Long-term outcome in 132 consecutive patients after posterior internal fixation and fusion for Grade I and II isthmic spondylolisthesis

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Object. The authors assessed the late outcome of patients with Meyerding Grade I and II isthmic spondylolisthesis (IS) who underwent posterior instrumentation and posterolateral fusion (PLF). Decompression and posterior internal fixation with PLF is the classic surgical treatment for painful low-grade IS. Nevertheless, outcome data are scarce and of limited value mainly because they represent small numbers of patients, short follow-up periods, or both.

Methods. The authors obtained data in the cases of 132 consecutive adult patients (mean age 40.6 years, range 15.2–69.9 years) with IS who underwent treatment between 1984 and 2003. Assessment involved analysis of responses to mailed questionnaires, clinical charts and, in cases in which unsatisfactory results were suspected, results of clinical reevaluations. Spondylolisthesis was present at L3–4 in three patients, L4–5 in 14, L3–4 in one, L3–5 in one, L5–S1 in 113, and S1–2 in one. Signs and symptoms included back and leg pain (65.3%), leg pain alone (26.3%), back pain alone (8.4%), and neurological dysfunction (18%).

At a mean follow-up duration of 9.9 years (range 0.5–19.4 years), favorable results were reported for back and leg pain in 91.7 and 87.1% of patients, respectively. The mean visual analog scale scores were 2.13 for back and 1.39 for leg pain. Eighty-four patients resumed full- or part-time work, and 56.8% were capable of performing housework more easily. In 45.5% of the patients analgesic medications were not required, and 43.9% required them sporadically. The majority (63.6%) of patients reported they would undergo surgery again and recommended it to others. Thirteen (9.9%) suffered adjacent-segment morbidity, and in seven (5.3%) pseudarthrosis was documented. There were two deep and one superficial infections (2.3%).

Conclusions. Posterior instrumentation and PLF, with possible neurodecompression, yielded favorable long-term results in this retrospective study of 132 patients with low-grade IS.

KEY WORDS • isthmic spondylolisthesis • spine surgery • posterior instrumentation • posterolateral fusion • outcome

In 1991 we reported the favorable initial results obtained in patients who underwent surgery for IS associated with low-back pain, radicular and pseudoradicular symptoms alone, or combined.15 These surgeries had been performed between 1986 and 1990 and involved neural decompression and internal fixation with either plates9–11 or a pedicular screw/rod system2,3 in conjunction with PLF.

New technologies have been introduced in recent years in the surgical treatment of IS. Among the most noteworthy are PLIF and ALIF in which various cages are placed for osseous fusion of the anterior column. These techniques are now regularly applied in cases of high-grade IS, but there is a trend toward an increased use of cages in patients with low-grade (Meyerding14 Grade I and II) IS as well.

In our institution, based on the 1991 report, we continued to use the aforementioned techniques for low-grade IS; however, we also place cages if the anterior column requires additional support in individuals with low-grade IS (those with high levels of physical activity, obesity, and frontal and/or sagittal imbalance) and almost always in patients with high-grade IS in whom reposition of the affected vertebra is required to restore spinal balance.

Although we continue to develop new cage-related procedures,16 we believe that posterior instrumentation-augmented fusion performed in conjunction with, if necessary, neurodecompression still represents a reliable and simple procedure to treat low-grade IS. Data regarding long-term results, however, are scarce (Table 1). In this retrospective study, we present the long-term results obtained in our patients.

