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Bohlman Technique Using Rialto Sacroiliac Fusion Implant for Treating L5-S1 High Grade Spondylolisthesis. Report of Two Cases

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Abstract

The article begins with a brief biography of H. Bohlman, a great orthopedist and person with strong impact on modern Medicine and Spine surgery. Using original Bohlamn technique with small modifications (instead of fibula graft used Rialto implant and performed posterior fixation L4-S2) we treated surgically two young females with L5 listhesis with success. **Methods:** Both patients were followed up during 1 year and 9 months and 1 year and 7 months. **Results:** Two young females of 18 years old with isthmic listhesis L5 were submitted to fixation L4-S2 and transsacral, transdical fusion with Rialto implant by Bohlman technique with partial reduction of listhesis. Both had resolution of the pain and have maintained a good clinical outcome at 1 year and 9 months and another one at 1 year and 7 months follow up.

Keywords

Bohlman Technique, Rialto Implant, Spondylolisthesis, Lumbar

1. Introduction

The original Bohlman technique involved posterior-only decompression, instrumentation, and fibular strut graft aiding in situ fusion, and the procedure historically yielded favorable results [1].

The first description of in situ fusion via an anterior approach was first performed by B.H. Burns in 1933, in which he utilized a tibial autograft strut to stabilize an L5-S1 spondylolisthesis. In March 1933, Burns operated a female patient with L5 spondylolisthesis using transperitoneal left-sided paramedial approach to the lumbosacral spine. A canal between the iliac vessels was drilled through the L5 vertebral body into the S1 vertebral body and spinal fusion using tibia au-

tograft was performed (**Figure 1**). However, there was no favorable outcome and the patient began again to suffer from lumbar pain 2 months after the operation. In 3 months, the article was published in the Journal "Lancet" [2].

In 1982, Bohlman and Cook adapted this protocol for spondyloptosis using a single incision posterior approach by introducing a fibular autograft across S1 into the L5 vertebral body in combination with a decompression and L4-S1 posterolateral in situ fusion to achieve 3-column fixation [1]. Early reports of the Bohlman technique described complications including fibular graft failure, slip progression, and pseudarthrosis; however, this was due largely in part to the lack of routine pedicle screw instrumentation associated with this time period. In subsequent decades, both the "modified" and "reverse" Bohlman technique have emerged. The modified techniques still involve a single-stage posterior approach but introduce pedicle screw fixation and replace the autograft with titanium cage, transsacral transvertebral screw fixation, transvertebral interbody cage, intrasacral rods, a variety of screws. The reverse Bohlman introduces a transabdominal component enabling improved restoration of sagittal alignment via anterior column reconstruction, as well as avoiding sacral laminectomy and retraction of the caudal dura. Overall, both the modified Bohlman and reverse Bohlman techniques have been reported with improved arthrodesis rates, symptom resolution, and favorable outcomes.

Original surgical technique described by Bohlman and Cook [1] was a 1-stage decompression with posterolateral and interbody fusion in which a fibular graft was utilized without reduction for lumbosacral spondyloptosis. As originally described, the patient is placed in the prone position with the right leg draped free to provide the surgeon with access to the graft donor site. Through a single posterior incision from L3 to S2, the bony anatomy is exposed by subperiosteal muscle stripping. A wide foraminotomy is performed to decompress the L5 and S1 nerve roots. The sacral prominence is osteotomized using a curved osteotome. Using a Penfield elevator, the dura mater is freed from the posterosuperior

