parietal peri-toneum, to which the ureter is attached, was lifted off with a cotton-tipped applicator and mobilized with the large prevertebral blood vessels to the right, beyond the medial line, then held with Steinman pins that were inserted into the L5 and S1 vertebral bodies. The iliolumbar vein and the metamerism of the lumbar blood vessels above and below the olisthetic level were ligated or clipped then cut.

No matter which level was involved, the disc was then excised, including the posterior common vertebral ligament. The discal mass behind the inferior part of the olisthetic vertebral body was carefully curedtted. The vertebral endplates were freshened until dense cancellous bone was exposed over the largest possible surface.

For the first 25 cases (24 L5-S1 and one L4-L5), only a tricortical, cortical–cancellable iliac crest graft was inserted with the cancellous side facing the freshened endplates; a space created by flexing the table to place the patient into slight lordosis, with no internal fixation added. Cancellous bone was used to fill the remaining spaces. The graft stability was reinforced when the table was returned to its flat position. In the next 40 cases, instrumentation was added to the graft: either a titanium plate was screwed into the two neighboring vertebral bodies in 17 cases (11 for L4-L5 and six for L5-S1) or a threaded cage with a cancellous bone graft inside was inserted in 23 cases (22 for L5-S1 and one for L4-L5) (Figs. 3 and 4).
Figure 4  X-rays of a L5-S1 fusion at a follow-up of 1 year.

Figure 5  CT scan of a L4-L5 fusion at a follow-up of 1 year, coronal reconstruction.

Figure 6  CT scan of a L4-L5 fusion at a follow-up of 1 year, sagittal reconstruction.

Statistical analysis

A t-test was performed to establish if the difference between the preoperative and postoperative value of the main radiographic parameters was significant. A P-value of 0.05 or less was considered significant.

Results

The average follow-up was 6.6 years (range 2.5–22 years).

Radiological results

The main results are given in Table 1. Fusion occurred in 59/65 patients (92%) (Figs. 5 and 6). The fusion rate was 97.5% when the segment was instrumented (39 of 40 cases) and 80% when it was non-instrumented (P=0.0177). The fusion rate was 77% for the L4-L5 level and 96% for L5-S1. In one case, the X-rays were not conclusive, but the functional result was excellent. Out of the five non-unions observed, three of them were at L4-L5, where fusion was attempted in only 13 cases (20%). One was instrumented with a plate, one with an oblique cage and the last case was the revision of a fusion attempted with graft alone. The two other failures were for L5-S1 fusion cases with graft alone. Four of the five non-unions were re-operated with a posterior approach and one with an anterior approach. One case of repeated non-union after a posterior approach with a surgical site infection required a third procedure with anterior fusion by tricortical graft. Finally, four of the five non-unions had healed after revision and one was doubtful with no signs of instrumentation failure.

Clinical results

The average VAS for lumbar pain was 2.1 (range 0–8) and had an average gain of 4.6 points relative to the preoperative assessment. The lumbar pain had disappeared in 18 cases (29%), clearly regressed in 25 cases (40%) (4 to 8 point reduction on VAS) and was moderately reduced in 13 cases (21%) (1 to 3 point reduction on VAS). There was no change in five patients (8%) and an increase in one patient.

The average VAS for radicular pain was 0.9 (range 0–5) at the last follow-up and had an average gain of 5 points relative to the preoperative assessment. The radicular pain assessment.
Table 1 Radiological changes at the last follow-up.

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Change</th>
<th>P (t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slippage</strong></td>
<td>12 mm (5−23)</td>
<td>8.5 mm (4−19)</td>
<td>−30%</td>
<td>0.058</td>
</tr>
<tr>
<td><strong>Lordosis (operated level)</strong></td>
<td>19° (−36−50)</td>
<td>23° (−20−38)</td>
<td>+4°</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Lumbar lordosis</strong></td>
<td>60° (34−90)</td>
<td>65.6° (34−96)</td>
<td>5.6°</td>
<td>n/s</td>
</tr>
<tr>
<td><strong>Disc height (operated level)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>0.26 (0−0.8)</td>
<td>0.71 (0.3−1.1)</td>
<td>+173%</td>
<td>0.04</td>
</tr>
<tr>
<td>Cages</td>
<td>0.23 (0−0.5)</td>
<td>0.80 (0.3−1.1)</td>
<td>+248%</td>
<td>0.02</td>
</tr>
<tr>
<td>Others</td>
<td>0.28 (0−0.8)</td>
<td>0.33 (0−0.54)</td>
<td>+0.18%</td>
<td>n/s</td>
</tr>
<tr>
<td><strong>Disc height (disc above)</strong></td>
<td>0.55 (0.5−1.1)</td>
<td>Same</td>
<td></td>
<td>n/s</td>
</tr>
<tr>
<td>L5-S1 disc height (for L4-L5 fusion)</td>
<td>0.5 (0−0.8)</td>
<td>0.38</td>
<td>−30%</td>
<td>0.03</td>
</tr>
</tbody>
</table>

had disappeared in 46 cases (74%), clearly regressed in seven cases (11%) (4 to 8 point reduction on VAS) and was moderately reduced in five cases (8.5%) (1 to 3 point reduction on VAS). There was no change in four patients (6.5%).

