Uninstrumented posterolateral spinal arthrodesis: is it the gold standard technique for I° and II° grade spondylolisthesis in adolescence?

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Accepted: 14 March 2009 / Published online: 5 May 2009
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Abstract We retrospectively reviewed the outcome of uninstrumented posterolateral spinal arthrodesis in 49 patients with lumbar isthmic spondylolisthesis grades I° and II° in adolescent patients in the time of surgery, who participate at follow-up, between 1980 and 1995. The goal of our study is to analyse the clinical and radiographic imaging at long follow-up in uninstrumented posterolateral arthrodesis and to evaluate the efficiency and the validity of surgical technique in young patients (<18 years). All patients had failed previous conservative treatment. The average age at follow-up was 33.5 years (range 25–42 years) and the average follow-up time was 19.7 years (range 12–27 years). The clinical outcome measures were the Oswestry Disability Index, the SF-36, and the visual analogic score. All measures assessed the endpoint outcomes at 20 years after surgery. The outcome of spinal fusion was good with 43 (87.7%) patients attaining solid fusion, pseudoarthrosis in 6 patients (12.3%). None of our patients complained of excessive postoperative wound pain. Additionally, no complications, such as wound infection, were encountered. Satisfactory results were obtained in 94% of patients and this was closely associated with the rate of successful fusion. The results suggest that clinical outcome is closely related to the attainment of solid fusion.

Keywords Spondylolisthesis · Uninstrumented · Posterolateral · Arthrodesis · Fusion · Adolescence

Introduction

Isthmic spondylolisthesis is the most common spondylolytic disorders until 6% at the age of 18 years. It is one of the most common causes of low back pain and sciatica in adolescents. Initial treatment is usually conservative, including rest, non-steroidal anti-inflammatory drugs, wearing of a body brace and physical therapy. Main indications for surgery are: intractable pain, progression of symptoms with radicular involvement, or progression of the slip [16, 31]. The operative procedure was uninstrumented posterolateral spinal arthrodesis that can be performed via posterior approach, with a choice of autogenous graft and allograft can be used for fusion. We have undertaken this retrospective clinical study to assess the outcome of posterolateral arthrodesis (APL) for the treatment of lumbar low-grade spondylolisthesis in adolescent patients. Aim of the study was to analyse the clinical and radiographic imaging at long follow-up in uninstrumented posterolateral arthrodesis (APL) and evaluate the efficiency and the validity of surgical technique in young patients (<18 years).

Materials and methods

A total of 65 consecutive patients who were managed surgically at our hospital for the treatment of low-grade isthmic spondylolisthesis I° and II° grades between 1980 and 1995 were asked to participate in the present study. Forty-nine patients (76%) agreed to participate. The

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reasons not to participate were travelling distances (ten patients) and lack of interest (six patients).

Thirty-four male, 15 female; the average age at the time of operation: 15 years (range 10–18 years).

The average age at follow-up was 33.5 years (range 25–42 years) and the average follow-up time was 19.7 years (range 12–27 years).

Preoperative evaluation involved complete clinical, neurological, functional, radiographic, and CT; at the follow-up the patients were evaluated by orthopaedic examinations, clinical questionnaire, radiological measurements, CT, and MRI evaluation.

Indication for surgical treatment

A large number of treatment choices are available for the child with spondylolisthesis, including no treatment, observation, limitation of activities, exercises, bracing, casting, repair of a pars defect, fusion, decompression, and reduction of the slippage. The problem is selecting the appropriate treatment for the individual child.

In making this choice the following factors are considered: pain and neurological problems (compromising the quality of life, non-responsive at conservative treatment); clinical symptoms (lumbar pain: 49 patients, radicular pain: 7/49 patients, neurological alterations: none); vertebral slippage (severe: 18/49 patients, evolutive: 41/49 patients).

We used the surgical procedure described by Wiltse, who used a posterolateral muscle-splitting technique, usually through a midline skin incision. This approach preserves the midline stabilizing ligaments, avoids contusion of the floating L5 lamina, and produces excellent results, as will be noted later [29, 30].

Clinical questionnaire

According to Fairbank [3] the Oswestry Disability Index (ODI) is scored from 0 (no disability) to 100 (total disability) and rates the limitations of various activities of daily living: personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and travelling; the index grades low back disability as follows: 0–19 minimal; 20–39 moderate; 40–59 severe; 60> crippled. One question specifically rates the intensity of pain.