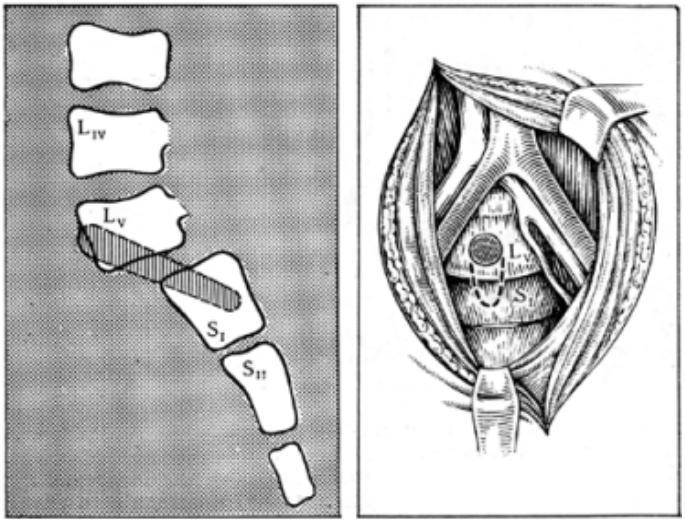

Figure 1. Illustration of anterior spinal fusion operation performed by Burns.

prominence at S1. A guide pin is placed between L5 and S1 nerve roots on each side. Each pin is approximately 1 cm lateral to the midline and is directed through the S1 body into the dislocated L5 body anteriorly. After confirming proper positioning with intraoperative lateral radiography, a cannulated drill bit is drilled over the wire to the desired diameter, taking care not to violate the anterior cortex of the L5 body. The fibula autograft is harvested and divided longitudinally. One-half of each graft is inserted into the prepared holes and countersunk 2 mm so as not to impinge on the dura. A standard bilateral posterolateral transverse process fusion, from either L3 or L4 to the sacral ala, is then performed using iliac crest grafts, and the wound is closed.

In 1990 Smith and Bohlman published a serie of eleven skeletally mature patients who had a high-grade lumbosacral spondylolisthesis treated by a single-stage operation that involved posterior spinal decompression, posterolateral arthrodesis with autogenous iliac-crest graft, and anterior arthrodesis with a fibular graft inserted from the posterior approach. They did not attempt to correct the deformity. Preoperatively, all but one patient had severe pain in the back and lower limb; the exceptional patient had severe pain only in the low back. All but one patient had sensory deficits and objective motor impairment before the operation, and five had cauda equina syndrome. Six patients had had a previous operation that had failed. The duration of follow-up ranged from two to twelve years. A solid fusion was obtained in all patients, and all had major or complete neurological recovery. The results did not deteriorate with time [3].

The spondylolisthesis always was a complex and challenging pathology with difficult treatment options, the techniques Bohlman and reverse Bohlman are used nowadays with good results, practically impossible to give advantage to one of them. It is difficult to understand why it is called reverse Bohlman technique, this technique was described and published in 1933 by Burns, the technique was represented in his drawing (**Figure 1**).

The fibular allograft was substituted in both techniques by mesh, bolts, screws [4] [5] [6] [7]. There are not large series to allow comparison of both techniques, that is why we think that all small series or even single case reports must be published and in the future it will possible to have wider impression about treatment algorithm. A recent 2021-year systematic search of PubMed, Cochrane, and Google Scholar for papers relevant to high listhesis was performed and found only twenty-one articles included after title, abstract, and full-text review and grouped to analyze the effect of surgical approach, instrumentation, reduction, and decompression on radiographic and clinical outcomes of patients [8].

We report two cases of L5 isthmic listhesis treated using original Bohlman technique but instead of fibular allograft was used Rialto (Medtronic) titanium sacroiliac implant filled with allograft and L4-S1 transpedicular screws, S2 sacroiliac screws fixation. Rialto implant is a hollow implant filled with bone graft and has fenestrations for bone growth, different length is disponible, the usual diameter is 12 mm. We considered that one stage posterior surgery is better tolerated, allow partial reduction under direct visual control of dura and roots af-

ter decompression and fusion with Rialto implant reduces comorbidity due to harvesting fibula allograft.