Clinical Material and Methods

Patient Population

Between July 1984 and February 2003, the senior author (T.M.M.) performed posterior placement of instrumentation and PLF in 159 consecutive patients with low-
<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Cases (female/male)</th>
<th>Mean Age (range), Yrs</th>
<th>Meyerding Grade</th>
<th>No. of Segments</th>
<th>Decompression Fusion Type</th>
<th>Implant/Fusion (no. of cases)</th>
<th>Fusion (no. of cases)</th>
<th>Mean FU (range)</th>
<th>Fusion/PA Success Rate</th>
<th>Success Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markwalder, et al., 1991</td>
<td>72 (34/38)</td>
<td>40 (15–65)</td>
<td>0–II</td>
<td>71</td>
<td>NS</td>
<td>Gill, nerve &amp;/or for &amp;/or MDE</td>
<td>PLF</td>
<td>no from preop 21% to 17% slip at 3 mos</td>
<td>Louis§ (59), CDI (7), 300‡ (6)</td>
<td>26 (3–48) mos</td>
</tr>
<tr>
<td>Zdeblick, 1993</td>
<td>187 (NS)</td>
<td>43 (27–79)‡</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>lam &amp;/or nerve root decomp &amp;/or MDE</td>
<td>PLF</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Ricciardi, et al., 1995</td>
<td>17 (6/11)</td>
<td>33 (17–51)</td>
<td>NS</td>
<td>0</td>
<td>NS</td>
<td>lam &amp;/or nerve root decomp &amp;/or MDE</td>
<td>PLF</td>
<td>NS</td>
<td>Luque II§ (42), DeLopnoll (23)</td>
<td>NS</td>
</tr>
<tr>
<td>Carragee, 1997 Mc Gaire &amp; Amandsson, 1997</td>
<td>20 (7/13)</td>
<td>19–51</td>
<td>NS</td>
<td>0</td>
<td>NS</td>
<td>Gill lam &amp; L-5 root decomp</td>
<td>PLF</td>
<td>NS</td>
<td>16 (9–28) mos, 100% F, 96%**</td>
<td>NS</td>
</tr>
<tr>
<td>Schnee, et al., 1997</td>
<td>14 (NS)</td>
<td>53.4 (24–77)‡</td>
<td>NS</td>
<td>0</td>
<td>NS</td>
<td>lam</td>
<td>PLF</td>
<td>yes</td>
<td>Isola§ (16), CDI (12), 381 (20)</td>
<td>36 (24–48) mos</td>
</tr>
<tr>
<td>Suk, et al., 1997</td>
<td>40 (29/11)</td>
<td>44.4 (30–60)</td>
<td>13</td>
<td>13</td>
<td>lam &amp;/or nerve root decomp &amp;/or MDE</td>
<td>PLF</td>
<td>final correction rate of 28.3%</td>
<td>CDI (45)</td>
<td>36/40 F, 20% probable</td>
<td>18% + 14% indeterminate</td>
</tr>
<tr>
<td>Thalgott, et al., 1997</td>
<td>21 (NS)</td>
<td>45 (25–59)</td>
<td>16</td>
<td>yes</td>
<td>lam &amp;/or nerve root decomp</td>
<td>PLF</td>
<td>yes</td>
<td>AO–DC§ (21)</td>
<td>36 (24–48) mos</td>
<td>95%**</td>
</tr>
<tr>
<td>Deguchi, et al., 1998</td>
<td>73 (27/46)</td>
<td>38 (19–66)</td>
<td>35</td>
<td>Gill &amp; for (for alone in reop)</td>
<td>PLF</td>
<td>NS</td>
<td>Luque II§ (15), CDI (12), 381 (20)</td>
<td>3.8 (1–7.4) yrs</td>
<td>90% F, 12% PA</td>
<td>primary 71%<strong>, final 85%</strong></td>
</tr>
<tr>
<td>Kim &amp; Lee, 1999</td>
<td>20 (15/5)</td>
<td>41.3 (21–57)</td>
<td>2</td>
<td>2</td>
<td>Gill</td>
<td>PLF</td>
<td>mean 15.2% to 9.8% slip</td>
<td>Steiffe (5), 360 (13)</td>
<td>5 (4–7.3) yrs</td>
<td>95% F + 90%**</td>
</tr>
<tr>
<td>Nooroaei, et al., 1999</td>
<td>45 (360)</td>
<td>43.5 (23–56)</td>
<td>0</td>
<td>lam (19); none (26)</td>
<td>PLF</td>
<td>NS</td>
<td>CDI (45)</td>
<td>12–24 mos</td>
<td>95% F</td>
<td>44/45**</td>
</tr>
<tr>
<td>Möller &amp; Hedlund, 2000</td>
<td>37 (12/16)</td>
<td>39 (18–55)‡</td>
<td>36</td>
<td>Gill lam</td>
<td>PLF</td>
<td>yes</td>
<td>CDI (45)</td>
<td>2 yrs</td>
<td>36/37 definitely, 77% by obs**</td>
<td>83% by patient</td>
</tr>
<tr>
<td>Madan &amp; Borce, 2002</td>
<td>21 (8/13)</td>
<td>42.2 (28–66)</td>
<td>8</td>
<td>lam &amp; for</td>
<td>PLF</td>
<td>mean 78.3% correction rate of 38.9–15.9% slip</td>
<td>Isola§ (16), CDI (12), 381 (20)</td>
<td>3.5 (2–1) yrs</td>
<td>90.5% F, 9.5% PA</td>
<td>81% Oswey**, 85% subjective</td>
</tr>
<tr>
<td>La Rosa, et al., 2003</td>
<td>18 (NS)</td>
<td>57.2 (32–74)‡</td>
<td>38.9% slip</td>
<td>NS</td>
<td>lam &amp; for (early cases)</td>
<td>PLF</td>
<td>SOCON–SRI</td>
<td>2 yrs</td>
<td>88.9% F</td>
<td>66.6% good</td>
</tr>
<tr>
<td>present study</td>
<td>132 (66/66)</td>
<td>40.6 (15.2–69.9)</td>
<td>88 (3 in 5)</td>
<td>Gill, nerve root decomp &amp;/or for &amp;/or MDE (85%)</td>
<td>PLF</td>
<td>SOCON–SRI</td>
<td>9.9 (0.5–19.4) yrs</td>
<td>Luque (13)</td>
<td>91.7% back, 87.1% leg pain relief</td>
<td></td>
</tr>
</tbody>
</table>

