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Health-Related Quality of Life Outcomes of Instrumented Circumferential Spinal Fusion for Pediatric Spondylolisthesis. A comparison with age and gender matched healthy controls

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Ethical committee approval was obtained from Turku University hospital. The ethical committee did not request informed consent from the patients as they underwent clinically standardized treatment protocol without additional examinations.

Counts: Words between Introduction and Discussion 2592 words (max, 2700 words), 5 tables

Abstract (298 words, max 300 words)

Study Design. A prospective study on the clinical, radiographic, and the health-related quality of life (HRQOL) outcomes in adolescents with spondylolisthesis undergoing instrumented circumferential spinal fusion compared with age and gender matched controls.

Objective. To determine the outcomes of pediatric spondylolisthesis patients minimum 2 years after surgery and to compare it with age and sex matched controls.

Summary of Background Data. There is limited evidence of the HRQOL of adolescent spondylolisthesis patients after surgery and no studies comparing it with healthy controls.

Methods. Twenty-six consecutive adolescents (mean age 14.7 years, range 10 to 18 years) who underwent instrumented reduction with intercorporeal spinal fusion for spondylolisthesis (11 low-grade, 15 high-grade) by a single orthopedic surgeon were included to this study cohort and matched by age and gender with two healthy controls. The HRQOL was measured with SRS-24 questionnaire before surgery, 6 months and 2 years after the surgery.

Results. The mean (SD) slip in the low-grade patients was 25% (13%) and 67% (15%) in the high-grade patients and 6% (7%) and 21% (25%) postoperatively, respectively ($p \leq 0.041$ for both comparisons). Three (12%) of the patients developed a non-union during follow-up. None of the patients developed a persistent neurologic deficit, but two (8%) patients presented with chronic postsurgical pain persisting 24 months. Seven (27%) of the patients had reoperations for any reason during the follow-up. SRS-24 pain and activity domains improved significantly from preoperative to 2-year follow-up ($p \leq 0.007$ for both). SRS pain, self-image, function domains and total score were significantly worse as compared with the 52 matched controls ($p \leq 0.020$ for all comparisons).

Conclusion. Risk of non-union is relatively low after instrumented spinal reduction in adolescents with spondylolisthesis. HRQOL improves significantly after instrumented reduction and circumferential spinal fusion in adolescents with spondylolisthesis, but remains at statistically lower level than in healthy controls.

Key words: Health-related quality of life; adolescent spondylolisthesis; SRS-24; outcome

Level of evidence: 2

Key points

- Risk of non-union is relatively low after instrumented spinal reduction in adolescents with spondylolisthesis.
- HRQOL improves significantly after instrumented reduction and circumferential spinal fusion in adolescents with spondylolisthesis
- HRQOL remains at statistically lower level at two-year follow-up than in healthy age and gender matched controls

Mini abstract (50 words, max 50 words)

A prospective comparative study on 26 adolescents with spondylolisthesis who underwent instrumented reduction and circumferential spinal fusion vs. 52 age and gender matched controls was performed. HRQOL improves significantly after instrumented reduction and circumferential spinal fusion in adolescents with spondylolisthesis, but remains at statistically lower level than in healthy controls.

Introduction

Spondylolisthesis is one of the most common causes of low back pain and radicular symptoms in the adolescent population^{1,2}. It is divided to low-grade and high-grade spondylolisthesis according to Meyerding classification: if the slip on a sagittal lumbar radiograph is less than 50% (Meyerding I-II) it is low-grade and if it is more than 50% (Meyerding III-V) it is high-grade^{3,4}. Low-grade spondylolisthesis is treated with pain medication, restriction of sports and operated only if there is persistent pain after conservative treatment⁵⁻⁸. In pediatric high-grade spondylolisthesis, it has been suggested that due to the risk of slip progression and symptoms being more the treatment should be operative with a short posterolateral fusion⁸⁻¹¹. Instrumented reduction seems to improve fusion rate as compared with in situ fusion¹², although the long-term health-related quality of life has been better with circumferential in situ fusion than with reduction¹³.

Previous smaller studies have suggested improvement in the health-related quality of life (HRQOL) after spinal fusion in children with spondylolisthesis^{14,15}, but guidance is limited in children as the largest series included also young adults¹⁶. The latter multicenter study suggested that the HRQOL improves in all the areas of SRS-22 questionnaire after the surgery in majority of patients, especially in the high-grade spondylolisthesis patients.