2. Surgical Technique

In our cases the approach was single stage posterior, with exposition of L4-S2, with subsequent implantation of L4, S1 transpedicular screws, S2 sacroiliac screw bilaterally and L5 transpedicular screws after posterior decompression (removal of L5 and S1 laminas, bilateral foraminectomy L5-S1) and good visualization of L5 roots. We used X-Ray; because our hospital does not have navigation system. After disc removal L5-S1 lateral bars are put in place. Only by these manipulations the listesis reduces partially (we had no intention to reduce radically the listesis, as our patients were balanced). Only after posterior fixation is done we perform transsacral fixation with Rialto implant, because in a not fixed spine the implant when passing through the disc space could impinge the L5 vertebra up with subsequent stretching the L5 roots that already are stretched by pathology, we consider this maneuver as a strategic key point in this technique. The Rialto implant is inserted after retracting a dura and making the trajectory with guidewire and subsequent drilling, as showed in Figure 2. The guidewire permits to measure the perfect length of implant, the implant is hollow and carry a generous amount of bone graft, the distal edge of implant closes with a cover that allow to avoid graft migration and neural elements compression.

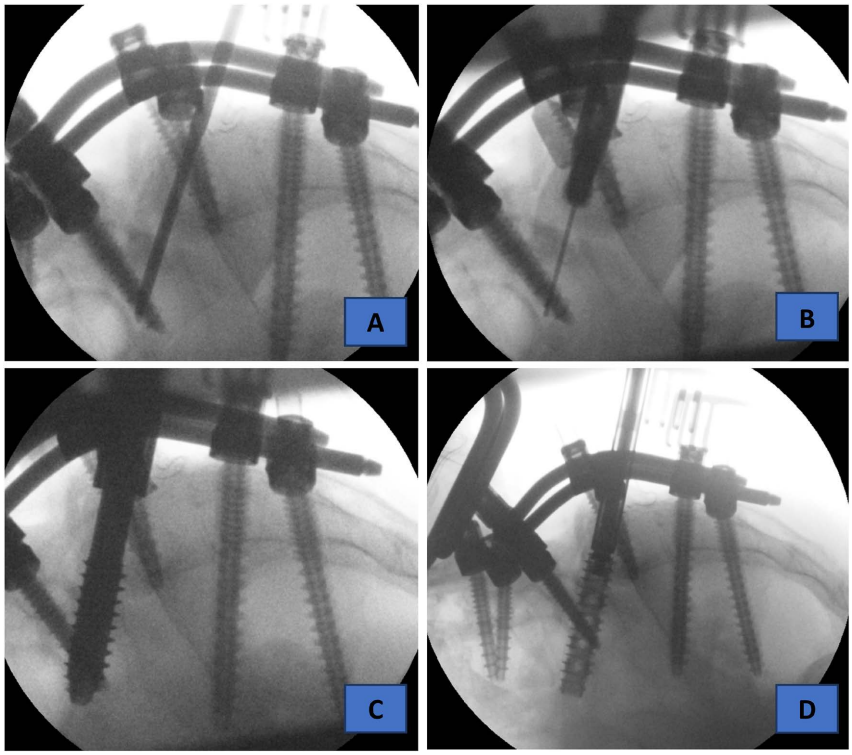

Figure 2. Surgical technique of transsacral transdiscal implant insertion: (A) transsacral, transdiscal guidewire in place; (B) drilling along the guidewire; (C) transsacral transdiscal tract making with reamer; (D) rialto implant in place.

We consider as advantages of the Bohlman technique with use of Rialto implant and L4-S2 fixation as follows:

- direct visualization of neural elements during surgical manipulations, diminishing the risk of neurologic deterioration;
- avoids vascular, abdominal, sexual, etc. complication linked with anterior approach as possible in reversed techniques, as vascular anatomy in high grade listesis is always abnormal;
- is one stage posterior surgery;
- Rialto implant caries good amount of graft, it carries less graft than mesh cylinder, but it has threads and the introduction is by screwing into already prepared bone tract, the introduction is smoother, avoiding the danger of neural structures damage, as using hummer for mesh cylinder introduction;
- S2 sacroiliac screw strengthen the fixation and avoids sacrum stress fractures or screws loosening;
- definitive fixing the spine before insertion of transacral, transdiscal implant is an important issue, that avoids nerve roots stretching and neurological deterioration.

