Pediatric Orthopaedic Society of North America

6300 N. River Road, Suite 727
Rosemont, Illinois 60018-4226
(847) 698-1692 • Fax: (847) 823-0536 • Website: www.posna.org

Spondylolysis & Spondylolisthesis Surgery in the Pediatric and Adolescent Patient

Position Statement

Diagnosis and Clinical Evaluation

Spondylolysis is relatively common in children and adolescents. The term spondylolysis is derived from the Greek words for vertebra (spondylo) and defect (lysis). The anatomic feature of spondylolysis is a defect in the pars interarticularis, and alone implies that there is no forward slippage of the superior vertebra. The term spondylolisthesis describes the forward displacement of the superior vertebra. Both conditions can coexist, thus they are intertwined when assessing the literature.

Spondylolysis and spondylolisthesis occur in both children and adults. While the anatomy is similar, the clinical presentation, physical exam findings, pathophysiology, natural history, and treatments are different in children and adolescents compared to older adults.

This position statement focuses on spondylolysis and spondylolisthesis in children, adolescents and young adults (<21 years old).

Spondylolysis is often described as secondary to trauma, and has not been found in non-ambulatory adults. It is more common in athletes involved in sports which require repetitive loading, twisting, flexion, and extension of the spine. Spondylolysis is cited as the most common identifiable cause of low back pain in the teenage athlete.

Spondylolisthesis is a relatively common condition of the lower lumbar spine. The term listhesis describes a slip as being an integral part of the condition. In children, the amount of slip can be low grade, in which the upper vertebra is slipped forward less than 50%, or high grade, in which the amount of upper vertebral slip is greater than 50% or associated with kyphotic angulation. Low grade slips can be asymptomatic or painful, and in rare cases can progress to a higher grade of slip. High grade slips can also be asymptomatic, but frequently are painful, and associated with hamstring tightness, pelvic and spine imbalance, and neural dysfunction. High grade slips are likely to progress, even to the point where the slipped vertebra is 100% displaced, which is known as spondyloptosis. The most dreaded complication of a high grade slip is cauda equina syndrome, which results in paralysis and/or bowel and bladder dysfunction.

Both spondylolysis and spondylolisthesis can cause disabling low back pain. Often symptoms are exacerbated by hyperextension movements of the lower back. Hamstring spasm/contractures and neurologic findings of radiculopathy may be present on physical exam.

Radiographic Evaluation of Spondylolysis and Spondylolisthesis

The defect of the lumbar pars may or may not be visible on the lateral and/or oblique radiographs. MRI is useful for ruling out other pathology, diagnosing occult or stress fractures of the pars, localizing neural compression in symptomatic patients, and offer essential anatomical detail for preoperative planning in high grade spondylolisthesis. Bone scan with SPECT imaging is a sensitive tool for diagnosis. CT scanning is also implemented to detail the bony anatomy of spondylolysis and spondylolisthesis, however, it requires radiation and does not illuminate soft-tissue or neural elements well.

Treatment

Non-operative treatment is successful in relieving symptoms in the majority of cases of acute symptomatic spondylolysis and mild spondylolisthesis. **Conservative measures** include activity modification, physical therapy, immobilization with a brace, and pharmacologic interventions for pain control.

Reference/ Evidence

1. Klein G, Mehlman CT, McCarty M. Nonoperative treatment of spondylolysis and grade I spondylolisthesis in children and young adults: a meta-analysis of observational studies. J Pediatr Orthop. 2009 Mar;29(2):146-56. **Level of Evidence: IV**

2. Kurd MF, Patel D, Norton R, Picetti G, Friel B, Vaccaro AR. Nonoperative treatment of symptomatic spondylolysis. J Spinal Disord Tech. 2007 Dec;20(8):560-4. **Level of Evidence: IV**

3. Debnath UK, Freeman BJ, Grevitt MP, Sithole J, Scammell BE, Webb JK. Clinical outcome of symptomatic unilateral stress injuries of the lumbar pars interarticularis. Spine (Phila Pa 1976). 2007 Apr 20;32(9):995-1000. **Level of Evidence: II**

4. Miller SF, Congeni J, Swanson K. Long-term functional and anatomical follow-up of early detected spondylolysis in young athletes. Am J Sports Med. 2004 Jun;32(4):928-33. **Level of Evidence: IV**

A **brace** may be used to relieve significant pain; however, it is less likely to heal a chronic spondylolytic lesion. If there is documentation of an acute or recent injury, a brace may be tried to facilitate healing of the lesion/fracture. A brace does not improve or correct forward slippage of the vertebra.