The SF-36 includes multi-item scales to measure eight dimensions regarding quality of life: physical function, role physical, bodily pain, general health, social function, role emotional, mental health, and vitality. It can be summarized in two measures related to physical and mental health. Each scale ranges from 0 (worst health state) to 60 (best health state).

Table 1 Preoperative radiological data (49) patients

Level of spondylolisthesis	Number of patients
L4–L5	5 (10%)
L5–S1	43 (88%)
L4–L5 and L5–S1	1 (2%)
Grade of the slip	
Meyerding grade I	18 (36.5%)
Meyerding grade II	31 (63.5%)

Table 2 Angle preoperative radiological data (49) patients

Angle preoperative	Degree (mean value)
Slippage angle	24° (7°–40°)
Lumbo/sacral angle	43 (88%)
Lumbar index (%)	79 (75–84)
Sacral inclination	65° (40°–85°)
Vertebral slip (%)	25 (5–50)
Lumbar kyphosis	–12° (–30° to 24°)

Radiology

Radiological examination is basic not only to the diagnosis of spondylolysis and spondylolisthesis, but also to the evaluation of their aetiology, gravity, and evolution.

Standing anteroposterior and lateral radiographs with flexion and extension lateral of the lumbar spine were made preoperatively and postoperatively at the time of the most recent follow-up evaluation were assessed for quality of fusion. The preoperative data regarding Meyerding grade, slip angle, lumbar-sacral angle, lumbar index, and sacral inclination. The main preoperative radiographic characteristics are summarized in Tables 1 and 2.

The extension of arthrodesis area was L4–S1: 5 patients (10%) and L5–S1: 44 patients (90%).

All patients were fitted preoperatively with either a lumbosacral corset or a chairback brace, and used this support for postoperative immobilization.

To evaluate the grade of arthrodesis callus, we used the Dawson's classification; posterior fusions (grading A0–A4, with A0 noting the absence of fusion and A4 noting solid bilateral fusion) was performed using the latest follow-up AP radiograph. Radiographic pseudoarthrosis was defined as the presence of a grade A0 or A1 posterior fusion mass.

To evaluate the formation of bilateral arthrodesis callus, we used the Christensen's classification; fusion, indicated this quality of fusion at all intended levels. If the fusion was doubtful on both sides of the interspace, the individual case could not be classified as fused.

MRI

In addition, MRI of lumbar spine was made at the time of the most recent follow-up visit.

The MRI examinations were performed on 45 patients with a 1.0 T superconducting imager (1.0 T Signa; GE Medical System, Milwaukee, WI, USA). T1-weighted spin echo and T2-weighted fast spin echo sequences were used in the sagittal direction with a slice thickness of 5 mm.

The following parameters were studied: intervertebral discs at the level of the fusion and one level above the fusion; the stage of facet joint at one level above the fusion; spinal canal and neural foramina.

Computed tomography

The CT examinations were performed on 49 patients. This is the most accurate investigation in the diagnosis of spondylolysis, except when there are impending stress fractures of the pars. In case of surgery, the CT view of the adjacent discs (superior–inferior) is important to determine how many levels have to be stabilized. We used the CT to evaluate the formation of bilateral arthrodesis callus, and definitive arthrodesis callus (cortical callus), fusion of inter-apophyseal joint.

Results

This retrospective study with a 20-year follow-up rate of 87.7% showed benefit from posterolateral fusion for isthmic spondylolisthesis with the Grade I and II slips in children and adolescents patients. The extension of arthrodesis area was L4–S1 in 5 patients (10%), L5–S1 in 44 patients (90%).

Intra-postoperative results

The mean operation time in the instrumented group was 90 min (range 50–120 min); the intraoperative blood loss was 240 ml (range 90–330 ml).

Neurological deficiencies that had not been present preoperatively were noted in some patients at the time of the most recent follow-up examination. There were no deep wound infections or deep vein thrombosis.

Eight patients had pain at the donor site (the iliac crest bone) for 15 days (mean value).

Physical examinations and questionnaire

At the time of the recent follow-up evaluation, all patients reported that symptoms had resolved completely and that only mild back pain was experienced occasionally.

The patients with muscular weakness at foot extension showed normal. The mean distances from the fingertips to the floor with forward bending were 6.5 cm, (range 1.2–9.5 cm). All patients resumed their full-time occupations and judged the result of surgery to be excellent.

The mean ODI score was 12 (range 0–26) for the posterolateral fusion; the results of the visual analogue scale (VAS) showed score of 9, there was no difference between the leg pain respect to the back pain. Ultimately, the SF-36 supported the other measures with regard to physical health; the score was 54 for SF-36 ISF and 55 for SF-36 ISM.