In this study we aimed to examine whether the HRQOL improves in children after operative treatment for spondylolisthesis using an instrumented reduction and circumferential spinal fusion. We also wanted to compare the HRQOL in these children with age and gender matched healthy controls and whether there is a difference in the HRQOL between operatively treated low-grade and high-grade spondylolisthesis patients. The hypothesis was that the HRQOL improves after surgery, is better in low-grade spondylolisthesis patients compared to high-grade spondylolisthesis patients, and is at similar level in these patients as compared to the healthy controls.

Materials and methods

Patients

From May 2009 to November 2017 twenty-six consecutive patients aged between 10 to 18 years with operatively treated spondylolisthesis were prospectively included to this study. All of the patients had pedicle screw instrumentation with intercorporeal fusion using TLIF cage or autologous structural bone graft. Nerve elements were widely decompressed for nerve roots (L5, S1) and cauda equinae. Reduction of the vertebra was performed in all patients except for the one with spondyloptosis (slip 100%) who underwent transsacral instrumentation and bone grafting in situ. Patients with low-grade spondylolisthesis had pedicle screws inserted into L5 and S1 to reduce the spondylolisthesis and patients with high-grade spondylolisthesis underwent instrumentation from L4 to S1 with iliac or S2AI screws¹⁷⁻²⁰. Transforaminal lumbar intercorporeal fusion cage was inserted in addition to standard posterolateral spinal arthrodesis. All patients were operated by a single orthopedic spine surgeon (IH) and had a minimum 2-year follow-up.

Outcome parameters

Clinical and radiographic follow-up as well as filling of Scoliosis Research Society-24 (SRS-24) outcome questionnaire²¹ were performed preoperatively, at 6 months, and at two years postoperatively. Therefore, the follow-up time in all patients was a minimum of 2 years (mean 3.3 years, range 2 to 10 years). Perioperative data was recorded and consisted of operation time, blood loss, and levels of instrumentation. Radiographic outcome was assessed from a standing radiographs of the spine. Standing spinal radiographs were taken prior the operation, 6 months and 2 years after the operation. Of these radiographs the percentage slip of the vertebra, lumbosacral angle, pelvic incidence, pelvic tilt, sacral slope, and lumbar lordosis (T12-S1) were measured as radiographic parameters²⁹. The high-grade spondylolisthesis patients were divided into balanced and unbalanced groups^{30,31}. For follow-up visits, the status of the instrumentation was evaluated (intact, broken screws or rods, signs of loosening). A routine CT scan was not obtained to evaluate spinal union at the final follow-up.

Healthy controls

Healthy controls were obtained from our previous study in which healthy adolescents and adults were asked to fill out a modified version of the original SRS health-related quality of life questionnaire (SRS-24)²¹: the SRS-22r questionnaire^{22,23}. Two controls were matched with each patient for age (+/- 2 years) and gender. Age matching was done with the age of the surgically treated patients in their last follow-up.

Scoliosis Research Society Outcome Questionnaire

The SRS-24 is the original disease specific questionnaire developed by the Scoliosis Research Society²¹. It originally measured and evaluated the HRQOL in operatively treated patients with adolescent idiopathic scoliosis. However, it has been broadly accepted and used to evaluate the HRQOL in patients treated operatively for other spinal problems as well, including pediatric lumbar spondylolisthesis²⁴⁻²⁶. The SRS-24 questionnaire consists of 24 questions concerning 7 domains: pain, general self-image, function from back condition, general level of activity, postoperative self-image, postoperative function, and satisfaction. Every question is scored from one to five and the maximum score of this questionnaire is 120. The higher the score, the better the outcome. The questions from 16 to 24 are about the treatment and can therefore be filled posttreatment only.

SRS-22r is an improved version of the SRS-24 questionnaire. Its questions are either exactly the same or close to the original SRS-24 questionnaire questions. In our study the control group members had filled SRS-22r questionnaire. Because the control group were healthy individuals and had not gone through operation only questions 1 to 15 from the original SRS-24 (preoperative domains) were used and compared with the similar questions of the SRS-22r (questions 1, 2, 4, 5, 6, 8, 9, 11, 12, 14, 15, 17, 18, 19, 20 from the SRS-22r). The domains were formed as follows: pain (SRS-24: 1, 2, 3, 6, 8, 11; SRS-22r: 1, 2, 4, 8, 11, 14), general self-image (SRS-24: 5, 14, 15; SRS-22r: 6, 19, 20), general function (SRS-24: 7, 12, 13; SRS-22r: 9, 15, 18), and general activity (SRS-24: 4, 9, 10; SRS-22r: 5, 12, 17)^{27,28}. There are eight exactly the same questions with exactly similar options in the SRS-24 and the SRS-22r and these questions were also compared across the groups (SRS-24: 1, 2, 3, 4, 5, 6, 7, 8; SRS-22r: 1, 2, 4, 5, 6, 8, 9, 11).

