

Indirect pars repair for pediatric isthmic spondylolysis: a case series

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Background: Isthmic spondylolysis (ISY) is a common cause of back pain in the pediatric population. Historically, non-operative treatments have had a very high success rate. The purpose of this study was to review the mid-term results of an indirect pars repair technique on reducing the visual analog score for pain (VAS), spondylolysis defect healing, complication rates and rates of return to pre-surgery activity level in pediatric patients who failed conservative care for ISY.

Methods: A retrospective review of all pediatric patients (<18 years old) treated surgically by one surgeon over a 5-year period was performed. Patients were treated with indirect pars repair utilizing pedicle screws and laminar hooks and local autograft. Preoperative VAS was compared to the final follow-up score, and return to activity was evaluated. Radiographs were reviewed to evaluate healing.

Results: Nine patients (6 females, 3 males) were treated surgically. Average age at the time of surgery was 15.4 years, (range, 13 to 17 years). Average length of final follow-up was 11.9 months (range, 6 to 24 months). Preoperative VAS averaged 5.6 points (range, 2 to 8 points) compared to final follow-up of 1.2 (range, 0 to 3). Definitive bony healing was noted in 7 of 9 cases (77.8%) with at least 6 months follow-up. Eight of nine patients (88.9%) returned to preoperative competitive sports activity level. No complications were noted during the follow-up period.

Conclusions: Pediatric patients treated surgically with indirect pars repair appear to achieve satisfactory mid-term outcomes. This technique appears safe, and has both a high healing rate and return to competitive athletics. Further study is needed to determine durability of this procedure.

Keywords: Pediatric; spondylolysis; spondylolisthesis; indirect repair; surgery; treatment

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Introduction

Isthmic spondylolysis (ISY) has a prevalence of 6% in the general population with new research suggesting a rate as high as 11.5% (1,2). This condition is a common cause of back pain in the pediatric population. Historically, non-operative treatments have had a very high success rate (3-5). Pain that is not manageable with conservative treatment, however, presents a dilemma for

spine surgeons. Many surgical options exist, including techniques for direct or indirect pars interarticularis repair, as well as spinal segment fusion. The purpose of our study was to review the mid-term results of an indirect pars repair on the visual analog score for pain (VAS) level, isthmic pars defect healing, surgical complication rates and the rates of return to sporting activity following surgery.

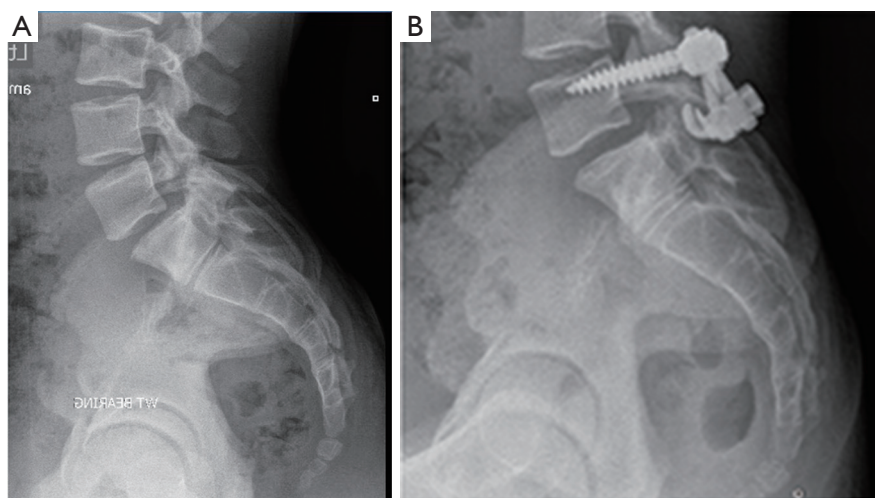


Figure 1 Indirect pars repair. (A) A preoperative lateral radiograph of a 15-year-old male patient (patient #3) with a transitional L5 spondylolysis with low-grade listhesis; (B) a 6-month follow-up lateral radiograph in the same patient following indirect pars repair with healing of the lysis and decrease in listhesis.