* AO–DC = Arbeitsgemeinschaft für Osteosynthesefragen–Dynamic Compression; decomp = decompression; F = fusion; for = foraminotomy; instr = instrumentation; lam = laminectomy; MDE = microdiscectomy; NS = not stated; obs = observation; PA = pseudarthrosis; SOCON–SRI = Solid Connection–Spondylolisthesis Reduction Instrument; TSRH = Texas Scottish Rite Hospital; VSP = Variable Spinal Plating; WSI = Wirbelsäulen Implantat.
† All types of spondylolisthesis.
‡ Refers to various groups of patients in article, including those with IS.
§ Semirigid hardware.
|| Rigid hardware.
** Refers to good and excellent success rates.
grade IS. Patients with higher-grade vertebral slippage (Grades III, IV, and higher) were not included in this study. Twenty-seven individuals were lost to follow-up review (10 due to noncompliance, six to emigration, six to unknown whereabouts, and five to death). Overall, follow-up data in the remaining 132 individuals (83%) were available for this study.

Preoperative clinical examination and classification were sometimes difficult because of patients’ severe pain. Nevertheless, we tried to classify pain into three patterns: back and leg pain (65.3%), leg pain alone (26.3%), and back pain alone (8.4%). Neurological dysfunction due to nerve root entrapment in the spondylolytic gap or due to disc herniation was present in 18%. Spondylolisthesis was documented at L3–4 in three patients, L4–5 in 14, L3–5 in one, L5–S1 in 113, and S1–2 in one.

At the first operation, patient age ranged from 15.2 to 69.9 years (mean 40.6 years). The male/female age distribution was similar between the 66 female and 66 male patients (15.2–69.9 years [mean 40.6 years] and 19.9–69.3 years [mean 40.7 years], respectively). Two girls (age 15.2 and 15.5 years, respectively) and one man (age 19.9 years) were younger than 20 years of age at the time of surgery.

Preoperative Assessment and Indications for Surgery

The diagnostic workup of patients in whom conservative treatment failed and the indication for surgery have been previously presented. Briefly, conventional radiography (anteroposterior, lateral, and oblique orientations and a dynamic lateral-view examination in maximal flexion and extension) was performed to assess the IS grade and a possible instability of theolisthetic motion segment. Early in this study, computerized tomography scanning sometimes combined with myelography was used to evaluate the spondylolytic gap and to delineate spondylolytic tissue provoking neurocompression within the spondylolytic zone and the neural foramen. Later in the series, MR imaging provided the same information in many instances. In uncertain cases, however, we continued to use computerized tomography myelography, which we consider to be the most reliable radiological examination to demonstrate neurocompression within the spondylolytic gap.

In cases of low-back pain due to instability of the spondylolisthetic motion segment in the absence of leg pain, patients were required to wear a probatory rigid jacket for a 3-week period to simulate the effect of internal fixation. Only patients who experienced significant pain relief during this probatory immobilization were candidates for surgery. In cases in which the origin of leg pain was unclear, this procedure helped to differentiate between radicular and pseudoradicular complaints and to determine whether decompression was required. Patients

FIG. 1. Bar graphs demonstrating results after surgery for back pain (upper) and leg pain (lower).

FIG. 2. Bar graphs demonstrating effects of surgery on use of analgesic medication (upper) and feasibility of housework (lower).
with severe neurological dysfunction underwent surgery without having to undergo probatory jacket immobilization.