Reference/ Evidence

1. Sairyo K, Sakai T, Yasui N, Dezawa A. Conservative treatment for pediatric lumbar spondylolysis to achieve bone healing using a hardbrace: what type and how long? J Neurosurg Spine. 2012 Jun;16(6):610-4. Epub 2012 Apr 20. **Level of Evidence: I**

2. Sairyo K, Sakai T, Yasui N. Conservative treatment of lumbar spondylolysis in

childhood and adolescence: the radiological signs which predict healing. J Bone Joint Surg Br. 2009 Feb;91(2):206-9. **Level of Evidence: IV**

3. Kurd MF, Patel D, Norton R, Picetti G, Friel B, Vaccaro AR. Nonoperative treatment of symptomatic spondylolysis. J Spinal Disord Tech. 2007 Dec;20(8):560-4. **Level of Evidence: IV**

4. Sys J, Michielsen J, Bracke P, Martens M, Verstreken J. Nonoperative treatment of active spondylolysis in elite athletes with normal X-ray findings: literature review and results of conservative treatment. Eur Spine J. 2001 Dec;10(6):498-504. **Level of Evidence: IV**

Indications for Surgery: Spondylolysis

Surgical treatment for spondylolysis (without significant spondylolisthesis) is indicated for the patient with significant pain and disability who is not responsive to a comprehensive conservative treatment program.

Reference/ Evidence:

1. Schlenzka D, Seitsalo S, Poussa M, Osterman K. Operative treatment of symptomatic lumbar spondylolysis and mild isthmic spondylolisthesis in young patients: direct repair of the defect or segmental spinal fusion?) Eur Spine J. 1993 Aug;2(2):104-12. **Level of Evidence: IV**

2) Schlenzka D, Remes V, Helenius I, Lamberg T, Tervahartiala P, Yrjnen T, Tallroth K, Osterman K, Seitsalo S, Poussa M. Direct repair for treatment of symptomatic spondylolysis and low-grade isthmic spondylolisthesis in young patients: no benefit in comparison to segmental fusion after a mean follow-up of 14.8 years. Spine J. 2006 Oct;15(10):1437-47. Epub 2006 Feb 7. **Level of Evidence: IV**

3) Frennered AK, Danielson BI, Nachemson AL, Nordwall AB: Midterm follow-up of young patientsfused in situ for spondylolisthesis. Spine 1991;16:409-416. **Level of Evidence: IV**

4) Cheung EV, Herman MJ, Cavalier R, Pizzutillo PD. Spondylolysis and spondylolisthesis in children and adolescents: II. J Am Acad Orthop Surg. 2006 Aug;14(8):488-98. **Level of Evidence: V**

Surgical management.

Surgical options for symptomatic spondylolysis (without significant spondylolisthesis), which has failed conservative intervention, are an instrumented spondylolysis repair or a single level fusion.

Reference/ Evidence:

1. Westacott DJ, Cooke SJ. Functional outcome following direct repair or intervertebral fusion for adolescent spondylolysis: a systematic review. *J Pediatr Orthop B.* Jun 1 2012. Systematic review of 9 studies comparing pars repair (80 pts) vs fusion (108 pts) found no significant different between groups. **Level of Evidence: IV**

2. Hioki A, Miyamoto K, Sadamasu A, et al. Repair of pars defects by segmental transverse wiring for athletes with symptomatic spondylolysis: relationship between bony union and postoperative symptoms. *Spine (Phila Pa 1976).* Apr 20 2012;37(9):802-807. Case series of 44 patients treated for spondylolysis found that bilateral fusion based on CT was associated with improved ODI compared to unilateral union or non union. **Level of Evidence: IV**

3. Debnath UK, Freeman BJ, Grevitt MP, Sithole J, Scammell BE, Webb JK. Clinical outcome of symptomatic unilateral stress injuries of the lumbar pars interarticularis. *Spine (Phila Pa 1976).* Apr 20 2007;32(9):995-1000. 42 patients with unilateral spondy were followed prospectively with initial conservative care x 6 months. 8 patients failed conservative care and required surgery with one patient with spina bifida having a persistent nonunion. ODI scores improved in all patients after surgery. **Level of Evidence: III**

4. Schlenzka D, Remes V, Helenius I, et al. Direct repair for treatment of symptomatic spondylolysis and low-grade isthmic spondylolisthesis in young patients: no benefit in comparison to segmental fusion after a mean follow-up of 14.8 years. *Eur Spine J.* Oct 2006;15(10):1437-1447. Long term follow up of 25 pts after repair and 23 pts after fusion at 14.8 years found no difference in functional outcomes with a slightly WORSE outcome in repaired patients vs fusion patients. **Level of Evidence: IV**