Methods

Institutional Review Board (IRB) approval was granted for our study (IRB # 16-728). A retrospective review of all pediatric patients (<18 years old) surgically treated for spondylolysis with or without low-grade spondylolisthesis, was performed. Surgeries were performed by one fellowship-trained pediatric orthopaedic surgeon (senior author RC Goodwin) and occurred between 2010 and 2015. This included a total of nine patients. Patients had failed at least 1 year of conservative treatment, including oral analgesics, physical therapy and activity modification prior to surgery. Gender, age at the time of surgery, sports participation and VAS levels were recorded. Patients were treated with an indirect pars repair utilizing pedicle screw instrumentation with laminar compression hook constructs and local spinous process autograft. At the time of surgery, a high-speed burr was used to decorticate the fibrous pars defect, the local spinous process autograft was placed into the defect area and laminar hooks in compression were applied (*Figure 1*). Post-operatively, patients were restricted from bending, lifting more than 10 pounds, twisting, or sports activities for 3 months. After this time, patients slowly returned to exercise activities, with full return to activities at 5 to 6 months after surgery.

The VAS difference at final follow-up was calculated. A two-tailed *t*-test was performed on the VAS score reduction to determine statistical significance. Preoperative and

final post-operative radiographs were reviewed to evaluate healing. All authors with varying degrees of surgical experience (2 residents, 1 fellow, 1 attending) reviewed final anterior posterior and lateral radiographs on three separate occasions. Overall interrater agreement (kappa) was determined between the four reviewers' responses. Complications that occurred during the treatment process were reviewed and recorded. Return to sport participation was determined at the final follow-up visit.

Results

Nine patients (6 females, 3 males) were treated surgically after failing conservative treatment. Cases included 6 bilateral L5 spondylolysis, 1 left L5 spondylolysis and 2 bilateral L4 spondylolysis. Two of the bilateral L5 cases exhibited low-grade spondylolisthesis (*Figure 1*). Average age at the time of surgery was 15.4 years, (range, 13–17 years). Average length of final follow-up was 11.9 months (range, 6–24 months). Preoperative VAS averaged 5.6 points (range, 2–8 points) and post-operative VAS averaged 1.2 (range, 0–3 points). The VAS was reduced on average by 4.4 points (range, 0–8 points), but this did not achieve statistical significance ($P=0.99$). Definitive bony healing was noted in 7 of 9 cases (77.8%) with at least 6 months follow-up line (*Table 1*). There was disagreement between raters in determining bony healing in one case. Overall agreement between raters was very high at 0.93 (6). Eight of nine patients (88.9%)

Table 1 Patient characteristics and outcomes

Case	Gender	Age at surgery (years)	Length of follow-up (months)	Levels involved (bilateral)	Pre-VAS	Post-VAS	Healed?	Sport	Return to sport?
1	Female	17	12	L5	6	0	Yes	Dance	Yes
2	Male	15	8	Left L5	7	2	Yes	Football	No**
3	Male	15	12	L5	3	0	Yes	Wrestling	Yes
4	Female	17	12	L5	3	3	No	Gymnastics	Yes
5	Female	17	24	L4	8	0	Yes	Dance	Yes
6	Female	15	6	L5	8	3	Yes	Softball	Yes
7	Female	13	6	L5	8	3	Yes	Dance	Yes
8	Female	15	6	L5	5	0	No*	Track	Yes
9	Male	15	21	L4	2	0	Yes	Basketball	Yes
Avg or total	6 female; 3 male	15.4	11.9	7 L5; 2 L4	5.6	1.2	7 yes; 2 no		8 yes; 1 no

*, 50% disagreement between raters; **, returned to non-collision sport only. Avg, average; VAS, visual analog score for pain.

returned to preoperative competitive sport activity level. No complications were noted during the study period, including infection, instrumentation failure, or neurological injury.

Discussion

ISY has a relatively high prevalence and is a common cause of back pain in pediatric patients. According to Klein *et al.*, a meta-analysis revealed that nearly 84% of patients did well by 1 year following conservative treatment (3). For those that continue to have pain and functional limitations, many surgical options have been developed. Pars repair techniques have been used in an attempt to spare spinal motion segments and minimize fusing the spine. These techniques include direct pars repair with cortical screws, indirect pars repair with posterior wiring, or a combination of pedicle screw instrumentation and some type of instrumentation to apply compression (laminar hooks, wiring, among others) (5,7-20). In adult cases or older pediatric patients with significant degenerative disc disease or high-grade spondylolisthesis, fusion techniques have been recommended (18,21-23).