**Surgical Technique**

In all patients, a standard midline approach was used to allow bilateral retraction of paravertebral musculature. Irrespective of the presence of clinically relevant signs of nerve root compression, 85% of patients underwent a typical Gill-type laminectomy or some variation of this decompressive procedure to remove spondylolytic tissue, Gill nodes, osseous arthritic spurs, and disc protrusions/herniations. This surgical policy was chosen to avoid causing secondary nerve root impairment due to the implant compressing the spondylolytic tissue left in place and/or the posterolaterally placed autologous bone grafts. In 33% of the cases, a significant disc herniation and radiculopathy related to the segment in question required that we perform microdiscectomy. In 15% of the cases the spinal canal was not opened prior to instrumentation and PLF because neurocompression was absent and the spinal canal and foramen widths were judged to be adequate. A Louis butterfly plate (88 cases) or a CD screw/rod construct (10 cases) was applied for one-segment fixation. In cases involving significant concurrent adjacent-segment morbidity (radiologically documented discopathy or facet joint arthrosis), however, these segments were included in the fusion. In these patients, we placed bilateral Louis plates (for two motion segments [eight cases], for three segments [five cases]) or CD constructs (for two motion segments [20 cases], for four segments [one case]). Autologous bone graft was harvested from the posterior iliac crest via either the midline incision or a second incision. Decompression was performed using microtechniques. Placement of pedicular screws was controlled using fluoroscopy and, in recent years, computer navigation. At the beginning of this series, patients frequently underwent surgery while under axial traction (Gardner–Wells tongs [25 kg]) to correct vertebral slippage and to reconstruct physiological lumbar alignment; however, because we observed a significant recurrence of slippage in the immediate postoperative course (7.8% immediately postoperative and 17% at 3 months, as demonstrated on conventional radiographs), we abandoned axial traction and we were content with the hyperlordotic supine position alone with less or no correction of the deformity. In fact, our patients have undergone in situ fusion since 1989. All surgeries were conducted by the senior author (T.M.M.). Postoperatively, patients underwent a 3-month course of removable rigid plastic jacket therapy. They were not allowed to sit down.

**Outcome Assessment**

Outcome data were retrospectively collected by means of mailed questionnaires (Figs. 1–5) and by review of the clinical records that contain the clinical controls and the conventional radiological examinations performed 6 and 12 weeks after surgery for all patients and later controls.

In the follow-up questionnaire patients were asked whether their back and leg pain had improved, whether they would undergo this type of surgery in the same situation again, whether they would recommend the procedure to others, and which therapy they needed at the follow-up time. Finally, their employment-related status was evaluated. Additionally, a Huskisson VAS was used to evaluate back and leg pain (0 [no pain]–10 [worst pain]). Patients in whom unsatisfactory results were suspected were reexamined.

**Results**

**Results of the Follow-Up Questionnaires**

Outcome data were obtained at a mean of 9.9 years (range 0.5–19.4 years) after the index operation in the 132 patients available for follow-up study. In seven the follow-up period was less than 2 years, and in 84 it was longer than 10 years. Results are summarized in Figs. 1 to 5. An overview of cases in which an unsatisfactory result was suspected is given in Table 2.

![Fig. 3. Responses to the question, Would you undergo the same surgery again?](image)

![Fig. 4. Responses to the question, Would you recommend the same surgery to others?](image)

The mean VAS scores for back pain and leg pain were 2.13 and 1.59. Forty-three patients (32.6%) recorded a VAS score of 0 for both back and leg pain and three
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(2.3%) a score of 10 for back and leg pain. Three patients (2.3%) reported a VAS score of 0 for back pain with residual leg pain and 26 (19.7%) a score of 0 for leg pain with residual back pain.

The paired Student t-test showed a statistically significant relationship (p < 0.0003) for VAS back and leg pain scores.

In the questionnaire 123 patients (93.2%) described their work status. Full-time employment in the previous or a different job was reported by 68 and part-time by 16; three received Workers’ Compensation for another ailment, one was unemployed, and one was completing a course for job retraining. Thirty-four were receiving at least a 50% disability compensation or had retired.

