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Long-term clinical, functional and radiological outcome 21 years after posterior or posterolateral fusion in childhood and adolescence isthmic spondylolisthesis

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Abstract Long-term radiological studies have shown that a high rate of fusion can be achieved with posterolateral spondylodesis. Radiological findings, however, do not always correlate with patient satisfaction and outcome. No studies have been conducted on the long-term results of functional outcome, including spinal mobility and trunk strength measurements, after operative treatment of spondylolysis and spondylolisthesis, as compared with the reference population. Of 129 consecutive patients with isthmic spondylolisthesis operated on with spondylodesis between 1977 and 1987, 107 (83%) participated in the study. Posterior spondylodesis was performed in 29 (27%) patients and posterolateral spondylodesis in 78 (73%) patients. The average follow-up time was 20.9 years (range 15.1–26.2 years). Radiographs obtained preoperatively and at the 2-year and final follow-ups were assessed for quality of the fusion and degenerative changes. Outcome was assessed at the last follow-up by physical examination, spinal mobility and non-dynamometric trunk strength measurements, and calculation of Oswestry disability index (ODI) scores. The fusion rate was 66% after posterior fusion and 83% after posterolateral

fusion. Degenerative changes in the lumbar intervertebral discs above the fusion level were noted in 13 (12%) patients. At the final follow-up 14% of patients reported back pain often or very often. The mean ODI score was 7.6 (0–68). Moderate disability was found in 6% of patients and severe disability in 1%; one patient was crippled. No correlation was found between disc degeneration or solidity of the fusion and the ODI score. Non-dynamometric trunk strength measurements corresponded with the reference values. Lumbar flexion, but not extension, was diminished when compared with that of the reference population. The overall long-term clinical outcome is good in patients with spondylolysis and spondylolisthesis operated on with posterior or posterolateral fusion. The clinical and radiological outcomes do not, however, appear to correlate with each other. Lumbar flexion is diminished, but the patients perform, on average, as well as the general population in non-dynamometric trunk strength measurements.

Keywords Spondylolysis · Spondylolisthesis · Spinal fusion · Functional outcome · Oswestry disability index

Introduction

The natural course of spondylolysis and low-grade (< 50%) spondylolisthesis is usually benign, and children and adolescents with symptoms should primarily be treated conservatively [7, 16, 19]. If, however, conservative treatment fails to relieve pain or the slip continues to progress, spinal fusion should be considered [15]. Watkins [25] described posterolateral in situ fusion as the gold standard of operative treatment. In this method transverse processes of the spondylolytic vertebrae are fused to the ala sacri. Long-term clinical and plain radiographic findings of posterolateral spinal fusion have been documented and are, on the whole, good [3, 5, 22–24]. It appears, however, that patient outcome does not always correlate with radiological results. Previous studies have not compared long-term functional results, including spinal mobility and trunk strength measurements, with the values of the reference population.

The purpose of the present study was to establish the long-term clinical, radiological and functional outcome after posterior or posterolateral in situ fusion in patients with symptomatic spondylolysis and low-grade spondylolisthesis and to compare their functional outcome with the values of an age and gender-matched reference population.

Material and methods

Patients

A total of 129 consecutive patients surgically treated at our hospital for symptomatic spondylolysis and isthmic spondylolisthesis between 1977 and 1987 was asked to take part in the study; 107 (82.9%) accepted the invitation. Posterior fusion was performed on 29 (27.1%) patients and posterolateral fusion on 78 (72.9%) (Table 1). The posterior fusions were performed between 1977 and 1982 and the posterolateral fusions between 1977 and 1987. The average age of participants at the time of operation was 15.3 years (range 8.1–19.8 years). The average follow-up time was 20.9 years (range 15.1–26.2 years).

Methods

Preoperative and postoperative data were collected from the patients' records. Physical examinations were conducted by three independent observers (T.L., V.R., I.H.). Anteroposterior and lateral radiographs of the lumbar spine were taken preoperatively, at 2 years postoperatively and at the last follow-up visit. In addition, flexion and extension radiographs were obtained at

Table 1 Patients' characteristics

Parameter	Number of patients (n = 107)
Mean (SD) age in years at time of surgery	15.3 (2.4)
Mean (SD) age in years at final follow-up	36.2 (4.6)
Male/female	59/48
Mean (SD) follow-up time in years	20.9 (3.5)
Slipped vertebra	
L4	4 (4%)
L5	102 (95%)
L6	1 (1%)
Posterior fusion (%)	29 (27.1%)
L4–S1	29 (27.1%)
Posterolateral fusion	78 (72.9%)
L5–S1	58 (54.2%)
L4–S1	19 (17.8%)
L4–L5	1 (0.9%)

the final follow-up visit. The Oswestry Disability Index (ODI) questionnaire [8] was mailed to the patients together with the invitation to participate in the study. Previously validated spinal mobility and non-dynamometric trunk performance tests were performed at the last follow-up visit [1, 2].