5. Ivanic GM, Pink TP, Achatz W, Ward JC, Homann NC, May M. Direct stabilization of lumbar spondylolysis with a hook screw: mean 11-year follow-up period for 113 patients. *Spine (Phila Pa 1976).* Feb 1 2003;28(3):255-259. 113 patients followed up at 11 years after direct repair for spondy/grade I spondylolisthesis found a 13% nonunion rate with older patients faring poorer than younger ones. No functional outcomes assessed. **Level of Evidence: IV**

6. Pellise F, Toribio J, Rivas A, Garcia-Gontecha C, Bago J, Villanueva C. Clinical and CT scan evaluation after direct defect repair in spondylolysis using segmental pedicular screw hook fixation. *J Spinal Disord.* Oct 1999;12(5):363-367. Small group of 7 patients - performed CT after pars repair and found only 2 had bilateral fusion but all patients had some improvement in pain scores. **Level of Evidence: IV**

Indications for Surgery: Spondylolisthesis

Indications for surgical treatment for spondylolisthesis include patients with significant pain and disability not responsive to a comprehensive conservative treatment program, patients (including asymptomatic patients) who show progression of the slip, and those with greater than a 50% slip.

Reference/ Evidence

1. Seitsalo S. Operative and conservative treatment of moderate spondylolisthesis in young patients. J Bone Joint Surg Br. 1990 Sep;72(5):908-13.
   Level of Evidence: III

2. Bourassa-Moreau E, Labelle H, Mac-Thiong JM. Radiological and clinical outcome of non-surgical management for pediatric high grade spondylolisthesis. Studies in Health Technology & Informatics. 158:177-81, 2010
   Level of Evidence: III (Conflicts in part with recommendation: Findings included similar quality of life scores in subjects with high grade spondylolisthesis who were treated operatively and non-operatively. While, the non-operative group was less functionally impaired initially, there was no worsening quality of life observed with follow-up.)

3. Harris IE, Weinstein SL. Long-term follow-up of patients with grade III and IV spondylolisthesis, treatment with and without posterior fusion. The Journal of Bone and Joint Surgery. Vol 69-A, No. 7, Sept 1987
   Level of Evidence: III (Conflicts in part with recommendation: Subjects with grade III and IV slips at presentation were found to have similar long-term outcomes with non-operative and operative management.)

4. Seitsalo S, Oosterman K, Hyvãrinen H, Tallroth K, Schlenzka D, Poussa M. Progression of spondylolisthesis in children and adolescents. A long-term follow-up of 272 patients. Spine. Vol 16, No. 4, 1991.
   Level of Evidence: III (Conflicts with recommendations: Findings were that risk of slip progression increased with worse slip percentage at initial presentation but risk of slip progression was not different between subjects receiving non-operative therapy and those receiving surgery. However, notable differences in slip percentage between the two groups existed at presentation.)

5. Pizzutillo PD, Hummer CD 3rd. Nonoperative treatment for painful adolescent spondylosis or spondylolisthesis. J Pediatr Orthop 1989 Sep-Oct; 9(5):538-40
   Level of Evidence: IV

6. Blackburne JS, Velikas EP. Spondylolisthesis in children and adolescents. The Journal of Bone & Joint Surgery. Volume 59-B, No. 4, November 1977
   Level of Evidence: IV

7. Pizzutillo PD, Hummer CD. Nonoperative treatment for painful adolescent spondylosis or spondylolisthesis. Journal of Pediatric Orthopaedics. Vol 9, No. 5, 1989.
Level of Evidence: IV

8. Wiltse LL, Jackson DW. Treatment of spondylolisthesis and spondylolysis in children. Clin Orthop Relat Res. 1976 Jun;(117):92-100.
Level of Evidence: V

9. Mardjetko S, Albert T, Andersson G, Bridwell K, DeWald C, Gaines R, Geck M, Hammerberg K, Herkowitz H, Kwon B, Labelle H, Lubicky J, McAfee P, Ogilvie J, Shufflebarger H, Whitesides T. Spine/SRS Spondylolisthesis Summary Statement. Spine Volume 30(6S) Supplement, 15 Mar 2005, p S3
Level of Evidence: V

10. Agabegi SS, Fischgrund JS. Contemporary management of isthmic spondylolisthesis: pediatric and adult. The Spine Journal 10 (2010) 530-543
Level of Evidence: V

11. Herman MJ, Pizzutillo, PD. Spondylosis and spondylolisthesis in the child and adolescent. Clinical Orthopaedics and Related Research. Number 434, pp. 46-54.
Level of Evidence: V

12. Smith, JA, Hu SS. Management of spondylosis and spondylolisthesis in the pediatric and adolescent population. Disorders of the Pediatric and Adolescent Spine. Volume 30 - Number 3 – July 1999.
Level of Evidence: V

13. Lonstein JE. Spondylolisthesis in children. Cause, natural history, and management. Spine. Volume 24, No. 24, pp 2640-2648
Level of Evidence: V

