Nonoperative Treatment Protocol for the Management of Acute Spondylolysis in Adolescent Athletes: Excellent Rates of Return to Sport and Clinical Resolution in 179 Patients

Patrick Nian, Amith Umesh, Ithika S Senthilnathan, Isabella G Marsh, Austin Camron Kaidi, Shevaun Mackie Doyle, John S Blanco, Roger F Widmann, Jessica Heidenberg Heyer

INTRODUCTION:

Spondylolysis is a defect of the pars interarticularis of the vertebrae, most commonly seen in the lumbar spine. The etiology of isthmic spondylolysis is generally considered a consequence of repetitive mechanical stresses to a congenitally weak portion of the vertebrae. The optimal nonoperative treatment algorithm for spondylolysis in adolescent athletes remains unclear, specifically with regards to length of activity restriction, need for bracing and time of initiating physical therapy (PT). This study aimed to (1) evaluate the clinical outcomes in a cohort of adolescent athletes who were treated nonoperatively for acute spondylolysis with a protocol of rest, bracing and PT, including the rates of clearance for return to sports (RTS), clinical resolution of pain, recurrent pain, recurrent acute spondylolysis, chronic spondylolysis, and surgical intervention; and (2) determine predictors of faster RTS clearance, recurrent acute spondylolysis, and progression to chronic spondylolysis.

METHODS:

This was a retrospective review of 179 adolescent athletes (68% male, mean age 14.4 ± 1.6 years) presenting with acute spondylolysis, defined as a stress reaction or defined fracture of the pars interarticularis with edema on magnetic resonance imaging, from February 2016 through August 2024. Of 466 patients identified by ICD-10 codes, 201 patients with chronic spondylolysis, 69 patients with insufficient follow-up, and 17 who did not receive bracing were excluded. All patients were treated nonoperatively by four fellowship trained pediatric orthopaedic surgeons with approximately 12 weeks of activity restriction and bracing, and eventual progression to PT around four to six weeks of treatment. Patients who failed to follow up or were not treated with bracing were excluded. The primary outcome of the study was functional recovery, defined as clearance to RTS. Rates of achieving RTS clearance and the time from initial presentation to clinical clearance for RTS were collected. Secondary outcomes included clinical resolution of pain, recurrence of pain, recurrent acute spondylolysis, progression to chronic spondylolysis (defined by persistence of pain with pars defect and lack of edema on MRI), and surgical intervention. Demographic variables (age, sex, sports played), injury characteristics (level, laterality, spondylolisthesis and associated grade, if present), and treatment variables (total bracing time and start time of physical therapy) were recorded. Multivariable linear and logistic regression analyses evaluated the association of demographic variables, injury characteristics, and treatment characteristics with time to RTS clearance and recurrent acute spondylolysis/chronic spondylolysis, respectively.

RESULTS:

179 patients were treated with rest, a mean bracing time of 11.0±2.3 weeks, and initiation of PT at a mean of 5.9±1.6 weeks. RTS clearance was achieved for 99% of patients at a mean of 13.3±3.9 weeks. 79% of patients had resolution of pain at their first follow up visit (mean of 6.8 ± 2.2 weeks from initiation of treatment), which increased to 96% by the second follow up visit (mean of 13.9 ± 3.6 weeks from treatment initiation). 78 (44%) had recurrent pain after completion of the protocol: 19 (10.6%) were diagnosed with recurrence of acute spondylolysis and 15 (8.4%) progressed to chronic spondylolysis. Five (2.8%) patients required surgical intervention (4 L5/S1 fusions, 1 pars fixation). Multivariable linear regression demonstrated that longer bracing ($\beta = 0.47$, 95% CI: 0.24 - 0.70, $p < 0.001$) and delayed initiation of PT ($\beta = 0.69$, 95% CI: 0.33 - 1.05, $p < 0.001$) were associated with paradoxical improvement in time to RTS clearance. Persistent pain at the first ($\beta = 1.70$, $p = 0.009$) and second ($\beta = 2.59$, $p = 0.050$) follow up visit were significant predictors of extended RTS clearance. An additional week of bracing was associated with 22% decreased odds (95% CI: 0.63 - 0.96, $p = 0.019$) of recurrent acute spondylolysis. Multi-level spondylolysis (OR: 8.21, 95% CI: 1.13 - 59.82, $p = 0.038$), persistent pain at the second follow-up visit (OR: 10.65, 95% CI: 1.79 - 63.51, $p = 0.009$), and each week delay in initiating PT (OR: 1.43, 95% CI: 1.08 - 1.90, $p = 0.013$) was associated with higher odds of recurrence of acute spondylolysis. Persistent pain at the first follow-up visit was associated with higher odds (OR: 4.95, 95% CI: 1.63 - 15.01, $p = 0.005$) of progressing to chronic spondylolysis following the initial acute injury.