Operating technique and postoperative treatment

The indication for operation was pain or neurological symptoms that were disturbing daily activities and not responding to conservative treatments. The main symptoms were back pain in 74 (69%) patients, back pain radiating to below the knee without neurological deficiencies in 18 (17%) patients, severe (> 30%) or increasing vertebral slip in ten (9%) patients, and neurological deficiencies or hamstring tightness causing symptoms in five (5%) patients.

Seventy-eight (73%) of the patients were operated on by standard posterolateral in situ fusion with iliac crest autogenous bone grafting. The fusion was from L5 to S1 in 58 (75%) patients and from L4 to S1 in 19 (24%) patients. One (1%) patient had a fusion between L4 and L5. Between 1977 and 1982, 29 (27%) patients had posterior fusion from L4 to S1 with a tibial osteoperiosteal autograft. The patients were mobilised at the second or third postoperative day and wore a soft brace for 4 months. No prophylactic antibiotics were administered.

Physical examinations

The patients underwent a systematic physical examination at the last follow-up visit. As well as demographic data, information was obtained on low back pain.

Height in centimetres and weight in kilogrammes were measured and the body mass index (BMI) was calculated [weight in kilogrammes/(height in metres)²]. The finger–floor distance was measured in centimetres. Patients performed the straight leg-raising test (SLR) while supine; the result was considered negative when the leg was raised over 60° without causing any back pain or radiating pain below the knee. Patellar and achilles tendon reflexes were tested (+/–). Muscle strength for great-toe extension and ankle dorsiflexion and plantar-flexion (normal/decreased/absent) were tested, as was skin sensitivity (normal/decreased/absent) in the dermatomes of L3–S1.

Oswestry disability questionnaire

Subjective disability was estimated by means of the ODI, which gives scores on a scale from 0 to 100. According to Fairbank et al. [8], the index grades low back disability as follows: 0–19 = minimal; 20–39 = moderate; 40–59 = severe; 60 ≥ crippled. The questionnaire was mailed to all patients before their follow-up visit. They completed it at home and brought it to the follow-up visit, during which their answers were checked.

Radiological measurements

The amount of vertebral slip was measured from standing lateral radiographs and was calculated according to the method of Laurent and Einola [14] as the quotient of sagittal displacement and the sagittal length of the slipped vertebral body expressed in percent. Lumbosacral kyphosis was measured between the posterior aspect of the first sacral vertebral body and the anterior wall of the body of L5. Lumbar lordosis was measured according to Wiltse and Winter [26] as the angle between the planes of the cranial end plates of L1 and L5. The distance from the upper posterior corner of L3 to the upper posterior corner of S1 was measured in millimetres. Disc height above the fusion level(s) was assessed semi-quantitatively from lateral radiographs with the aid of four subgroups, as recommended by Saraste et al. [20]: 0 = normal; 1 = disc height reduced by less than 50%; 2 = disc height reduced by at least 50%; 3 = disc space completely obliterated. Segmental motion was measured from extension and flexion radiographs taken at the last follow-up visit. Segmental movement of more than 3° at fusion level(s) was defined as non-union, since movement less than that was considered a possible measurement error. An independent observer measured all radiographs. Our study group has previously published the intra-observer and interobserver reliability of same radiological parameters in patients with

spondylolisthesis. For more detailed information see Seitsalo et al. [22].

Spinal mobility and non-dynamometric trunk performance tests

Functional tests, including spinal mobility and trunk muscle strength measurements, were carried out by the same physiotherapist. Spinal mobility was determined by measurement of lumbar flexion and extension, in degrees, with a goniometer [1]. Trunk side-bending was measured with a tape measure from the fingertips on the thigh to the floor, in centimetres [1]. Individual spinal mobility measurements were graded as abnormal when the values were below the mean –2 SD of the age-matched and gender-matched Finnish reference values previously reported by Alaranta et al. [1]. Non-dynamometric trunk strength was measured by repetitive sit-up, arch-up and squatting tests [2]. The trunk strength results were scored from 1 (poor) to 5 (excellent). The result was poor when it was –1 SD below the mean of the reference values and excellent when it exceeded the mean by +1 SD.