14. Herman MJ, Pizzutillo PD, Cavalier R. Spondylosis and spondylolisthesis in the child and adolescent athlete. Orthop Clin N Am 34 (2003) 461-467.
Level of Evidence: V

15. Cavalier R, Herman MJ, Cheung EV, Pizzutillo PD. Spondylosis and spondylolisthesis in children and adolescents: I. Diagnosis, natural history, and nonsurgical management. J Am Acad Orthop Surg 2006; 14:417-424.
Level of Evidence: V

16. Cheung EV, Herman MJ, Cavalier R, Pizzutillo PD. Spondylosis and spondylolisthesis in children and adolescents: II. Surgical management. J Am Acad Orthop Surg 2006; 14:488-498.
Level of Evidence: V

17. Radcliff KE, Kalantar SB, Reitman CA. Surgical Management of spondylosis and spondylolisthesis in athletes: Indications and return to play. Spine conditions Vol 8, No. 1, Jan/Feb 2009
Level of Evidence: V

18. McTimoney CA, Micheli LJ. Current evaluation and management of spondylosis and spondylolisthesis. Curr Sports Med Rep. 2003 Feb 2(1):41-6.
Level of Evidence: V

19. Boxall D, Bradford DS, Winter RB, Moe JH. Management of severe spondylolisthesis in children and adolescents. J Bone Joint Surg Am. 1979 Jun;61(4):479-95.
Level of Evidence: V

An instrumented one or two level fusion, with or without slip reduction, is reported to have a high rate of clinical success in preventing further slip progression and improving pain. When slippage is progressive, surgery should be undertaken without delay, before a large amount of forward slippage is allowed to occur. Surgery for high grade slips, particularly for those patients with spondyloptosis, is technically demanding. The procedure frequently involves nerve decompression and exploration, posterior pedicle fixation, anterior interbody support, vertebral reduction and posterior fusion.

Outcomes of Spondylolysis and Spondylolisthesis surgery

Commonly used tools to assess the efficacy of spine surgery include clinical outcome measures and postoperative radiographic images to assess fusion, alignment, and surgical instrumentation. Numerous studies in the medical literature report good clinical and radiographic success with surgical intervention, as high as 95%. Patients with high grade, severe spondylolisthesis are the group with the highest complication rate. Complications can include nerve root injury, dural tears, loss of fixation, implant breakage or failure, non union, progression of the deformity, need for revision surgery, pelvic or spinal imbalance, or infection.

Summary

The majority of patients with spondylolysis and mild spondylolisthesis do not require surgery.

The current standard of care for surgical intervention includes symptomatic spondylolysis not responsive to non-operative therapies, spondylolisthesis not responsive to non-operative therapies, documented progression of spondylolisthesis slippage (with or without symptoms), and high grade spondylolisthesis (with or without symptoms).

References (previously placed in the statement)

Altaf F, Osei NA, Garrido E, Al-Mukhtar M, Natali C, Sivaraman A, Noordeen HH. Repair of spondylolysis using compression with a modular link and screws. J Bone Joint Surg Br. 2011 Jan;93(1):73-7.

Cheung EV, Herman MJ, Cavalier R, Pizzutillo PD Spondylolysis and spondylolisthesis in children and adolescents: II. Surgical management. J Am Acad Orthop Surg. 2006 Aug;14(8):488-98.

Fan J, Yu GR, Liu F, Zhao J, Zhao WD. A biomechanical study on the direct repair of spondylolysis by different techniques of fixation.Orthop Surg. 2010 Feb;2(1):46-51.

Molinari RW, Bridwell KH, Lenke LG, Baldus C. Anterior column support in surgery for high-grade, isthmic spondylolisthesis.Clin Orthop Relat Res. 2002 Jan;(394):109-20.

Smith JA, Deviren V, Berven S, Kleinstueck F, Bradford DS. Clinical outcome of trans-sacral interbody fusion after partial reduction for high-grade l5-s1 spondylolisthesis.Spine 2001 Oct 15;26(20):2227-34.

Smith JA, Hu SS. Management of spondylolysis and spondylolisthesis in the pediatric and adolescent population. Orthop Clin North Am. 1999 Jul;30(3):487-99, ix. Review.

Transfeldt EE, Mehbod AA. Evidence-based medicine analysis of isthmic spondylolisthesis treatment including reduction versus fusion in situ for high-grade slips.Spine 2007 Sep 1;32(19 Suppl):S126-9.

This statement includes passages and references listed in

POSNA Study Guide Spondylolysis
(http://www.posna.org/education/StudyGuide/spondylolysis.asp)

and the POSNA Study Guide on Spondylolisthesis
(http://www.posna.org/education/StudyGuide/spondylolisthesis.asp)