

# Functional outcome following direct repair or intervertebral fusion for adolescent spondylolysis: a systematic review

Daniel J WESTACOTT, Stephen J COOKE

Department of Orthopaedics, University Hospital of Coventry and Warwickshire, UK

Corresponding Author: Mr Daniel Westacott
c/o Julie Moran
Paediatric Trauma & Orthopaedics
Office 4 (ABS10011) Ward 16 (Children's Unit)
University Hospital
Clifford Bridge Road
Coventry
CV2 2DX

Conflicts of Interest and Sources of Funding: None Declared

**Abstract**

A systematic review of the literature was performed to establish if direct repair of the pars defect or intervertebral fusion achieves better Oswestry Disability Index scores in adolescent spondylolysis or low grade spondylisthesis. Nine studies met the inclusion criteria, reporting a minimum total of 80 direct repairs and 108 fusions due to presumed replication of data between studies. Little statistically or clinically significant difference could be established between the two interventions. The only comparative study showed improved long term outcome with fusion. Further well-designed prospective comparative studies are required to establish the optimum treatment for this condition.

**Key Words**

Spondylolysis

Spondylolisthesis

Pediatric

Outcome Assessment

Oswestry Disability Index

Surgery

## Introduction

Spondylolysis is a condition affecting the lumbar spine in which there is a unilateral or bilateral defect of the pars interarticularis. Such defects have been identified in 11.5% of adult Caucasians and the majority remain asymptomatic [1,2]. However, the condition can cause pain and progress to spondylolisthesis. Symptoms are more likely to occur in children and adolescents undertaking sports that involve repetitive forced hyperextension of the lower back, such as gymnastics [3]. Spondylolysis is considered to be a fatigue fracture due to the high stresses put through the lumbar spine, particularly the L5 pars interarticularis, as a consequence of our bipedal gait.

Treatment is usually conservative and the majority of cases will settle with abstinence from sport and physiotherapy [4]. For persistent pain, or in cases of neurological compromise, surgery may be indicated. This traditionally involved posterior or posterolateral fusion of the affected segment [5,6]. However, it has been proposed that this might cause unnecessary stiffness and next level disc degeneration due to the loss of a spinal motion segment. Therefore, attention has turned more recently to direct repair of the defect. Various techniques have been described, involving internal fixation of the defect, either with a screw or cerclage wiring [7-9]. Healing may be augmented by autologous iliac crest bone graft. While this has the benefit of being a smaller operation, non-union and pseudarthrosis rates of up to 25% have been reported [10]. This is higher than following fusion [11]. Furthermore, Seitsalo et al [12] demonstrated that fusion does not significantly increase the rate of degeneration in the adjacent disc above the fusion in

a group of patients treated surgically for symptomatic spondylolysis. Fusion remains the treatment of choice for high grade spondylolisthesis and any slip associated with spina bifida, degenerative disc or facet disease, dysplastic bony changes or segmental instability [13]. The grading system for spondylolisthesis, as described by Meyerding, is detailed in Table 1.

Due to the lack of clarity as to the optimum surgical intervention, this review aims to establish if there is a difference in functional outcome between direct repair of the defect and intervertebral fusion for adolescent spondylolysis or low grade spondylolisthesis.

**Methodology**

For this review, functional outcome will be evaluated using the Oswestry Disability Index (ODI). This patient-reported score is among the leading disease-specific outcome measures for lumbar disorders [14]. It has been validated for a number of different lumbar conditions [15-17] and has been used as a bench mark to validate numerous other instruments [14]. 0-19% is considered as minimal disability, 20-39% moderate, 40-59% severe, and over 60% as crippled [18]. For lumbar surgical procedures, the minimum clinically important difference in ODI score has been calculated as 12.8 points [19]. The ODI has not been validated in the management of adolescent spondylolysis.