Maximum walking time was one hour or more in 52 patients (84%) and unlimited in 36 patients (58%). The other 10 patients had an average of 30 minutes (16%). The intensity of painful claudication at the follow-up had been reduced in 44 cases (71%). It had completely disappeared in 32 cases (51.5%), was unchanged in 15 patients (24%) and had increased in three cases (5%) in patients who initially had a maximum walking distance of 30 minutes or less. The radiculopathy had disappeared in eight of the 11 cases. Three patients still had an unchanged deficit that was rated as 4 and one had a partial regression. Thirty-eight patients (61%) had resumed work, with 34 of them in the same position as before, with an average delay of 8.6 months. Thirteen patients (21%) had not restarted in their occupation. Five (8%) had retired as of the last follow-up and six (10%) never had an occupation.

The average postoperative Oswestry score was 17% (range 0−55%), which was a gain of 38 points relative to the preoperative value. The average postoperative Beaumont score was 16.5 (range 9−20), which was a gain of 7.3 points relative to the preoperative value or a relative 68% gain.

Complications and morbidity

We found one case of transient retrograde ejaculation that persisted out to sixth months after the procedure, and one case of urinary urgency in a 50-year-old woman. There were no vascular injuries during the spinal approach but nine patients required transfusion towards the end of the procedure. There were no thromboembolic complications; all the patients were given anticoagulants for at least one month. There were no surgical site infections, but one patient had an unexplained postoperative fever that resolved with antibiotics.

Discussion

Although multiple surgical techniques have been used to treat isthmic spondylolisthesis, only nine randomized studies have been published [11−19]. All of them describe posterior fusion and their alternatives. There have been seven published retrospective studies where an anterior approach was used to treat isthmic spondylolisthesis [6,20−25].

In a recent review of literature, Kwon et al. [2] analyzed the functional results of three fusion techniques used to treat isthmic spondylolisthesis. They found 74.8, 86.4 and 89.6% good results for isolated posterior fusion (26 published studies), circumferential fusion (nine studies) and isolated anterior fusion (six studies). These results were difficult to compare since the evaluation methods and follow-up period were not the same from one study to another. Jacobs et al. [1] performed a systematic literature review and found the functional results of the various techniques to be comparable. However, good results were achieved in 43 to 100% of cases after PLF (with nine of the 25 series having a rate below 70%). The results seemed more consistent with anterior fusion, since various series reported 85 to 94% good results. Thus there appears to be a trend for better functional results with anterior fusion, as had been previously noted by Ghosez et al. [26]. This is related to the appearance or worsening of disc degeneration in the fused segment. In fact, Rolander [27] and Onimus et al. [28] have shown that motion persists, despite a successful PLF. It is quite conceivable that the persistent stresses on the disc in the segments fused by the posterior approach were at the root of the pain in the cases of disc degeneration. Weatherley et al. [29] confirmed this hypothesis by observing that lumbar pain had disappeared after anterior fusion procedure in patients presenting with stubborn lumbar pain after PLF. Furthermore, the superior pedicular screws were implicated in the involvement of the facet joints above the fusion site, which could have generated the pain [30].

The functional results depend on many factors such as gender and the type of preoperative occupation [31]. There is broad agreement on the fact that the functional results are correlated with the rate of bone fusion (P<0.002) [19]. Kwon et al. [2] found an average fusion rate of 83.3%, 98.2% and 74% for posterolateral, circumferential and isolated anterior fusion procedures, respectively, which does not reflect on the differences in functional results. Jacobs et al. [1] found a fusion rate of about 80% for posterolateral and posterior interbody fusion and noted that three of the
five series with anterior fusion procedures had a fusion rate of 60% or less [21–23]. In this meta-analysis, the fusion rate in the Christensen et al. study [21] was 47% with a non-union rate notably higher in the two-level fusion procedures. Similarly, Tsuji et al. [23] reported a fusion rate of only 53%. But the fusion procedures were not instrumented in these two ALIF series. In other reports of anterior fusion, the fusion rate was between 75 and 90% [20,23–26]. In our series, three of the five cases of non-union occurred in non-instrumented fusion procedures, even though this technique was used in only 14 of our 65 cases. This confirms the need to add spinal instrumentation to a bone graft. Many studies seem to show the advantages of using BMP to obtain fusion, but its use is controversial, particularly because of its cost and uncertainty over the optimal dose [32,33]. Other than the typical contra-indications, inflammatory reactions with osteolysis, radiculitis or hemorrhagic cysts have been reported [32–34]. Thus BMP use is possible and probably wise, but in a limited number of indications that are still not well defined.