Traditional direct screw fixation across the defect was popularized by Buck in 1970 (8). Various posterior wiring techniques have been popular as well, including Scott's wiring and other modifications of this technique (24,25). Tokuhashi and Matsuzak described pedicle screw instrumentation with

laminar compression hooks (11). Prior to this, Morscher *et al.* described placing lateral mass screws and using laminar compression hooks (10). Modern instrumentation and techniques have changed, but the principle remains the same: create a biologic and mechanical environment to limit motion at the defect and promote healing.

Deguchi *et al.* studied spinal motion in cadaveric models with various pars repair and fixation techniques (14). Techniques included Bucks fixation, Scott's wiring, modified Scott's wiring and a pedicle-screw-rod-hook construct. The screw-rod-hook construct allowed the least amount of motion across the defect during flexion. Fan *et al.* studied the biomechanics of the Texas Scottish Rite Hospital (TSRH) hook screw and screw-rod fixation methods and found these to provide more rigidity during rotation than either Scott's or Buck's technique (17). Westacott *et al.* performed a systematic review of the literature which revealed little clinical difference between pars repair or fusion techniques (26). One comparative study demonstrated improved long-term outcomes with fusion.

Several authors have published recent case series results on pars repairs. Dai *et al.* described a 93% good or excellent result after direct repair with or without facet fusion for 46 patients (13). Patients with disc disease noted on MRI underwent simultaneous facet fusion with the direct pars repair in the study. de Bodman *et al.* described restoration of spine stability and a decrease in the Oswestry Disability Index (ODI) in 35 patients treated with a modified-Buck

direct repair technique with a mean follow-up of 10 years (9). Chung *et al.* reported favorable 2-year results and high bony healing rates on 6 patients with indirect pars repairs for multilevel spondylolysis (18). Roca *et al.* reported results on 19 patients with indirect pars repair and found that patients younger than age 20 had a 92% defect healing rate and better outcomes than those older than age 20 (16). Snyder *et al.* reported defect healing results of nearly 90% on 16 patients with a median age of 16 years (27). Patients were treated with Buck's direct repair and recombinant human bone morphogenetic protein (rhBMP-2) regardless of age or gender, as well as bracing, with all athletes returning to play by final follow-up. Deguchi *et al.* studied the long-term results of 52 patients treated with 1 of 3 different pars repair techniques, including Scott's, modified Scott's, or Buck's technique (14). The authors found the best outcomes with the modified Scott's technique. Karatas *et al.* studied 16 patients that were divided between undergoing either direct screw repair or indirect repair with pedicle screw and laminar hook repair (28). The authors quote a 100% healing rate in both groups by 6 months after surgery, and excellent or good results in 88% of patients, feeling that either repair technique is acceptable.

Our study reviewed the results of indirect pars repair with pedicle screw fixation and laminar compression hooks in a pediatric population only. The technique in our series utilized a simple and familiar midline approach, modern spine instrumentation and locally harvested spinous process autograft. We did see a consistent reduction in VAS following surgery, and a high rate of both the defect healing and return to sports by 6 months after surgery. This was true for the 2 patients (patient #3 & #7) that demonstrated low-grade listhesis, with a 3-point and 5-point reduction in VAS respectively. One patient who was unable to return to the collision sport of football (patient #2) was able to return to basketball at a competitive level. To our knowledge, no patients have required any further surgical interventions.

There are several limitations to our study, including the retrospective nature of this case series. Although there was a high rate of agreement between raters, no advanced imaging was used to determine true bony defect healing. The follow-up period is also brief, averaging just under 11 months. Longer-term study will be needed to judge the durability or success of this procedure with time.

Conclusions

Pediatric patients treated surgically with the indirect pars

repair technique described, appear to achieve satisfactory mid-term results. A high percentage of patients returned to a competitive sporting activity level and had defect healing on follow-up radiographs. This technique appears safe with no complications observed in this case series. Further study and longer-term follow-up within this group is needed to determine the surgical durability of this procedure.

Acknowledgements

None.

Footnote

Conflicts of Interest: RC Goodwin paid consultant for Stryker. The other authors have no conflicts of interest to declare.

Ethical Statement: Cleveland Clinic Institutional Review Board (IRB) approval of was granted for our study (IRB # 16-728).

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