Patients Requiring Reexamination

Fifteen individuals (11.4%) who have reported a VAS score greater than 5 for back pain, leg pain, or both were asked to undergo reevaluation because pain status was considered to reflect a long-term failure. Seven of 15 patients underwent reexamination, five were only available by phone call/family physician interview, and three were lost to follow up (Table 2). The values obtained in the latter were adopted unchanged for calculations. Five patients suffered from adjacent-segment morbidity (mechanical overcharge of the adjacent disc and/or facet joints and/or ligamentous apparatus with subsequent degenerative changes); two experienced facet joint irritation (pain on lumbar spine extension and on palpation of the facet joints; one underwent fusion at an outside hospital and the residual complaints remain unclear), one suffered painful diffuse idiopathic skeletal hyperostosis, and two sustained a new disc herniation/discopathy. In two other patients the result of the clinical evaluation was ambiguous; however, both refused further examination. Two patients presented with an extraspinal disease (one with gonarthrosis and one in whom pain origin was likely nonsomatic). One patient suffered a whiplash injury in a car accident. Residual radicular pain after operative treatment of IS in cases involving disc herniation was present in another two individuals. Finally, in another patient living abroad, the origin of pain remains unclear but some of his back pain was due to known adjacent-segment morbidity and at least part of the leg pain was due to vascular occlusive disease.

Patients who were reexamined for late-onset failure were pain free for a mean period of 4.7 years after the index operation.

Three of these 12 patients were working full time, whereas seven received Workers’ Compensation of 50% or more (two received 100% compensation for spinal disorder and one received 100% for another ailment) and two were retired.

Further Surgical Interventions and Complications

In 54 patients the fusion material was removed 2.5 years (range 0.5–10.1 years) after the index operation because of their relatively young age and/or sporting activities (six patients, age < 25 years), implant loosening with recurrent back pain, and in one instance because of deep infection. One fractured butterfly plate that had not caused further damage was removed after 2.7 years.

After the corrective procedure, clinically relevant adjacent-segment morbidity was observed in 13 cases (9.9%). Nine of these patients underwent a repeated operation: three decompressions of a narrow spinal canal (after 0.6, 1.8, and 7.9 years, respectively [these patients had been free of pain until a slow progressive apparition of a neurogenic claudication]), three microdiscectomies for disc herniations (at 4.3, 4.9, and 5.7 years, respectively [these patients had been free of pain until the sudden occurrence of radiculopathy]), one for placement of CD screw/rod instrumentation (at 15 years), one for translamellar screw fixation (at 10.1 years), and one for plate fixation (at 6.6 years) due to low-back pain secondary to mechanical overcharge (that is, adjacent segment morbidity), which presented as slowly progressive low-back pain. In four of these patients concurrent ablation of the osteosynthesis material was performed. After the second intervention the clinical course was uneventful and none of these cases was considered representative of long-term failure, even those individuals in whom only decompressive surgery was performed. Two women had to undergo immediate repeated operation when malpositioned pedicular screws were discovered.

Seven patients (5.3%) presented with a pseudarthrosis (radiologically or intraoperatively diagnosed). They underwent the following therapies/corrective surgeries: one
TABLE 2

