SURGICAL TECHNIQUE

S₂ Alar-iliac Fixation: A Powerful Procedure for the Treatment of Kyphoscoliosis

Zhen Liu, MD, Yong Qiu, MD, Huang Yan, MD, Zong-shan Hu, MD, Feng Zhu, MD, Jun Qiao, MD, Lei-lei Xu, MD, Bin Wang, MD, Yang Yu, MD, Bang-ping Qian, MD, Ze-zhang Zhu, MD

Department of Spine Surgery, Drum Tower Hospital, Medical School of Nanjing University, Nanjing, China

The purpose of this study was to introduce a powerful technique for the treatment of kyphoscoliosis. There are currently multiple techniques for sacropelvic fixation, including trans-iliac bars and iliac and iliosacral screws. Several studies have documented the use of these instrumentation techniques; however, a ubiquitous problematic issue concerns the need for separate incisions for the use of offset connectors, which add to surgical time and morbidity. Any additional dissection of the skin, subcutaneous tissue or muscle in this area is believed to increase the incidence of complications of wound healing. However, as stated above, the above-mentioned techniques require separate incisions for the use of offset connectors, which add to surgical time and morbidity. The novel technique of S₂ alar-iliac (S2AI) pelvic fixation has been developed to address some of these issues. However, a technique for achieving correction of kyphoscoliosis with pelvic obliquity in adult patients with spinal deformity has not previously been described. Our entry point is based on the S₁ foramen and is typically up to 5 mm caudal and 2 to 3 mm lateral to that foramen. Once the S₁ foramen has been identified, a blunt instrument can be used to probe the alar ridge. The screw trajectory is 40°–50° from horizontal and 20°–30° caudal, aimed toward the greater trochanter and rostral to the sciatic notch. A 36-year-old female patient presented with a 3-year history of low back pain, and progressive thoracolumbar kyphoscoliosis. In this typical case, we performed S2AI fixation with transforaminal lumbar interbody fusion and hemivertebra resection technique to treat her lumbosacral kyphoscoliosis. Satisfactory improvement in her preoperative lumbar kyphoscoliosis was found at 3-month follow-up.

Key words: Kyphoscoliosis; Pelvic fixation; Pelvic obliquity; S₂ alar-iliac fixation

Introduction

Tremendous advances have been made in improving fusion rates and outcomes in adult patients with spinal deformities. Pelvic fixation, still a challenging area in spine surgery, is constantly evolving; the optimal technique is still being developed and redefined. Although still controversial, pelvic fixation remains a viable method for achieving fixation at the base of long construct fusions. Indications for pelvic fixation include adult degenerative scoliosis, flat-back syndrome and kyphosis, pelvic obliquity, high-grade spondylolisthesis and fracture dislocations involving the lumbosacral junction.^{1–4} There are multiple techniques for sacropelvic fixation, including trans-iliac bars and iliac and iliosacral screws. Several studies have documented the use of these instrumentation techniques, however, a ubiquitous problematic issue concerns the use of separate incisions for the use of offset connectors, which add to surgical time and

morbidity.^{5,6} Any additional dissection of the skin, subcutaneous tissue or muscle in this area is believed to increase the risk of complications of wound healing.

Recently, use of S₂ alar-iliac (S2AI) screws to reduce these drawbacks in a variety of clinical settings has been reported.^{7–10} The S₂ starting point is immediately caudal to the first sacral superior articular facet and in line with the pedicles of the lumbar spine. In addition, this approach eliminates the need for dissection of the subcutaneous tissue over the iliac crest or the sacral paraspinal muscle. A previous study has reported that S2AI screws minimize implants prominence. Additionally, the average depth of the insertion point from the skin, measured on the transverse CT plane, is 15 mm deeper for the S₂-iliac technique than the starting point for posterior superior iliac spine insertions,¹¹ thus potentially reducing the rate of implant prominence and simplifying the technique for achieving pelvic fixation.

Address for correspondence Ze-zhang Zhu, MD, Department of Spine Surgery, Drum Tower Hospital, Medical School of Nanjing University, Nanjing, China 210008 Tel: 0086-25-68182022; Fax: 0086-25-68182022; Email: drliuzhen@163.com

Disclosure: The authors have no conflicts of interest to declare.

Received 22 August 2015; accepted 10 December 2015

Pelvic fixation in adults with substantial thoracolumbar or lumbar deformity requiring fusion to the sacrum remains a challenge for surgeons treating spinal deformity. We believe that the S2AI technique for pelvic fixation provides some advantages. The S2AI screw is essentially a modified trajectory S₂ alar screw placed across the sacroiliac (SI) joint into the ilium.^{8,12} S2AI screws, which are lower profile and in line with cephalad instrumentation, have been employed clinically in adult and pediatric subjects with good results.^{4,12} However, a technique for achieving correction of adult kyphoscoliosis has not previously been described. Therefore, we here introduce the S2AI technique for the treatment of adult kyphoscoliosis.