All patients were asked: “Would you go through the operation again, now that you know the course and the result?” At the 20-year follow-up, 91.8% answered “yes”.

Radiological results

Forty-three patients (87.7%) demonstrated incorporation of the graft with solid fusion. Fusion was identified by the presence of bridging trabecular bone between the transverse process and the sacrum; radiographs documented pseudoarthrosis in 6 patients (12.3%). None non-unions were re-operated on and all were stable at the last follow-up visit because the back pain was experienced occasionally; indicating incidental asymptomatic pseudoarthrosis.

By the Dawson’s radiograph classification, 36 (73.5%) patients demonstrated an excellent arthrodesis callus (A4); 7 (14.3%) patients demonstrated good posterior fusion (A3), and 6 (12.2%) patients showed evidence of posterior pseudoarthrosis.

By the Christensen’s radiograph classification, 43 cases (87.7%) were classified as fused at all intended levels by all observers (Fig. 1). Four of the 49 observers found doubtful fusion; and 2 found non-union.

The mean vertebral slip was 25% (range 5–50%) preoperatively, 29% (range 0–50%) at the last follow-up visit. Marked progression of the slip at the last follow-up visit was <10% (Fig. 2).

The mean lumbosacral kyphosis increased from -12° (-30° to 24°) preoperatively to -8° (range -15° to -4°) at final follow-up (Tables 3, 4).

At the level of the fusion, the MRI signal intensity of the disc was reduced in T2-weighted images in 20 (55.5%) of 36 disc. At one level above the fusion, the intensity and height of all discs were normal in T2-weighted images in 24 (66.6%) of 36 disc (Fig. 3); in addition, 10 (27.7%) disc spaces were narrowed. None of the patients had spinal stenosis. At one level above the fusion, the stage of facet joint osteoarthritis was in 11 (30.5%) of 36 patients.

CT scans of 49 patients revealed the solid fusion in 43 patients (87.75%) of 49, with the bridging intertransverse bone. We analysed the formation of bilateral arthrodesis

Fig. 1 A 31-year-old, follow-up 22 years. The AP radiographs show the solid bilateral fusion (A 4)

callus in 43 patients (Fig. 4), the fusion of inter-apophyseal joint at the level of arthrodesis in 42 patients (85.7%; Table 5).

Usually we used an autogenous graft because it provides a much better outcome, and the most popular donor site is the iliac crest bone.

Discussion

A large number of treatment choices are available for the child with spondylolisthesis, including no treatment, observation, limitation of activities, exercises, bracing, casting, repair of a pars defect, fusion, decompression, and reduction of the slippage. The problem is selecting the appropriate treatment for the individual child. In making this choice the following factors are considered: initial symptoms, age, growth potential, physical findings (especially neurologic signs), and the amount of displacement and slippage (slippage percentage and slippage angle) [16].

The overall management plan for children with spondylolisthesis most often followed is based on recommendations in Wiltse [28] and Jackson [30]. A slippage of 5–50% in an asymptomatic child, observe with radiographs, no limitation of activities is recommended or regarding participation in contact sports, or sports

Fig. 2 A 37-year-old, follow-up 23 years. The lateral radiographs show the stability of the slippage

Table 3 Postoperative radiological results data (49) patients

Extension of arthrodesis	Number of patients
L4–S1	5 (10%)
L5–S1	44 (90%)
Vertebral slip (%)	29 (8–50)
Lumbar kyphosis	−8° (−15° to −4°)

Table 4 Postoperative Christensen's classification data (49) patients

Arthrodesis	Number of patients
Fusion	43 (87.75%)
Doubtful fusion	4 (8.1%)
Non-fusion	2 (4.15%)

with lumbar hyperextension (football, gymnastics); a slippage of less than 50% in a symptomatic child, institute non-operative therapy (exercises, brace, activity modification), with the same, if the pain persists, fusion should be performed.

Fig. 3 MRI evidenced the conservation of intervertebral disc at the level above the arthrodesis callus

Fig. 4 The CT scan showed the formation of bilateral arthrodesis callus

Surgical stabilization of the spondylolisthesis should be considered for the symptomatic child whose condition does not respond to non-operative management and when pain prevents full participation in normal activities.

Table 5 Postoperative CT-scan results data (49) patients

Arthrodesis	Number of patients
Fusion	43 (87.75%)
Non-fusion	6 (12.25%)

The basic procedure is a bilateral posterolateral fusion (transverse process to sacral alae) using autologous iliac bone graft. In slippages of less than 50%, this involves a single-level L5–S1 fusion, with the fusion extending to L4 with more severe slippages, because the L5 transverse process is anterior and inferior to the sacral alae [7, 19].