Summary results in patients reporting poor outcome*

<table>
<thead>
<tr>
<th>Age (yrs),</th>
<th>Sex</th>
<th>Follow Up</th>
<th>Technique &amp; Segment</th>
<th>VAS Pain Score†</th>
<th>Clinical &amp; Radiological Findings</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>78, F</td>
<td>reexam</td>
<td>b-fly L5–S1, MDE</td>
<td>NR (0)</td>
<td>10 (0)</td>
<td>normal pain-free lumbar mobility; no neurological deficit; no radicular complaints; takes analgesics for knee pain</td>
<td>leg pain due to gonarthrosis: 2 ops for knee prosthesis w/residual pain; retired</td>
</tr>
<tr>
<td>53, M</td>
<td>reexam</td>
<td>b-fly L5–S1</td>
<td>0 (0)</td>
<td>7.2 (5.8)</td>
<td>lumbar mobility slightly restricted; neurologically normal; positive Mennell sign; no analgesics</td>
<td>residual radicular pain (L-5) in IS w/discal herniation; same work as before, full time</td>
</tr>
<tr>
<td>41, F</td>
<td>reexam</td>
<td>b-fly L5–S1</td>
<td>4.5 (5.9)</td>
<td>6.2 (6.3)</td>
<td>normal pain-free lumbar spine; neurologically normal; no analgesics</td>
<td>two uneventful pregnancies after fusion; low-back complaints in adjacent segment(s); irritation of sacroiliac joint responsible for leg pain. Workers’ Compensation 66% (spine)</td>
</tr>
<tr>
<td>62, F</td>
<td>reexam</td>
<td>b-fly L5–S1, MDE</td>
<td>8 (8)</td>
<td>6 (6)</td>
<td>painful restriction of low-back mobility due to muscular hypertension; no analgesics; neurologically normal</td>
<td>origin unclear; extravertebral factors possible; patient refuses assessment; no analgesics; work: retired</td>
</tr>
<tr>
<td>59, F</td>
<td>reexam</td>
<td>b-fly L5–S1</td>
<td>7.2 (7.2)</td>
<td>2.1 (2.1)</td>
<td>painful restriction of low-back mobility; painful sacroiliac joint; abolished ankle jerk; no radiological complaints; takes analgesics</td>
<td>adjacent-segment fusion by other surgeon; origin of residual pain unclear; Workers’ Compensation 100% (spine)</td>
</tr>
<tr>
<td>48, F</td>
<td>reexam</td>
<td>b-fly L5–S1, MDE</td>
<td>8.3 (8.3)</td>
<td>8.7 (8.7)</td>
<td>painful restriction of low-back mobility; positive SLR test at 70°; daily analgesics; neurologically normal; MRI shows new disc herniation of adjacent segment/</td>
<td>new disc herniation of adjacent segment w/radicular symptoms; Workers’ Compensation 100% (spine)</td>
</tr>
<tr>
<td>65, M</td>
<td>reexam</td>
<td>b-fly L5–S1</td>
<td>6.2 (6.2)</td>
<td>4.5 (4.5)</td>
<td>painful restriction of lumbar mobility; muscular hypertension; neurologically normal; takes analgesics; diffuse skeletal hyperostosis w/exemption of 3 lumbar segments; solid fusion of olisthetic segment</td>
<td>diffuse idiopathic skeletal hyperostosis; overcharge of remaining mobile segments of lumbar spine; Workers’ Compensation 50% (spine), now retired</td>
</tr>
<tr>
<td>38, M</td>
<td>PC</td>
<td>b-fly L5–S1</td>
<td>6.4 (2)‡</td>
<td>2.3 (0)</td>
<td>leg pain resolved; back pain at bone donor site; otherwise no back pain</td>
<td>refuses reexam as his daily activities are almost unrestricted; work: new job, full time w/minor restrictions</td>
</tr>
<tr>
<td>63, M</td>
<td>PC</td>
<td>b-fly L5/S1</td>
<td>10 (2)</td>
<td>10 (2)</td>
<td>marked leg &amp; back pain almost every day; subjective weakness of the lt leg</td>
<td>objective findings as reported by physician almost normal; patient never consulted for low back pain in last 2 years; lives in geriatric institution due to other diseases &amp; psychological problems; eventual profit from his complaints; no analgesics; Workers’ Compensation 100% for other disorders; now retired</td>
</tr>
<tr>
<td>47, M</td>
<td>PC</td>
<td>CD L4–S1</td>
<td>9.3 (9.3)</td>
<td>9.3 (9.3)</td>
<td>VAS the same; hyposensibility, otherwise subjectively normal neurologically; mobility of lumbar spine painfully restricted; takes analgesics</td>
<td>lives abroad; physician confirms the complaints as indicated by the patient; known adjacent-segment morbidity; leg: symptomatic vascular occlusive disease; Workers’ Compensation 69% &amp; family support (equivalent to 100%)</td>
</tr>
<tr>
<td>43, F</td>
<td>PC</td>
<td>b-fly L5–S1, MDE</td>
<td>1.2 (1.2)</td>
<td>6.6 (6.6)</td>
<td>VAS the same; mainly leg pain; car accident w/whiplash injury after op; suffers from ISJ arthrosis, fibromyalgia, osteoporosis; takes analgesics including morphine</td>
<td>unsatisfactory outcome but multiple other causes that might influence outcome; Workers’ Compensation 50% (spine)</td>
</tr>
<tr>
<td>54, F</td>
<td>PC</td>
<td>CD L4–S1</td>
<td>7.1 (6.5)</td>
<td>6.7 (6.7)</td>
<td>back pain improving slightly but worse than before</td>
<td>unsatisfactory outcome but patient is able to work full time</td>
</tr>
</tbody>
</table>

*B-fly = Louis butterfly plate; ISJ = sacroiliac joint; MDE = microdiscectomy; NR = no response; PC = phone call; reexam = reexamination; SLR = straight leg raising.

† Value in parentheses indicates the corrected VAS values.