Statistical analysis

Ethical Committee approval

Ethical committee approval was obtained from our university hospital. The ethical committee did not request informed consent from the patients as they underwent clinically standardized treatment protocol without additional examinations.

Results

A total of 26 consecutive adolescents (mean [SD] age at the time of surgery 14.7 years [$\pm$ 1.9 years]) who underwent operative treatment for spondylolisthesis were included to this study (Table 1). Eleven (42%) of the patients had low-grade and 15 (58%) had a high-grade slip. One of the high-grade spondylolisthesis was spondyloptosis (slip 100%, Meyerding V). The indication for surgery was either a low-grade slip with ongoing symptoms after a year of conservative treatment or a high-grade spondylolisthesis. Conservative treatment consisted of restriction of sports, pain medication and in some cases brace treatment to relieve the pain. Associated pain scoliosis was seen in two (18%) patients with a low-grade spondylolisthesis and in 10 (67%) patients with a high-grade spondylolisthesis (Table 2). Additionally, idiopathic scoliosis was found in 3 (27%) patients in a low-grade spondylolisthesis group and six (40%) patients in a high-grade spondylolisthesis group. Two patients with a high-grade spondylolisthesis had earlier undergone spinal arthrodesis for adolescent idiopathic scoliosis.

Seventeen (65%) of the patients were asymptomatic at the end of follow-up and did not develop any complications.

Radiographic outcome

Preoperatively the mean slip in the low-grade patients was 25% ($\pm 13\%$) and 67% ($\pm 15\%$) in the high-grade patients (Table 2). After instrumented reduction the slips were 6% ($\pm 7\%$) and 21% ($\pm 25\%$), respectively. Similarly, the lumbosacral angle remained at 10° degrees pre- and postoperatively in the low-grade group, but improved from 14° ($\pm xx^\circ$) to 10° ($\pm yy^\circ$) degrees in the high-grade group. Unbalanced pelvis occurred preoperatively in eight (53%) of the high-grade patients and in seven (47%) at two-year follow-up (N.S.).

Complications

Three (12%) of the patients had a cerebrospinal fluid leak during the primary operation, which was noted and closed during the primary operation without further events. None of the patients developed a persistent neurologic deficit, but five (19%) patients had radicular pain at least occasionally postoperatively during the follow-up time. Two (8%) of these patients presented with chronic postsurgical pain persisting 2 years. Seven (27%) of the patients had reoperations for any reason during the follow-up time. Three (12%) of the patients (one with low-grade and two with high-grade slip) developed a pseudoarthrosis, two of them have undergone a revision procedure, one of them twice (5 years and 8 years after the primary operation). One (4%) patient developed spondylolisthesis to upper level (L4-5) and needing fusion over this level eight months after the primary operation. Four (15%) patients had mechanical discomfort from the iliac screws and they were removed later on. In one of these four patients a persistent postoperative cerebrospinal spinal fluid leakage required a re-revision to seal the leak. There were no deep surgical site infections.

Quality of life and SRS scores in surgically treated spondylolisthesis patients

Twenty-two (85%) patients completed the SRS-24 questionnaire preoperatively and twenty-three (88%) patients filled the same questionnaire two years after the surgery. The SRS-24 pain and activity domains improved significantly from preoperative to 2-year follow-up ($p \leq 0.007$ for both) (Table 3). The SRS-24 scores were higher in all domains except postoperative function in the high-grade spondylolisthesis patients as compared to the low-grade spondylolisthesis patients, but none of these differences reached statistical significance.

Comparison of Quality of life and SRS scores in operatively treated spondylolisthesis patients and healthy controls

The SRS scores in pain, self-image and function domains and the total SRS score were significantly lower in the surgically treated spondylolisthesis patients at their 2-year follow-up visit than in the age and gender matched healthy controls ($p < 0.05$ for all comparisons, table 4). The spondylolisthesis patients reached healthy controls only in the activity domain during the 2-year follow-up time. When low-grade and high-grade spondylolisthesis patients were compared separately to healthy controls it was noted that the low-grade spondylolisthesis patients had statistically significantly lower scores in pain ($p = 0.002$), self-image ($p = 0.027$) and function ($p < 0.0001$) domains whereas the high-grade spondylolisthesis patients had statistically significantly lower scores in the pain ($p = 0.020$) and the function ($p < 0.0001$) domains (table 5).