Case 1. Young 18 years old female, athletic, presented with lumbar pain and left leg paresthesia, bilateral irradiated pain to the legs. Urodynamic study showed neurogenic bladder and electromyography revealed left S1 radiculopathy. CT scan and MRI revealed grade III L5 isthmic listhesis (**Figures 3(A)-(C)**). She was operated on: L4-S2 screw fixation, tanssacral, transdical L5-S1 fusion with Rialto implant, as described above. The postoperative period was uneventful with resolution on radicular pain, discharged at eighth day after admission. CT scan, X-Ray confirmed good arthrodesis material positioning, partial reduction of listhesis (**Figures 4(A)-(D)**, **Figure 5**). Good fusion was proved on CT scan at 1 year and 9 months after surgery (**Figure 6**), the patient is doing well, presenting no complain.

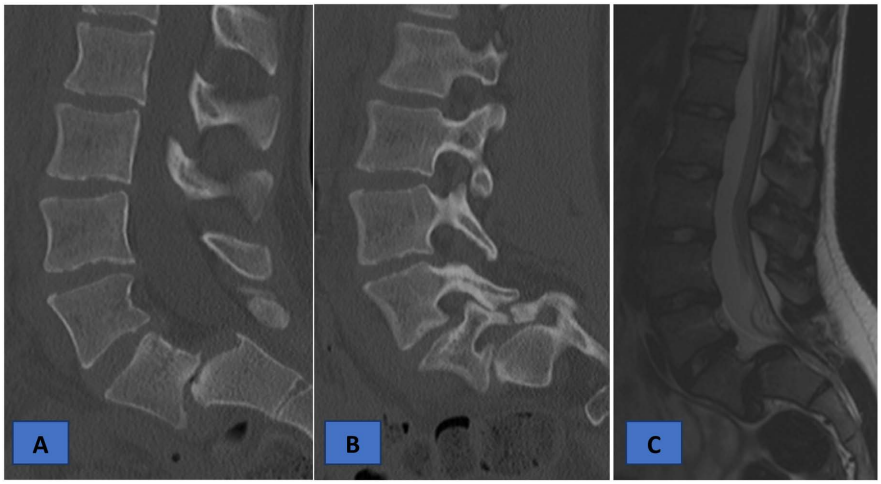

Figure 3. (A) CT scan: L5 anterior listhesis. (B) CT scan: Isthmic lysis. (C) MRI: confirms L5 listhesis.

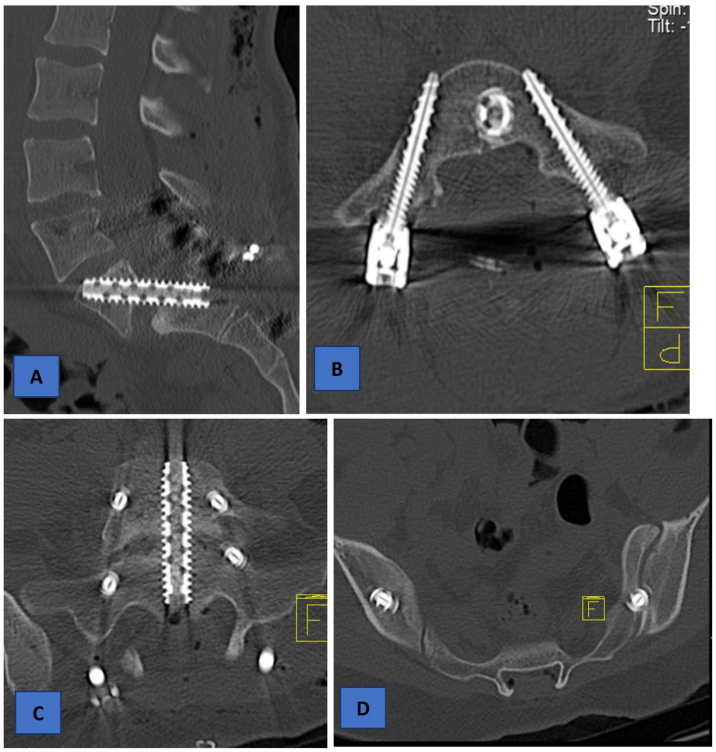

Figure 4. (A) Sagittal CT scan, Rialto implant in place; (B) transpedicular screws L5; (C) Coronal slice show good transdical position of the implant; (D) S2 sacroiliac screws.