‡ Pain at site of bone graft harvesting, not for back.

* B-fly = Louis butterfly plate; ISJ = sacroiliac joint; MDE = microdiscectomy; NR = no response; PC = phone call; reexam = reexamination; SLR = straight leg raising.
Isthmic spondylolisthesis

patient refused further surgical measures, one underwent surgical evacuation of a deep infection (after 0.7 years) and experienced spontaneous resolution of pain, two required 360° fusion (at 1.3 and 2.7 years [the latter after traumatic fracture of the original implant]), one underwent ALIF (at 0.8 years), one obese patient underwent placement of a screw/rod instrumentation and graft (at 0.2 years), and one underwent instrumentation-augmented PLIF (at 0.6 years). In two men (1.5%) ALIF was performed to treat “persistent microinstability of the anterior column” (residual intercorporeal motion after instrumentation-assisted fused PLF) rather than pseudarthrosis; in one this was the affected segment (at 1.5 years) and in the other the adjacent segment was included in the initial construct (at 2 years).

Because of the small number of patients in the group of late-occurring failures we were not able to perform a statistical analysis to establish a relation between adjacent-segment morbidity and pseudarthrosis formation or to determine statistical values for other parameters such as age, sex, weight, number of levels fused, slip angle, or preoperative sagittal balance.

During the postoperative period one woman suffered from septicaemia originating from a paranasal sinus infection and another woman from superficial wound infection and concurrent peritonitis due to acute diverticulitis. A male patient suffered a cerebrovascular accident 3 months after the operation. Conservative therapy in these three patients produced full recoveries.

In addition to the aforementioned patient who presented with a surgically treated deep wound infection two other infections occurred, one deep infection (10 years) and one superficial wound infection (occurring shortly after surgery) both of which were successfully treated with antibiotic therapies. The overall infection rate was 2.3%.

Discussion

In the present study we found that placement of posterior instrumentation in conjunction with PLF yields favorable results in adults with Grade I and II IS during a mean follow-up period of 9.9 years after the operation (in 91.7% for back pain and 87.1% for leg pain). This procedure is associated with a low rate of adjacent-segment morbidity, pseudarthrosis formation, and infection. In most cases, patients return to work and normal daily activities. In our view, the few general complications observed in this series were not related to the surgical procedure itself. Analysis of our results confirms the early favorable trend we reported in a 1991 analysis (95.8% with favorable outcome after a mean of 26 months), and our results are supported by the intermediate and (few) late results found in the literature (Table 1). Despite certain drawbacks that we will discuss, we conclude that low-grade IS is efficiently treated by this procedure and that patient satisfaction is obtained in most cases. Nevertheless, there remain some patients with persistent problems. Despite low incidences of adjacent-segment morbidity (9.9% [13 cases]) and pseudarthrosis formation (5.3% [seven cases]), we believe that these two parameters contribute to poor outcomes in a significant manner. We are aware that the rates of adjacent-segment morbidity and of pseudarthrosis formation include only symptomatic patients requiring reevaluation. Were systematic radiological studies performed in all patients, these figures would likely increase. The question arises as to whether these results can be improved.

Currently, instrumented PLIF or ALIF procedures or 360° circumferential fusions are probably the only alternatives that might yield better outcomes. These three techniques are usually associated with superior single-level fusion rates compared with instrumentation-assisted PLF.12,19 Adjacent-segment morbidity, however, is more likely to occur in rigid constructs than in instrumentation-augmented PLFs, which may exhibit some residual mobility in the anterior compartment.10 This assumption is supported by recent studies in which instrumented PLFs was associated with a better clinical outcome in patients with Grade I and II IS than those who had undergone PLF.12,19 In addition, PLIF is associated with an increase in the following: operative time, blood loss, tissue trauma, and risk of neurological damage. Considering these advantages and disadvantages as well as the results of our study, we believe that 360° fusions, instrumentation-augmented PLIFs or ALIFs should only be undertaken in cases of high-grade IS (if a preserved intervertebral space remains), whereas in cases of Grade I and II IS an instrumented PLF alone is adequate treatment. None of the present patients had been primarily treated by interbody fusion; however, we currently prefer to undertake PLIF in patients with low-grade IS if there is spinal imbalance—for example, a disturbed lumbosacral angle, verticalization of the sacrum, pelvic retroversion, or abnormal lumbar lordosis—or in individuals who are highly physically active and in those who are obese.