Discussion

This is a first study published comparing the HRQOL of the operatively treated spondylolisthesis patients with healthy age and gender matched controls. It shows that the HRQOL improves in pain and activity domains in spondylolisthesis patients after surgery but reaches equal level compared to healthy controls only in the activity domain. Surprisingly, the low-grade spondylolisthesis patients had lower values in all the domains of the SRS questionnaire except for the activity than the healthy controls, whereas the high-grade spondylolisthesis patients had lower values only in the pain and function domains. This could be partly explained by the different indications for surgery between the two groups: low-grade spondylolisthesis patients were operated only if persistent pain was present after conservative treatment whereas high-grade spondylolisthesis patients were all recommended to undergo spinal arthrodesis regardless of the symptoms.

Comparison with previous data

In previous studies, the HRQOL has improved after surgical treatment for pediatric spondylolisthesis^{14,16}. Bourassa-Moreau et al¹⁵ published a study 2013 where they measured HRQOL of the conservatively treated and the surgically treated high-grade spondylolisthesis patients during 2-year follow-up. In their study there were 23 patients in the surgically treated group and only 5 patients in the conservatively treated group. The decision of the surgical treatment was not standardized but left for the treating surgeon. The age of the patients was between 10 and 20 years at initial presentation. In their study the HRQOL improved in all the domains of SRS-22 for the surgically treated high-grade spondylolisthesis patients and stayed the same in the conservatively treated high-grade spondylolisthesis patients. They did not compare the HRQOL in conservatively vs surgically treated patients. Tsirikos et al¹⁴ examined fusion rates and the HRQOL of the low-grade spondylolisthesis patients who failed the conservative treatment and went through in situ posterolateral arthrodesis without instrumentation. In their study all 36 adolescent patients (aged between 9.8 to 17.3 years) had spinal fusion but the pars interarticularis fracture (spondylolysis) persisted at least in one side in most of the patients. In their study the HRQOL improved statistically significantly in all the domains of the SRS questionnaire following surgery.

In a prospective multicenter study done by Bourassa-Moreau et al¹⁶ the HRQOL of the surgically treated spondylolisthesis patients improved in all the domains of the SRS-22 questionnaire 2 years after the surgery compared to the SRS-22 prior the surgery. In their study young adults were included to the study cohort, as the age limit was between 10 and 25 years at surgery. When comparing separately low-grade and high-grade spondylolisthesis patients they found out that in the low-grade spondylolisthesis patients' the pain and function domains improved after surgery whereas in high-grade spondylolisthesis patients all of the domains improved statistically significantly after surgical treatment for spondylolisthesis. In their study indication for surgery and technique of the surgical intervention were treating surgeon's decision. In the current study the pain and activity domains improved from preoperative to 2-year follow-up in the surgically treated adolescents with spondylolisthesis. However, only the activity domain was at the same level than in the age and gender matched healthy controls.

Carreon et al³² have defined the minimum clinically important difference (MCID) defined for SRS-22r questionnaire for appearance/self-image, activity and pain domains after surgical correction of adolescent idiopathic scoliosis. In this study the MCID for pain domain was 0.20, 0.08 for activity domain and 0.98 for the appearance domain. There are no similar definitions to surgically treated children with spondylolisthesis. In our study the improvement was 0.68 in the pain, 0.19 in the self-image, and 0.89 scores in the activity domains. Improvements in the pain and activity domains are significantly above the MCID level as defined for operatively treated scoliosis patients and it can be assumed that the changes in these domains are over the minimum clinically important difference also in the spondylolisthesis patients. In our previous study adolescents operated for AIS had similar scores of the SRS-24 domains except for the function domain at five-year follow-up than in the age and gender matched healthy controls²⁸. We hypothesize that pain may have more pronounced effect on health-related quality of life than pure spinal deformity does.

Limitations and strengths

Children needing surgical treatment for spondylolisthesis are relatively rare even in an academic pediatric spine unit. Thus, the number of surgically treated patients was relatively small. One limitation of this study was the somewhat different questionnaires used (the SRS-24 and SRS-22r); however, we chose to keep the same original SRS-24 questionnaire in the surgical treatment group to provide data from preoperatively to minimum 2 years postoperatively. To provide comparable questionnaires, we used the 15 most similar preoperative questions from the SRS-24 and SRS-22r, including 8 questions that were exactly the same, to form the pain, activity, self-image, and function domains. The strengths of this study include a comparison with an age and gender matched healthy control group with two matched controls to each surgically treated spondylolisthesis patient. Also this is a prospective, consecutive cohort study, where the indications for surgery were clear and all of the patients were operated using a similar surgical technique by a single orthopaedic spine surgeon. The follow-up time was a minimum of two years. The SRS-24 questionnaire used in this study is standardized, validated and widely used.

Conclusions

In conclusion, the SRS-24 scores in pain and activity domains improved statistically significantly after the surgery for spondylolisthesis during 2-year follow-up time. However the scores in pain, self-image and function domains were significantly lower as compared to age and sex matched healthy controls.

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