## Literature Search and Study Selection

A search of the Medline database (1945-present) was performed using OvidSP on 6th February 2012. The search strategy is detailed in Table 2. As recommended by the Cochrane Handbook of Systematic Reviews [20], a variety of search terms were employed, combining index terms and free-text terms, to identify papers dealing with patient-reported outcomes. Abstracts were assessed for relevance and full-texts were reviewed of those that met the inclusion criteria on initial assessment. The reference sections of these papers were scrutinised for further relevant articles.

Studies were included if a patient group with average age of less than 21 years received direct repair or intervertebral fusion for spondylolysis or low grade spondylolisthesis (Meyerding Grade I and II) and was assessed post-operatively with the Oswestry Disability Index. All levels of evidence were included but case reports and case series with fewer than five patients were excluded.

## Results

127 studies were identified by the Medline search strategy. The process by which articles were selected is detailed in Figure 1. 14 were selected for full-text assessment on the basis of their abstract. Nine studies met the inclusion criteria and are detailed in Table 3. Two were excluded because the average age was over 21 [11,21], two because the ODI was not used in patient assessment [22,23], and one was excluded because too few patients were

in the appropriate age group [24]. All the included studies were level III or IV evidence. Formal evaluation of methodological quality was not performed but the key weaknesses of the studies are detailed in Table 4. Pooled statistical analysis was not attempted due to the variability of surgical procedures performed in each group and the apparent likelihood of patient duplication between studies, as detailed in Table 4.

Four studies reported outcome following direct repair of the defect. Altaf et al reported a prospective case series of 20 patients with L5 spondylolysis, pain lasting more than 12 months despite conservative treatment and a normal disc on MRI. They were treated with direct stabilization of the pars defect using a pair of pedicle screws connected by a U-shaped modular link passing beneath the spinous process [25]. The defect was filled with autologous bone graft and compression achieved by tightening the link to the screws. Average ODI decreased from 54 pre-operatively to 8 post-operatively. The authors concluded that 90% of patients had an excellent clinical outcome and state that the strength of this construct removes the need for post-operative immobilization, although the non-union rate was 20%, with half of these being symptomatic.

Debnath et al performed direct repair of a spondylolytic defect without associated spondylolisthesis on 22 young athletes [26] who had failed conservative treatment, although the term ‘athlete’ was not defined. 19 patients underwent a Buck’s repair (passing a cortical lag screw across a grafted defect), modified to include bone grafting of the lamina and the transverse process. Three patients received Scott’s wiring, using an 18-gauge stainless steel wire passed around the transverse processes and tightened in a

figure-of-eight over the spinous process. Mean ODI dropped from 39.5 to 10.7. Two patients that underwent Scott's wiring required revision to posterolateral fusion for non-union. The authors conclude that a modified Buck's fusion results in a significant improvement in ODI for professional sportsmen and women.

Debnath et al also reported the outcome in 42 patients with unilateral pars defects [27]. The majority responded to conservative treatment with activity modification, bracing and physical therapy but eight remained symptomatic and underwent modified Buck's fusion as previously described, following a positive response to local anaesthetic pars infiltration. They were treated contemporaneously at the same centre with those reported in Debnath's earlier work, so there may be some duplication of patients between the two studies. Mean ODI dropped from 39.4 to 6.4, the best outcome of any repair, although the lesions were unilateral and therefore not associated with a spondylolisthesis. One patient with spina bifida suffered a symptomatic non-union, requiring posterior fusion.

Koptan et al treated ten patients who had developed spondylolysis following correction of painless idiopathic scoliosis [28]. Local anaesthetic infiltration of the pars defect was used to confirm the cause of pain. In five cases, a 1mm double cable was looped between a pedicle screw and the spinous process bilaterally. Five cases received a modular construct similar to that used by Altaf et al. All had iliac crest bone graft placed in the defects. Mean ODI dropped from 52 to 11.