Figure 5. X-Ray at 9 months after surgery.

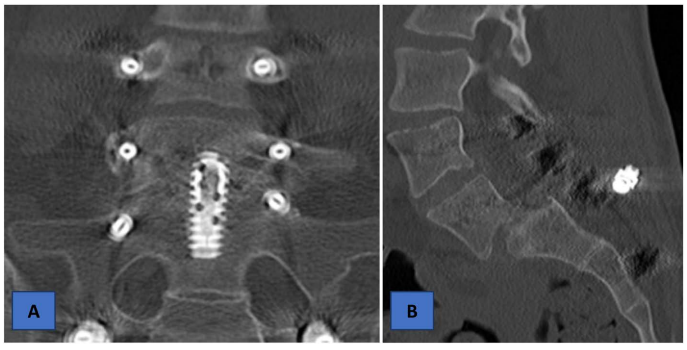

Figure 6. (A) Coronal slice; (B) sagittal slice showing fusion at 1 year and 9 months after surgery.

Case 2. Same age (18 years) school girl, presented with lumbar pain and bilateral legs paresthesia. Electromyography showed left L5 radiculopathy. X-Ray and MRI diagnosed grade IV anterior isthmic listhesis L5 (**Figure 7(A)**, **Figure 7(B)**). The patient was operated on, using the same technique. Also, the postoperative period was uneventful, discharged at eighth day after admission. Postoperative X-Ray, CT scan proved partial reduction (**Figure 8**) and at 1 year and 7 months fusion was confirmed at CT scan (**Figure 9**).

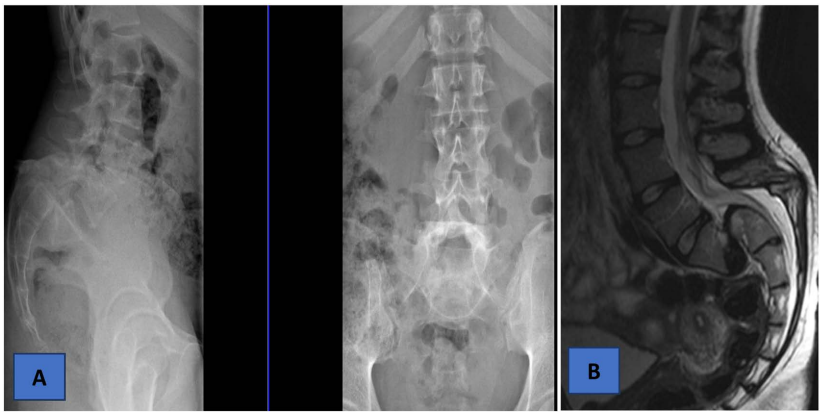

Figure 7. (A) X-Ray; (B) MRI revealing grade IV L5 listhesis.