Statistics

Results are given as mean and (SD) or range. Statistical comparisons were performed by the Mann–Whitney test. Correlations were calculated by Spearman's rank correlation test. *P* values less than 0.05 were considered significant.

Ethical considerations

The informed consent of all participants was obtained. Permission to perform this study was obtained from the Ethics Committee of the hospital district where the study was conducted.

Results

Physical examinations and Oswestry disability index

The mean BMI was 25.3 kg/m² (range 18.1–37.6 kg/m²). The mean distance from fingertips to floor in forward bending was 4.9 cm. The SLR test was positive in five (5%) patients. Neurological deficiencies were only occasional (Table 2). The mean ODI was 7.6 (range 0–68) and revealed moderate disability in seven (6%) patients (index score 20–39) and severe disability in one (1%) patient (score 40–59); one patient was crippled (score > 60). The mean ODI in patients with pseudoarthrosis was 9.6 (range 0–22). Fourteen (14%) patients reported back pain often or very often.

Table 2 Neurological findings on physical examination

Finding	Number of patients (<i>n</i> = 107)
SLR positive (< 60°) (%)	5 (5)
Muscle weakness (%)	2 (2)
Sensory deficiency (%)	3 (3)
Weak or absent reflexes (%)	8 (7)

SLR straight leg rising test

Radiological measurements

The mean vertebral slip was 28% (range 5–50%) preoperatively, 29% (range 5–56%) at 2 years and 26% (range 0–78%) at the last follow-up visit. Marked progression (> 10%) of the slip at the last follow-up visit was noted in 11 (10%) patients, whose mean preoperative slip was 34%. A decrease in the lumbar intervertebral disc height above the fusion level was noted in 11 (10%) patients. A decrease by one grade was noted in eight (7%) patients and by two grades in three (3%) patients. The mean lumbosacral kyphosis increased from –10.8° (range, –4.2° to 51°) preoperatively to –6.9° (–46° to 59°) at final follow-up.

A total of 20 (19%) non-unions was observed. Ten of these were after posterior fusions and ten after posterolateral fusions, giving non-union rates of 34.5% after posterior fusions and 12.8% after posterolateral fusions ($P = 0.0017$). Nine non-unions were re-operated on and all were stable at the last follow-up visit (see Complications). Eleven (10%) patients had segmental motion in extension and flexion radiographs at the last follow-up visit, indicating incidental asymptomatic pseudoarthrosis. The mean vertebral slip remained at the same level during the follow-up period. There was a significant worsening in the lumbosacral kyphosis, from –10.4° (range –42° to –51°) preoperatively to –7.2° (–46° to –59°) at the 20-year follow-up (Wilcoxon signed rank sum test, $P = 0.0005$).

The ODI score did not show any correlation with preoperative or postoperative slip (in percent), lumbosacral kyphosis or lumbar lordosis. There was no difference in ODI or individual scores between patients with non-union and solid fusion.

Spinal mobility and non-dynamometric trunk performance tests

The results of the trunk strength and spinal mobility measurements are listed in Table 3. The most notable finding was the decreased lumbar flexion recorded in 47 (43.5%) patients. Abnormalities in trunk strength measurements were rare. No correlations were observed between the severity of the slip, lumbar lordosis or lumbosacral kyphosis and the trunk strength measurements.

Table 3 Trunk strength and spinal mobility measurements

Characteristic	Number of patients (<i>n</i> = 107)
Mean (SD) sit-up score	3.6 (1.2)
Mean (SD) arch-up score	4.2 (1.0)
Mean (SD) squatting score	3.9 (1.2)
Abnormal ^a lumbar flexion [number of patients (%)]	47 (46)
Abnormal ^a trunk side-bending [number of patients (%)]	6 (6)
Abnormal ^a lumbar extension [number of patients (%)]	0 (0)

^aAbnormal when below the mean –2 SD of the age-adjusted and gender-adjusted general population values (Alaranta et al. [1])

No correlations were observed between radiographic parameters or ODI and spinal mobility.