In situ posterolateral fusion provides excellent results with all degrees of slippage. Wiltse fuses in situ without decompression, no matter how high the degree of slippage. He reports good results with negligible complications, even in slippages of more than 50% with sciatica and neurologic change, in which cases he reports good or excellent results in 30 patients and a 100% fusion rate [31]. Other reports confirm these results [8, 10, 11, 15, 25].

The posterolateral region of the spine is one of the more challenging fusion environments because of the large gap that must be spanned by bone, the relatively poor vascularity of this region, the tensile stresses present in this region of the spine, and the presence of motion when the fusion is performed without supplemental internal fixation [1, 27].

The fusion rate in our series was high (87.7%); the foregoing survey of 49 cases confirms previous reports of the efficacy of achieving lumbar arthrodesis with our technique of placement of autogenous iliac bone graft laterally over the transverse processes.

The time surgery was minimal (about 90 min), the bloodless operation was about 240 ml, the complication was insignificant. As for the technique we have describe, our patients did not encounter any of the co-morbidities with a short operative time and minimal blood loss noted. The data are comparable to rates reported in the literature [5, 6, 17, 18, 26].

We had none postoperative infections in our series. We tentatively attribute this finding to the treatment with non-instrumented fusion. After instrumented posterior, deep infections have been reported in 0–4.7% of patients [12, 18, 26]. Instrumentation hardware and a longer operation time would appear to increase the risk of deep infection.

Several different questionnaires and clinical outcome tools have been used to measure patient satisfaction after posterolateral fusion. Seitsalo [22] employed four pain-based outcome categories; Thomsen [26] and Moller [18] used various VAS-based questionnaires and Gehrchen [5]

used a questionnaire with items about medication, vocational status, pain.

We used the ODI as a subjective outcome tool in our retrospective study. Good subjective outcome was noted in 46 patients (ODI < 20). In these studies, 94% overall patient satisfaction was observed in a follow-up. The results were strongly supported by patient-based outcome measures.

The posterolateral fusion effectively prevented further anterior slip of mild-to-moderate spondylolisthesis during the 20-year follow-up. Marked progression was seen only in <10% of patients. Lumbosacral kyphosis tended to increase, possibly partly due to disc atrophy fusion level; nevertheless, it remained within normal values in most of our patients.

The assessment of the condition of the intervertebral discs on MRI did not reveal marked changes if compared to the follow-up. No spinal stenosis was seen on MRI. Mild narrowing of the neural foramina L5–S1 was registered in 28% of the patients. Signs of disc degeneration were present, but they were not correlated to pain or to the outcome of the patients. In 70% of patients we observed the conservation of intervertebral disc and inter-apophyseal joints at the levels above the arthrodesis callus.

Kakiuchi [13] reported on 16 patients, 10 of whom (62%) had clear signs of disc degeneration below the slipped vertebra on preoperative MR images. After a mean follow-up of 25 months, 13 (81%) were symptom-free regardless of the degree of degeneration on the MRI scans before operation. The remaining three patients showed major improvement.

Posterolateral spinal fusion in situ is accepted as the gold standard for the treatment of mild (slip < 50%) spondylolisthesis [2, 26]. The fusion rate has usually been high and is comparable to circumferential fusion [4]. Despite solid fusion, however, some progression in the slip has been reported [23]. Patient satisfaction has generally been good as measured by different quality-of-life questionnaires [5, 24, 26].

Some investigators [14, 21] are of the opinion that in low-grade spondylolisthesis, an instrumental reduction of the slip is unnecessary.

The present study was a one-centre study, which gave the possibility of standardizing both the patient selection and the surgical techniques. This, we believe, improved the design and power of the study. It is important to emphasize that many patients with low back pain are well treated conservatively and only after a need a spinal fusion. The majority of our patients had back pain for more than 1 year, and they had not benefited from conservative treatment methods.

Conclusion

The uninstrumented posterolateral arthrodesis is a reliable surgical technique; represent a gold-standard in spondylolisthesis I° and II° grade in young patients [20]. It is a safe and efficient procedure in young patient population. According to the questionnaire, however, this finding is correlated with clinical outcome.

The procedure required abundant autologous bone, because the quality of arthrodesis can conditioned the surgical results.

Conflict of interest statement None of the authors has any potential conflict of interest.

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