Numerous studies have shown no significant differences between the results of fusion with or without associated reduction for Grade 1 or 2 spondylolisthesis [26,35,36]. In our study, despite no reduction being performed, we observed 30% spontaneous reduction in the slippage, which was probably related to the patient being positioned in dorsal decubitus, the use of skeletal muscle relaxants and the discectomy. Given our reported functional results and the absence of radiographic deterioration in the disc above the fusion site after a 6.6-year follow-up, we conclude that for low-grade spondylolisthesis, reduction of the slippage should not be the main goal.

The anterior approach is often criticized because it does not allow for nerve root decompression. However, many studies (including two randomized studies with 42 and 77 patients) showed no benefit on the progression of radicular pain of adding posterior decompression to the fusion procedure [12,18,37]. In our series, radicular pain disappeared or clearly regressed in 85% of cases, which is consistent with most of the published series with ALIF for low-grade isthmic spondylolisthesis [21,23]. Johnson et al. [38] made a distinction between radicular pain without objective neurological deficit and more severe neurological deficits that should be decompressed in their opinion. Even if few of our patients presented with an objective neurological deficit, the radicular affection was mostly the consequence of the hypermobility of the olisthetic level, which is treated with an interbody fusion. Decompression also occurs secondary to the discectomy and disc height restoration, which only occurred when an interbody cage was inserted. Thus these implants have an undeniable advantage if one of the goals is to restore disc height. In the current study, four of the five patients who had a radicular pain VAS of 5 or higher had no postoperative improvement in the disc height.

The complication rate reported in the various studies is quite variable, because an event is not always considered as complication in one series, but might be in another [1]. The anterior approach is often criticized because of the risk of genito-urinary complications [21,39,40] but the rate is extremely variable between the series, from 0.42 [41] to 17% [40]. In our experience, these complications are rare as long as electrocautery is not used in the retroperitoneal tissue, as was advocated more than 40 years ago [42]. The transfusion rate was high for a surgical series using the anterior approach. We believe this is due to the relatively “old” nature of this series, where the first patients were operated on without the aid of video monitors and tricortical grafts were harvested, which involved more hemorrhagic procedures. No transfusion was needed in the last 20 patients in our series.

Jacobs et al. [1] lament that the studies on isthmic spondylolisthesis only rarely report on the progression in the adjacent levels, which nevertheless is an important consideration in young adults with a long life expectancy. The effect of age on the functional results is well known and probably related to the degeneration of adjacent discs [43]. Many authors have reported that radiologic appearance of degeneration in the discs adjacent to a lumbar or lumbosacral fusion for isthmic spondylolisthesis was not correlated with the deterioration in functional results [6,30,44]. In the current series, we observed no change in the disc height in the level above the fusion. The improved lordosis could explain this favorable progression in the discs above the fusion.

Isthmic spondylolisthesis at L4-L5 was a less favorable indication for good results relative to spondylolisthesis at L5-S1. This could be explained by the postoperative progression of the L5-S1 disc. Ishihara et al. [6] found 100% disc degeneration in the level below the fusion on MRI with 73% in the levels above. We also observed this degeneration, with an average loss of 30% of the preoperative disc height at L5-S1 below a fusion at L4-L5. The demands generated by the fusion could be higher at the level below the fusion than the level above.

Conclusion

Anterior lumbar interbody fusion for isthmic spondylolisthesis led to fusion in 92% of cases; the fusion rate was 97.5% once instrumentation (cages or plates and screws) was used systematically. Drastic discectomy at the olisthetic level performed in combination with disc height restoration provides radicular decompression and effectively treats disc-related lumbar pain, which is often concurrent. Reducing the slipped vertebra does not seem to be necessary to obtain a good functional result. In the same way, it seems that restoring the local lordosis and not touching the posterior spinal structures (muscles, facet joints) limits the risk of degradation of the levels above the fusion in the medium term.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