Three studies were identified that reported functional outcome after posterior or posterolateral fusion. It appears that these studies report the same patient group from different perspectives. Remes et al compared outcome with abnormal MRI findings [29], Lamberg et al looked at functional and radiological outcomes [30], while Helenius et al compared ODI to the Scoliosis Research Council questionnaire [31]. Post-operative mean ODI ranged from 6.3 for posterolateral fusions to 11.3 for posterior fusions.

One study, published in two papers reporting early and long term follow up, compared direct repair with intervertebral fusion [32,33]. Schlenzka et al compared outcome in 28 patients who underwent Scott's wiring with 28 who received posterolateral segmental fusion without instrumentation. At mean follow-up of 54 months there was no significant difference in ODI between repair and fusion. However, the fusion group did significantly better at mean follow-up of 14.8 years.

**Discussion**

On the basis of the data included in this review of the literature, it is very difficult to recommend one intervention over the other in terms of outcome, particularly when considering the lack of quality comparative data from well-designed studies. While a number of case series describing various methods of direct repair suggest good results [25-28], these were comparable to those of fusion in the largest studies [29-31].

The only study drawing direct comparisons between the two treatments suggested fusion to provide better outcome in the long term [33]. While this was statistically significant, the difference between an ODI score of 4 and 11 may not be clinically significant, with both groups sitting within the bracket of 'minimal disability'. There were important methodological weaknesses of the study, including treatment allocation, differing post-operative protocols and differing pathologies in terms of defect level and degree of slip.

It should also be noted that the direct repairs in the comparative study were performed using Scott's wiring. Kip et al found that screw fixation has greater biomechanical strength than wiring and is therefore more likely to lead to union of the defect [34]. Two of the three patients that underwent Scott's wiring in the study by Debnath et al required revision for non-union [26].

One of the proposed advantages of direct repair is preservation of the motion segment and prevention of next level disc disease. Remes et al found no correlation between outcome

and abnormal MRI findings [29]. Schlenzka et al found no difference in the MRI signal intensity of the disc above the operated segment between repair and fusion [32], bringing into question the theoretical benefit of direct repair. They also observed increased operative time, blood loss and re-operations in the direct repair group. Furthermore, given the non-union rate of up to 20% with direct repair [25,26], the case in its favour becomes harder to argue. That said, these studies were not able to link non-union with worse functional outcome. Direct repair may be considered less invasive but most still use iliac crest bone graft which has significant donor site morbidity [35]. Due to pseudarthrosis and progression of slip, secondary fusion becomes necessary in up to 57% of direct repairs, depending on technique [36].

The level of the defect should be considered when deciding treatment method. A posterolateral fusion has been suggested to be the gold standard for L5 spondylolysis [37], with repair reserved for more cephalad defects. The majority of the fusions in this review were performed at L5. However, many repairs were also performed at this level (including all the cases in the study by Altaf et al). Degree of slip may impact upon the preferred treatment. Schlenzka et al demonstrated better outcome with fusion than direct repair. The patients in the repair group had a greater degree of slip on average than both the patients in the fusion group and the patients in the other studies that reported on direct repair. It may be that direct repair should be reserved for cases with minimal or no slip.

The total number of patients in this review is comparatively small, with a maximum of 88 patients undergoing direct repair and 346 patients treated by fusion. However, it is likely

that there is duplication of patients between the two studies by Debnath et al as they were performed at the same centre and the study periods coincide. Furthermore, it seems very likely that Helenius et al, Remes et al and Lamberg et al all report the same population. It is unclear when the fusions reported by Schlenzka et al were performed. This replication means that there may be as few as 80 direct repairs and 108 fusions included in this review, with all of the fusions having been performed at the same centre.

It must be remembered that the ODI has not been validated in adolescent spondylolysis. The SRC questionnaire may be a more appropriate instrument in adolescents as it includes questions on cosmetic appearance and does not feature questions on sexual function. Helenius et al showed it to correlate well with the ODI in patients undergoing fusion for adolescent spondylolysis [31]. Furthermore, the ODI had not been validated to be used in Finnish at the time these studies were presented, although this has now been performed [38]. There were also inconsistencies in the use of the ODI between studies. Schlenzka et al modified the tool, removing the question on sexual function [32].