Technique

Typical Case

A 36-year-old female patient presented with a 3-year history of low back pain, and progressive thoracolumbar kyphoscoliosis. A diagnosis of congenital scoliosis with a left L₃ hemivertebra was made. Plain radiographs of the whole spine showed a lumbar scoliosis with a Cobb angle of 78° and a substantial thoracolumbar kyphosis (58°, Fig. 1). The presence of these clinical manifestations required surgery comprising: (i) T₁₀–S₂ fusion; (ii) left L₃ hemivertebra resection; and (iii) L₅S₁ transforaminal lumbar interbody fusion (TLIF).

Surgical Technique

The patient was placed in a prone position under general endotracheal anesthesia. Neuropotential monitoring and cell savers were utilized intra-operatively. A posterior median incision was performed and the targeted fused vertebrae exposed. Pedicle screws were inserted into the targeted fused segments using a standard free-hand technique, after which S₂ alar iliac screws were placed using O-arm Surgical Imaging System/StealthStation image guidance (Medtronic, Minneapolis, MN, USA). First, the StealthStation reference arc was affixed to the L₅ spinous process, with the arc rotated as distally as possible; the O-arm was then used to provide real-time CT scanning for intraoperative navigation. After image acquisition, the O-arm data were transferred to the StealthStation navigation system for CT-quality multiplanar reconstructions of the pelvis, providing verification for both an entry point and trajectory. Our entry point was based on the S₁ foramen and, as is typical, was up to 5 mm caudal and 2 to 3 mm lateral to the foramen. Once the S₁ foramen had been identified, a blunt instrument was used to probe the alar ridge. The screw trajectory was 40°–50° from horizontal and 20°–30° caudal and aimed toward the greater trochanter, rostral to the sciatic notch (Fig. 2).

After placement of instrumentation, a unilateral pre-bent titanium rod was installed for temporary support and a vertebral column resection performed at L₃, including the entire hemivertebra and superior and inferior intervertebral discs. The spinal deformity was then corrected using

Fig. 1 An illustrative 36-year-old female patient with congenital scoliosis. (A) Plain radiographs of the whole the spine showing lumbar scoliosis with a Cobb angle of 78° and a substantial thoracolumbar kyphosis (58°). (B) Radiographs at 3-month follow-up show satisfactory improvement in lumbar kyphoscoliosis and restoration of coronal and sagittal balance.

Fig. 2 (A, B) The entry point is based on the S₁ foramen, typically up to 5 mm caudal and 2–3 mm lateral to the foramen. (C–E) The screw trajectory is 40°–50° from horizontal and 20°–30° caudal, towards the greater trochanter and rostral to the sciatic notch.

distraction on the concave side and compression on the convex side; the osteotomy surfaces were closed simultaneously.

Next, an intervertebral cage was filled with autologous bone graft and inserted obliquely in a posterolateral to anteromedial position in the L₅S₁ disc space with a TLIF technique. A wake-up test was performed shortly after correction of the deformity.

Finally, pedicle screws were locked and a posterolateral spinal graft and drainage placement were performed. An antibiotic, cefuroxime, was used post-operatively, and dexamethasone and mannitol were administered for 3–5 days.

Follow-up

Satisfactory improved in preoperative lumbar kyphoscoliosis was found at 3-month follow-up (Fig. 1).

Discussion

Distal fixation in operations to correct spinal deformity is crucial when arthrodesis to the sacrum is indicated. Traditional sacropelvic fixation includes trans-iliac bars and iliac and iliosacral screws. However, these require separate incisions for the use of offset connectors, thus increasing the surgical time and incidence of complications.¹³

Iliac Screw Technique

Achieving solid fusion at the lumbosacral junction in surgery for spinal deformity is challenging. Fixation with iliac screws is a widely practice technique which can improve biomechanical strength and achieve acceptable clinical results.^{14,15}

However, it has several drawbacks, including utilization of more connectors, screw prominence, late pain and extensive surgical dissection.¹⁶ Use of the S₂ iliac technique may address some of these issues with lumbopelvic fixation.

S2AI Fixation Technique

The S2AI sacropelvic fixation is a new technique described contemporaneously by Sponseller¹⁷ and Kebaish¹⁸ for use in pediatric and adult subjects, respectively. O'Brien *et al.* subsequently adapted it for use in minimally invasive applications.¹⁸ Ilyas *et al.* found that S2AI technique is associated with significantly fewer clinical and radiographic complications in adult patients than the iliac screw technique.¹³ The S2AI technique for pelvic fixation is a modification of an S₂ alar screw driven through the sacroiliac articulation into the iliac wing. This technique is preferable because the screws have a lower profile and are in line with cephalad instrumentation.¹¹

S2AI Combined with TLIF and Hemivertebra Resection

In this illustrative case, we performed L₃ hemivertebra resection and kyphoscoliosis correction to restore coronal and sagittal balance. L₅S₁ TLIF stabilizes the lumbosacral junction, achieves *en bloc* fusion and reduces the rate of implant failure. Additionally, pelvic obliquity can be readily corrected with the S2AI technique. Therefore, we perform L₅S₁ TLIF with S2AI screws and hemivertebra resection to obtain a solid foundation and improve coronal balance.