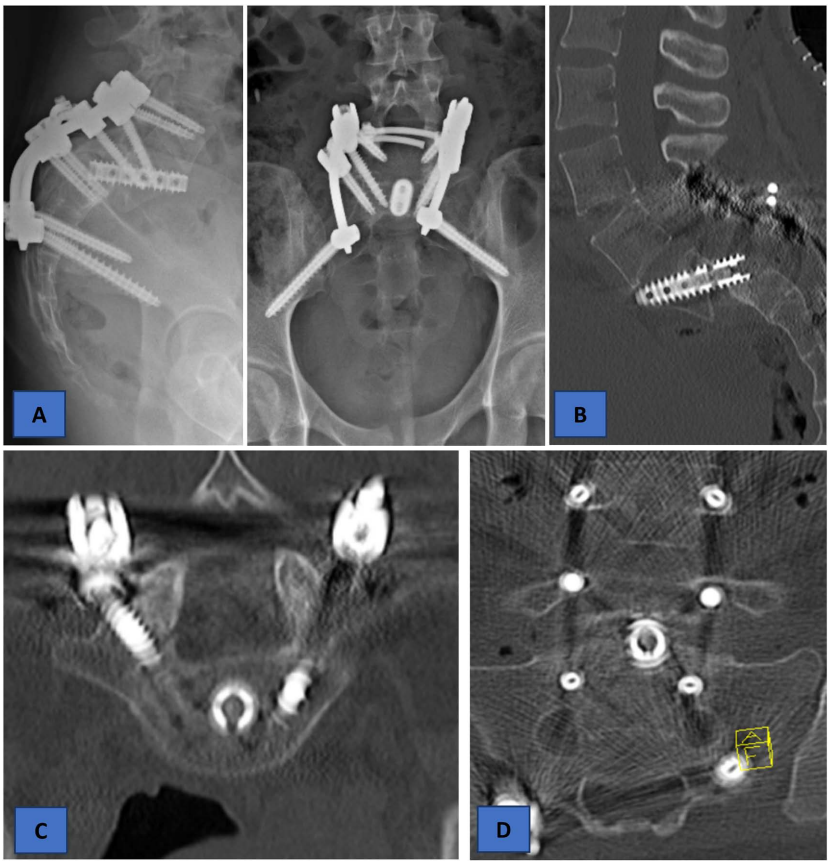

Figure 8. (A) Postoperative X-Ray; (B) CT scan showing partial reduction; (C) L5 transpedicular screws; (D) coronal ST scan view.

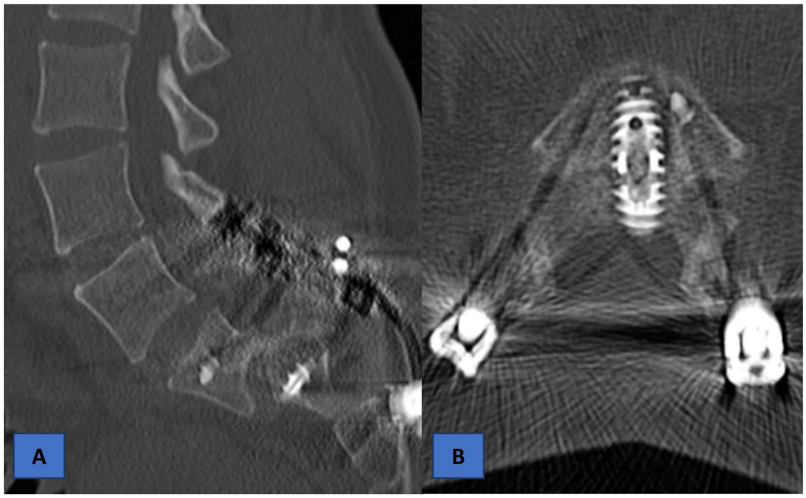

Figure 9. (A) Sagittal; (B) coronal CT scan slices confirming fusion at 1 year and 7 months after surgery.

3. Discussion

To establish treatment of high-grade spondylolisthesis based on pelvic parameters, Hresko *et al.* [9] elaborated a classification system that divides lumbosacral spondylolisthesis into low and high slip grade and in into balanced (high SS/low PT) or unbalanced (low SS/high PT) types. The pelvis in high grade spondylolisthesis can be considered to be balanced when the SS is high and PT is low, thereby the global spine balance is invariably normal and fusion without reduction is justified. In an unbalanced pelvis that shows a low SS and high PT reduction techniques should be considered.

No single technique has been proved to be better than the other. The reduction is not necessary for patients with balanced sacro-pelvis because their spino-pelvic balance is similar to normal individuals.