Due to the apparent long term advantage of fusion and the lack of clarity as to the theoretical advantages of direct repair, a randomised controlled trial is necessary to establish the optimum mode of treatment for this condition. The issues of level of disease and degree of slip would have to be addressed, either through inclusion criteria or randomisation. Subgroup analysis may be required to separate the efficacy of the various interventions described. The outcome measures should include clinician-based evaluation (range of movement and trunk strength), radiographic analysis (union rates and disc

degeneration), and patient-reported outcomes, including the ODI and SRC questionnaires. A long time period will be required for recruitment and follow-up for an RCT in this condition, so in the meantime the authors look forward to the long term outcomes from the studies of direct repair featured in this review.

In conclusion, this systematic review does not demonstrate a clinically significant difference in functional outcome, as measured by the ODI, between direct repair and fusion for paediatric spondylolysis or low grade spondylolisthesis. Further well-designed prospective studies are necessary.

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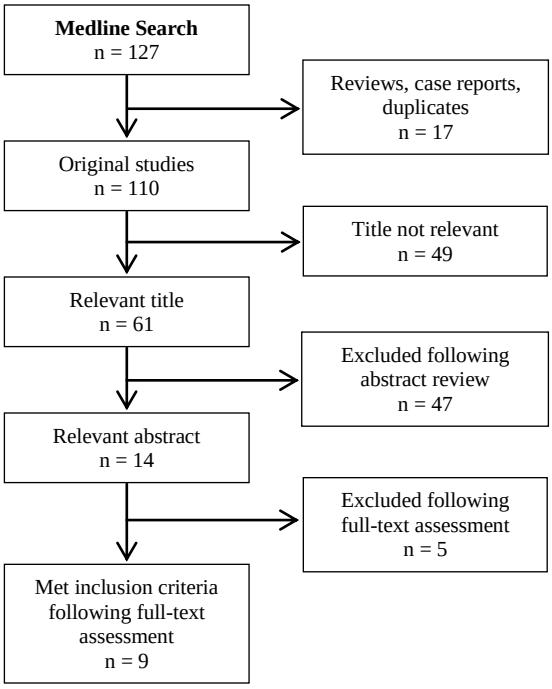


**Figure 1.** Flowchart demonstrating the process of article selection

| | | |
|---|---|---|
| Low Grade | Grade I | 0-25% displacement |
| | Grade II | 25-50% displacement |
| High Grade | Grade III | 50-75% displacement |
| | Grade IV | 75-100% displacement |
| | Grade V | >100% displacement (spondyloptosis) |

**Table 1:** Grading system for spondylolisthesis.

| | | |
|---|---|---|
| 1 | Spondylolysis/su [Surgery] | 251 |
| 2 | Spondylolisthesis/su [Surgery] | 1604 |
| 3 | 1 or 2 | 1750 |
| 4 | limit 3 to (english language and humans and "all child (0 to 18 years)") | 415 |
| 5 | Treatment Outcome/ or Disability Evaluation/ or Pain Measurement/ or oswestry.mp. or Questionnaires/ | 791423 |
| 6 | "Outcome Assessment (Health Care)"/ | 40525 |
| 7 | 5 or 6 | 823138 |
| 8 | 4 and 7 | 127 |