In our initial report15 we treated five patients with 360° anterior and posterior fusion. These five patients were excluded from the present analysis because we now think that this represented surgical overtreatment due to less expertise. Furthermore, these patients did not meet the study criteria.

During the study period 33 patients underwent instrumentation-based PLIF (23 cases) or ALIF (10 cases)10 for Grade II or higher IS or for Grade II IS if the patients met the criteria pertaining to interbody fusion. An analysis of the long-term results in these individuals and their comparison to those obtained in the PLF series has not yet been performed.

There also arises the question of whether repositioning of the spondylolisthetic segment is mandatory to achieve an improved outcome. The patients treated earliest in the series underwent axial traction, with almost complete reduction of deformity, during fluoroscopically guided surgery; however, after mobilization of the patient the spondylolisthesis recurred (as demonstrated on radiological control studies obtained after 6 and 12 weeks in all patients), even in those in whom rigid CD instrumentation had been applied. For these individuals, the segment fused with approximately one-fifth reduction of the initial slippage.10 Without precise analysis, we were unable to glean an obvious disparity in outcome between the first patients surgically treated under axial traction and the later ones in whom traction was not applied. Therefore, we believe, as others (see Table 1) that reduction of the spondylolisthesis is not required in most cases of low-grade IS to effect a better outcome. Analysis of the results obtained in cases involving a semirigid construct (101 Louis plates) com-
pared with those obtained in cases involving a rigid implant (31 CD constructs) revealed no implant-related disparity of outcomes. In addition, the initial relationship between Louis and CD constructs reappeared almost unchanged in the group involving late-onset failure (101 to 31 compared with 10 to two, respectively [Table 2]).

One third of our patients presented with nerve root compression due to overt disc herniation or foraminal nerve entrapment. They required microdiscectomy. In this study, there was no difference in outcome between individuals who underwent or did not undergo microdiscectomy. Thus, microdiscectomy did not influence outcome.

In this retrospective study there are several limitations and possibilities of error. We included patients treated with screw/rod and screw/plate constructs in this study. In our view, the differences in rigidity between these systems is negligible when used for this indication. As mentioned previously, recurrence of spondylolisthesis was observed even in patients in whom CD constructs were placed.

Questionnaires are known to provide unreliable results in some instances. Nevertheless, many investigations rely on this instrument, all the more because this is the only reasonable method of acquiring results in such a cohort as that presented here. To enhance the reliability of our results, patients indicating an unsatisfactory outcome (arbitrarily defined as a VAS score > 5) were invited to undergo clinical reevaluation (Table 2).

Seventeen percent of patients were lost to follow up and some were not willing to undergo reexamination. It is possible that some of the latter suffered from an extraspinal ailment (for example, gonarthrosis) as was the case in patients who did undergo reexamination (all were initially believed to have a spinal problem and, in fact, some suffered from other conditions). It is possible that a few patients underwent further treatments in other medical facilities (that is, for implant ablation).

There was an astonishing discrepancy between the surgeon’s definition of a successful outcome (91.7% and 87.1% for back and leg pain, respectively) and the patient’s willingness to undergo the same procedure again and recommend it to others (63.6% each). This observation may be related to our quite restrictive postoperative protocol that forbids the patient from sitting down and includes mandatory external immobilization in a rigid jacket for 3 months.

We believe that several patients reporting an unsatisfactory outcome intensified their complaints because they were seeking Workers’ compensation.

Because our patients did not respond to conservative treatment or because other surgical procedures are significantly more invasive, it was impossible to form control groups and compare our data with nonsurgical or other surgical modality data. For the same reasons, randomization was not feasible. In addition, the results of our early series encouraged us to continue to use instrumentation-assisted PLF in this condition.

Conclusions

In summary, based on the present retrospective study, we believe that posterior internal fixation combined with PLF for low-grade (Grade I and II) IS is an appropriate surgical modality. It is associated with favorable long-term results; back and leg pain reliably resolved; the incidence of clinically relevant adjacent-segment morbidity was low as was the rate of pseudarthrosis formation; and most patients resumed work, usually the same as before surgery. Therefore, we continue to restrict cage-assisted PLIF and ALIF to patients presenting with Grade III or higher IS and, currently, as an exception of this rule, for patients with frontal and/or sagittal imbalance irrespective of Meyerding grade, for obese patients, and individuals engaged in highly physical activities. In our opinion, at the present time, posterior instrumentation with PLF, and eventual neurodecompression are a reliable surgical modality for the treatment of Grade I and II IS.

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