The ODI score showed, however, inverse correlations with the scores for sit-up ($r_s -0.31$, 95% CI –0.48 to –0.12, $P = 0.001$) and arch-up ($r_s -0.30$, 95% CI –0.47 to –0.11, $P = 0.002$) tests but not with those for squatting tests.

Complications

Pseudoarthrosis was observed in 20 patients. Eleven patients had no symptoms and nine (8.3%) had disturbing pain and underwent re-operation(s) after primary spinal fusion. In those patients who had stable fusion no-one developed late neurological complications. One deep infection and eight subcutaneous seromas were noted postoperatively. The deep infection healed with revision and antibiotic treatment, and all seromas healed uneventfully.

Discussion

Posterolateral in situ spinal fusion is accepted as the gold standard for treatment of mild spondylolisthesis [5, 7, 11, 24]. The fusion rate has usually been good and is comparable to circumferential fusion [9]. Despite solid fusion, some progression in slip has been reported [21]. Patient satisfaction has generally been good as measured by quality-of-life questionnaires [5, 10, 18, 22, 24].

Several different questionnaires and clinical outcome tools have been used to measure patient satisfaction after posterolateral fusion. Seitsalo [21] employed four pain-based outcome categories; Thomsen et al. [24] and Möller and Hedlund [18] used various visual analogue scale (VAS)-based questionnaires and Gehrchen et al. [10] used a questionnaire with items about medication, vocational status, pain, etc. In these studies, 70%–87% overall patient satisfaction was observed in a follow-up

of 2–13 years. We used the ODI as a subjective outcome tool in our retrospective study. Good subjective outcome was noted in 92% (ODI < 20). The amount of vertebral slip preoperatively or postoperatively did not, however, correlate with the ODI score in our series.

The fusion rate in our series was high (81%) and is comparable to rates reported recently [10, 11, 17, 18, 24]. Pseudoarthrosis was most commonly noted in patients who underwent posterior fusion (10/29) with tibial osteoperiosteal autograft. The mean ODI score in patients with pseudoarthrosis was 9.6, indicating that fusion failure does not necessarily mean poor subjective outcome.

Pseudoarthrosis was more common after posterior fusion. This is probably partly due to the type of bone graft (tibial osteoperiosteal) and partly due to the fact that two levels are fused. Poor results with use of this type of graft have been reported previously after scoliosis surgery [12].

A major concern after spondylodesis is the fate of the intervertebral disc above the fusion level. In the present study, degenerative changes in the lumbar intervertebral discs above the fusion level were noted in only 13 (12%) patients. This value is comparable to or only slightly higher than the prevalence noted in healthy middle-aged individuals without spinal disease [6]. It is, however, markedly lower than the prevalence of degenerative changes noted in patients with instrumented posterolateral fusion for chronic low back pain [4]. A partial reason for this finding may be the younger age of the patients in our study.

Here, 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. Their preoperative slip and ODI at the follow-up were similar to those in the rest of the patients. Lumbosacral kyphosis tended to increase, possibly partly due to disc atrophy at fusion level; nevertheless, it remained within normal values in most of our patients.

There are no previous studies reporting the long-term results of functional outcome, including spinal mobility and trunk strength measurements, after operative treatment of spondylolysis and spondylolisthesis compared with the reference population. Although all of our patients had fusion in the lower lumbar spine, they performed, on average, as well as did the age-matched, sex-matched healthy reference population in non-dynamometric trunk strength measurements [1, 2]. A surprising finding was the high percentage of patients (44%) with reduced lumbar flexion. It is unclear why lumbar flexion, but not extension, is affected.

We had only one postoperative deep infection in our series, even though no prophylactic antibiotics were administered. We tentatively attribute this finding to the treatment with non-instrumented fusion. After instrumented posterior or posterolateral fusion, deep infections have been reported in 0%–4.7% of patients [13, 18, 24]. Instrumentation hardware and a longer operation time would appear to increase the risk of deep infection.

Conclusions

Standard uninstrumented posterolateral spinal fusion gives a satisfactory long-term fusion rate and good functional outcome and patient satisfaction in low-grade childhood and adolescence symptomatic spondylolisthesis. A higher rate of pseudoarthrosis is related to posterior fusion. According to the ODI score, however, this finding does not correlate with poor clinical outcome. Lumbar flexion is somewhat reduced, but, otherwise, the operation does not affect trunk mobility or strength.

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