**Table 2:** Medline Search Strategy

| | Population | Direct Repair | Fusion | Mean ODI score as % (Range) ± SD |
|---|---|---|---|---|
| Altaf et al, 2011 [25] | 20 patients with L5 splY (9 with grade I splI) | Modular link between pedicle screws | | Pre-op: 54 (42-78)<br>Post-op: 8 (0-42)<br><br>Mean follow-up: 4 years<br>Mean age: 13.9 |
| Debnath et al, 2003 [26] | 22 young athletes with uni- or bilateral splY at L3, L4 or L5 | 19 modified Buck's repair<br>3 Scott's wiring | | Pre-op: 39.5 ± 8.7<br>Post-op: 10.7 ± 12.9<br><br>Follow-up at 2 years<br>Mean age: 20.2 |
| Debnath et al, 2007 [27] | 8 patients with unilateral splY | Modified Buck's repair at L3, L4 or L5 | | Pre-op: 39.4 ± 3.6<br>Post-op: 6.4 ± 5.2<br><br>Follow-up at 2 years<br>Mean age: 20 |
| Helenius et al, 2005 [31] | 108 patients with splY or low grade splI, 95% at L5 level | | 29 posterior<br>79 postero-lateral | 8.2 (0-68)<br><br>Mean follow-up: 20.9 years<br>Mean age: 15.9 |
| Koptan et al, 2011 [28] | 10 patients with splY at L3, L4 or L5 (3 with grade I splI) | Looped wire or modular link between pedicle screws | | Pre-op: 52 (46–74)<br>Post-op: 11 (0–34)<br><br>Mean follow-up: 4.5 years<br>Mean age: 16 |
| Lamberg et al, 2005 [30] | 107 patients with splY or low grade splI, 95% at L5 level | | 29 posterior<br>79 postero-lateral | 8.2 (0-68)<br><br>Mean follow-up: 20.9 years<br>Mean age: 15.3 |
| Remes et al, 2006 [29] | 103 patients with splY or low grade splI, 95% at L5 level | | 29 posterior<br>79 postero-lateral | Posterior: 11.3 (0–68)<br>Posterolateral: 6.3(0–48)<br>Mean follow-up: 21.0 years<br>Mean age: 15.9 |
| Schlenzka et al, 1993 [32] | Adolescent splY +/- low grade splI | 28 patients, L3, L4 or L5: Scott's wiring with autologous bone graft | 28 patients, all L5 level: posterolateral fusion | Repair group: 7.6 ± 8.9<br>Fusion group: 8.6 ± 11.8<br><br>Mean follow-up: 54 months<br>Mean age: 18.2 for repair, 16.2 for fusion |
| Schlenzka et al, 2006 [33] | Longer term follow-up of previous study group | As above | As above | Repair group: 11.4 (0-52)<br>Fusion group: 4.3 (0-16)<br>*P* = 0.02<br><br>Minimum 11 year follow-up |

**Table 3:** Results of included studies. splY = spondylolysis, splI = spondylolisthesis

| Study | Design | Level | Weaknesses |
|---|---|---|---|
| Altaf et al, 2011 [25] | Prospective case series | IV | Unclear patient selection and post-operative protocol<br>No independent observer |
| Debnath et al, 2003 [26] | Prospective case series | IV | Unclear inclusion criteria<br>Unclear treatment allocation<br>Likely patient overlap with following study |
| Debnath et al, 2007 [27] | Prospective case series | IV | Unclear patient selection<br>Small sample size<br>Likely patient overlap with previous study |
| Helenius et al, 2005 [31] | Retrospective case series | IV | Inconsistency of fusion technique and level<br>Unclear treatment allocation<br>Attrition bias<br>Likely patient overlap with studies by Schlenzka et al |
| Koptan et al, 2011 [28] | Prospective case series | IV | Small sample size<br>Other spinal pathology present<br>Inconsistency of treatment |
| Lamberg et al, 2005 [30] | Retrospective case series | IV | Same patient group as Helenius et al, one unexplained missing patient |
| Remes et al, 2006 [29] | Retrospective case series | IV | Same patient group as Helenius et al, without 5 claustrophobic patients who could not undergo MRI |
| Schlenzka et al, 1993 [32] | Non-randomised comparative trial | III | No pre-operative scoring<br>Treatment group decided by surgeon's preference<br>Difference between groups in disease level and degree of slip<br>Attrition bias |
| Schlenzka et al, 2006 [33] | | III | |

**Table 4:** Methodology of included studies