Supporting Information

Additional supporting information may be found in the online version of this article on the publisher's web-site.

Video S1: S₂ alar-iliac pelvic fixation**References**

1. Crawford CH 3rd, Carreon LY, Bridwell KH, Glassman SD. Long fusions to the sacrum in elderly patients with spinal deformity. *Eur Spine J*, 2012, 21: 2165–2169.
2. Jain A, Hassanzadeh H, Strike SA, Menga EN, Sponseller PD, Kebaish KM. Pelvic fixation in adult and pediatric spine surgery: historical perspective, indications, and techniques: AAOS exhibit selection. *J Bone Joint Surg Am*, 2015, 97: 1521–1528.
3. Schwend RM, Waters PM, Hey LA, Hall JE, Emans JB. Treatment of severe spondylolisthesis in children by reduction and L4-S4 posterior segmental hyperextension fixation. *J Pediatr Orthop*, 1992, 12: 703–711.
4. Sponseller PD, Zimmerman RM, Ko PS, et al. Low profile pelvic fixation with the sacral alar iliac technique in the pediatric population improves results at two-year minimum follow-up. *Spine (Phila Pa 1976)*, 2010, 35: 1887–1892.
5. Bridwell KH, Edwards CC 2nd, Lenke LG. The pros and cons to saving the L5-S1 motion segment in a long scoliosis fusion construct. *Spine (Phila Pa 1976)*, 2003, 28: S234–S242.
6. Tsuchiya K, Bridwell KH, Kuklo TR, Lenke LG, Baldus C. Minimum 5-year analysis of L5-S1 fusion using sacropelvic fixation (bilateral S1 and iliac screws) for spinal deformity. *Spine (Phila Pa 1976)*, 2006, 31: 303–308.
7. Emami A, Deviren V, Berven S, Smith JA, Hu SS, Bradford DS. Outcome and complications of long fusions to the sacrum in adult spine deformity: Luque-Galveston, combined iliac and sacral screws, and sacral fixation. *Spine (Phila Pa 1976)*, 2002, 27: 776–786.
8. Mattei TA, Fassett DR. Low-profile pelvic fixation with sacral alar-iliac screws. *Acta Neurochir (Wien)*, 2013, 155: 293–297.
9. O'Brien JR, Matteini L, Yu WD, Kebaish KM. Feasibility of minimally invasive sacropelvic fixation: percutaneous S2 alar iliac fixation. *Spine (Phila Pa 1976)*, 2010, 35: 460–464.
10. Zhu F, Bao HD, Yuan S, et al. Posterior second sacral alar iliac screw insertion: anatomic study in a Chinese population. *Eur Spine J*, 2013, 22: 1683–1689.
11. Chang TL, Sponseller PD, Kebaish KM, Fishman EK. Low profile pelvic fixation: anatomic parameters for sacral alar-iliac fixation versus traditional iliac fixation. *Spine (Phila Pa 1976)*, 2009, 34: 436–440.
12. Nottmeier EW, Pirris SM, Balseiro S, Fenton D. Three-dimensional image-guided placement of S2 alar screws to adjunct or salvage lumbosacral fixation. *Spine J*, 2010, 10: 595–601.
13. Ilyas H, Place H, Puryear A. A comparison of early clinical and radiographic complications of iliac screw fixation versus S2 alar iliac (S2AI) fixation in the adult and pediatric populations. *J Spinal Disord Tech*, 2015, 28: E199–E205.
14. Lebowitz NH, Cunningham BW, Dmitriev A, et al. Biomechanical comparison of lumbosacral fixation techniques in a calf spine model. *Spine (Phila Pa 1976)*, 2002, 27: 2312–2320.
15. Kuklo TR, Bridwell KH, Lewis SJ, et al. Minimum 2-year analysis of sacropelvic fixation and L5-S1 fusion using S1 and iliac screws. *Spine (Phila Pa 1976)*, 2001, 26: 1976–1983.
16. Shen FH, Mason JR, Shimer AL, Arlet VM. Pelvic fixation for adult scoliosis. *Eur Spine J*, 2013, 22(Suppl. 2): S265–S275.
17. Sponseller P. The S2 portal to the ilium. *Semin Spine Surg*, 2007, 2: 83–87.
18. O'Brien JR, Yu WD, Bhatnagar R, Sponseller P, Kebaish KM. An anatomic study of the S2 iliac technique for lumbopelvic screw placement. *Spine (Phila Pa 1976)*, 2009, 34: E439–E442.