The consensus appears to be that partial reduction offers biomechanical advantages and that in situ fixation will inevitably provide an inferior result due to persistent physical deformity or construct failure. [10] [11] [12]

The advantages of in situ fusion include a lower risk of neurological deficit, shorter operative times, and less blood loss. [13] [14], however, it is associated with a high rate of pseudarthrosis. [11]

The Bohlman technique with Rialto implant provided excellent fixation and allowed successful fusion with partial reduction and positive clinical outcomes in these two cases. This technique is less technically demanding, avoiding graft harvesting, demonstrated solid fusion and positive clinical outcome without neurological injury. It is a single stage, posterior approach that provides 360-degree arthrodesis that avoids morbidly due to graft harvesting, also avoids vascular structures and permits direct visual control of neural elements. Anterior approaches involve the risks such as injury to the iliac vessels, sympathetic plexus with retrograde ejaculation, retroperitoneal hematoma, ileus, incisional hernia, and wound infection [15]. Also, this technique is more demanding and requires a vascular

access surgeon for the approach and after anterior stabilization, supportive posterior instrumentation is needed, it is more time consuming.

Reporting these small series in the future will permit to establish a solid treatment paradigm of high grade listhesis. In the majority of recently published papers the authors prefer reverse technique, even though with similar results, but with increased risks, in our opinion.

4. Conclusions

The Rialto implant, used in a Bohlman technique for isthmic listhesis L5, allowed to achieve excellent fixation in the reported cases. The original Bohlman technique is one stage posterior approach that is technically less demanding just by being one stage approach increased more by using Rialto implant, though excluding additional morbidity by harvesting fibular strut graft implant. The presented cases demonstrated solid fusion and positive clinical outcome without neurological deterioration. The advantage of this technique, associated with pedicle screw instrumentation, is that all 3 columns of the spine can be fixated through a singular incision avoiding the risks of neurologic injury from spondylolisthesis reduction or the morbidity associated with anterior lumbar exposure.

Brief biography of the Father of Cotemporary Spine Surgery: Henry H. Bohlman, MD, FAOA, lived from 1937 to 2010, known as "Father of Contemporary Spine Surgery", honored as an AOA Pillar of the Orthopedic Profession, graduated from the University Maryland Medical School in 1964 following an internship in Medicine and Pediatrics at University Hospital in Baltimore and a year of General Surgery. He carried out his orthopedic training at John Hopkins Hospital. There he trained with Robbie Robinson, who described the Smith-Robinson approach to the anterior cervical spine. He came to University Hospitals in Cleveland and Case Western Reserve University as an instructor in orthopedic surgery. He spent 27 years as Chief of the Acute Spinal Cord Injury Unit at the Veterans Administration Medical Center and Professor of Orthopedic Surgery and Director of the University Hospital Spine Institute. He was the President of the Cervical Spine Research Society from 1988-1989, President of the Federation of Spine Association in 1994, was the Civilian National Consultant to the United States Air Force Surgeon General's Office for spine surgery.

In 2006, he was inducted in the Johns Hopkins Society of Scholars for Distinguished Contributions in the Field of Scholarship and received the Leon Wiltse Award from the North American Spine Society (NASS) for contributing greatly to the art and science of spinal disorder management through service to NASS. In 2008, he received the Nicolas Andry Award for Lifetime of Achievements in Spine Surgery.

H. Bohlman was consulting editor for the Journal of Bone and Joint Surgery and the Journal Spine. As an author, published 121 peer-reviewed articles and 45 book chapters. He lectured the world over and was a Visiting Professor, course lecturer or paper presenter on 445 occasions. He directed the Spine Fellowship

Program at the University Hospitals Case Medical Center and helped train 81 domestic fellows, who proceeded to predominately full-time academic positions in this country. Also, there were 35 foreign fellows from other universities around the world who were trainees under H. Bohlman. In 2010, H. Bohlman was awarded the Distinguished Physician Award which is the University Hospital's highest achievement for lifetime service.

Conflicts of Interest

The authors report no conflicts of interest or financial disclosures with respect to the research, authorship, and/or publication of this article.

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