DISCUSSION AND CONCLUSION:

Our nonoperative spondylolysis protocol that utilized activity restriction, bracing, and PT demonstrated high rates of RTS clearance and clinical resolution of pain. Bracing time was associated with accelerated RTS clearance and decreased odds of recurrence. Persistent pain was an important clinical sign indicating extended time to RTS clearance, acute spondylolysis recurrence, and potential progression to chronic spondylolysis. These results demonstrate the success of our spondylolysis protocol involving 12 weeks of bracing with initiation of physical therapy at 4 to 6 weeks following rest.

Table 1. Age, Sex, and Sports Descriptive Statistics of the 179 Patients with Acute Spondylolysis

Characteristic	N=179
Age, years ± SD	14.4 ± 1.6
Sex, n (%)	
Male	122 (68.2)
Female	57 (31.8)
Sports Played, n (%)	
Soccer	43 (24.0)
Basketball	41 (22.9)
Lacrosse	25 (14.0)
Football	22 (12.3)
Baseball	18 (10.0)
Other[a]	137 (76.5)
Multi-sport athlete, n (%)	75 (41.9)

SD: Standard Deviation.
[a]Other sports included tennis (17), track/cross country (15), gymnastics (14), volleyball (11), weight lifting (11), skiing/snowboarding (10), miscellaneous (59).

Table 2. Descriptive Statistics of Diagnosis Characteristics in 179 Patients with Acute Spondylolysis

Spondylolysis Laterality, n (%)	
Left	44 (24.6)
Right	32 (17.9)
Bilateral	103 (57.5)
Spondylolysis Levels, n (%)	
L2	1 (0.6)
L3	7 (3.9)
L4	43 (24.0)
L5	120 (67.0)
S1	1 (0.6)
Multi-level spondylolysis	7 (3.9)
Type of Spondylolysis, n (%)	
Stress Reaction (no fracture line)	28 (15.6)
Defined fracture line without spondylolisthesis	123 (68.7)
Spondylolysis with Spondylolisthesis	28 (15.6)
Grade 1	28/28 (100)

Table 3. Descriptive Statistics of Non-operative Bracing and Physical Therapy Protocol in 179 Patients with Acute Spondylolysis

Brace Type, n (%)	
Hard brace	170 (95.0)
Soft brace	9 (5.0)
Mean bracing time, weeks ± SD*	11.0 ± 2.3
Mean PT initiation time, weeks ± SD	5.9 ± 1.6
Clinical resolution (lack of pain) at 1st follow-up visit, n (%)	141 (78.8)
Clinical resolution (lack of pain) at 2nd follow-up visit, n (%)	172 (96.1)
Noncompliance, n (%)	4 (2.2)
Non-compliant with bracing	2
Non-compliant with activity restriction	2
RTS Clearance Rate, n (%)	178 (99.4)
Mean time of RTS, weeks ± SD	13.3 ± 3.9
Recurrence of pain, n (%)	78 (43.6)
Recurrence of acute spondylolysis	19 (10.6)
Progression to Chronic spondylolysis	15 (8.4)
Surgical intervention, n (%)	5 (2.8)

SD: Standard Deviation; RTS: Return to Sport; PT: Physical Therapy.
*Excludes 2 patients who were non-compliant with brace-wear