Feasibility of Rialto Sacroiliac Fusion Implant for Trans-Sacral Fixation of High Grade L5 Listhesis Treatment, a Series of Cases

**ABSTRACT**

**Introduction:** Using the original Bohlman technique with small modifications (instead of fibula graft used Rialto implant and performing posterior fixation L4-S2) we treated surgically two young females with high grade L5 listhesis and a case of postoperative pseudarthrosis after lumbosacral fixation with success. The detailed, staged surgical technique is described, also with description of pitfalls and their avoidance. **Methods:** The patients were followed up during 2 year and 9 months and 2 year and 7 months, the third patient’s follow up is shorter, because this is a recent case. **Results:** Two young females of 18 years old with isthmic listhesis L5 were submitted to fixation L4-S2 and trans-sacral, trans-discal fusion with Rialto implant by Bohlman technique with partial reduction of listhesis. Both had resolution of the pain and has maintained a good clinical outcome at 1 year and 9 months and another one at 1 year and 7 months follow up. The third case, 79 years old male, was a postoperative pseudarthrosis L5-S1 solved with the use of the same type of trans-sacral implant, associated with S2 sacroiliac (S2 SAI) screws. **Conclusion:** Circumferential fusion is a robust arthrodesis with a low risk of pseudarthrosis, fusion without reduction is advised in patients with a balanced pelvis, acceptable global sagittal balance, few neurological symptoms. Partial reduction may be achieved during the fixation after posterior osseous elements removal of L5 vertebra. **In-situ fixation can be augmented with trans-sacral Rialto implant.**

**Keywords:** Bohlman technique; Rialto implant; Spondylolisthesis; Lumbar

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**RESUMO**

**Introdução:** Utilizando a técnica original de Bohlman com pequenas modificações (ao invés de enxerto de fíbula utilizou-se implante de Rialto e realizando fixação posterior L4-S2) tratamos cirurgicamente duas jovens com listese L5 de alto grau e um caso de pseudoartrose pós-operatória após fixação lombossacra com sucesso. A técnica cirúrgica detalhada e estagiada é descrita, além da descrição de suas falácias e o que deve ser evitado. **Métodos:** Os pacientes foram acompanhados durante 2 anos e 9 meses e 2 anos e 7 meses, sendo que o seguimento do terceiro paciente é mais curto, por se tratar de um caso recente. **Resultados:** Duas jovens do sexo feminino, 18 anos, portadoras de listese ístmica L5, foram submetidas à fixação L4-S2 e fusão transssacral, trans-discal com implante de Rialto pela técnica de Bohlman com redução parcial da listese. Ambas tiveram resolução da dor e mantiveram boa evolução clínica, uma em 1 ano e 9 meses e outra em 1 ano e 7 meses de seguimento. O terceiro caso, homem de 79 anos, foi uma pseudoartrose pós-operatória L5-S1 resolvida com o uso do mesmo tipo de implante trans-sacral, associado a parafusos S2 sacroilíaco (S2 SAI). **Conclusão:** A fusão circunferencial é uma artródeose robusta com baixo risco de pseudoartrose, recomendando-se fusão sem redução em pacientes com pelve equilibrada, equilíbrio sagital global aceitável e poucos sintomas neurológicos. A redução parcial pode ser obtida durante a fixação após a remoção dos elementos ósseos posteriores da vértebra L5. A fixação in situ pode ser aumentada com implante de Rialto transsacral.

**Palavras-chave:** Técnica de Bohlman; Implante Rialto; Espondilotíase; Lumbar
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.

The first description of in situ fusion via 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 autograft 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”.

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. 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 introduces pedicle screw fixation and replaces the autograft with titanium cage, trans-sacral trans-vertebral screw fixation, trans-vertebral interbody cage, intra-sacral 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 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 prone position with the right leg draped free to provide the surgeon access to the graft donor site. Through a single posterior incision from L3 to S2, the osseous 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 posterolateral 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 closed.

In 1990, Smith and Bohlman published a series 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 patient, with one exception, presented severe pain in the back and lower

Figure 1. A and B. Illustration of anterior spinal fusion operation performed by Burns.
limb; the “exceptional patient” presented severe pain only in the low back. Pre-surgically all patients, except for one, had sensory deficits and objective motor impairment, and five had cauda equina syndrome. Six patients had had a previous surgery that had failed. They followed up them from two to twelve years. A solid fusion was achieved in all patients, with all of them showing major or complete neurological recovery, resulting in no deterioration with time.

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, and it is 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, and screws. 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 be 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.

We report three 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 (Figure 2).

We considered that one stage posterior surgery is better tolerated, allow partial reduction under direct visual control of dura and roots after decompression and fusion with Rialto implant reduces comorbidity due to harvesting fibula allograft.

**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 SAI screws 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, since our facilities 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 sagittal balanced). Only after posterior fixation is done we perform trans-sacral 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 3. 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.

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;
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- 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 trans-sacral, trans-discal 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 4A and 4B). She was operated on: L4-S2 screw fixation, trans-sacral, trans-discal 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

Figure 3. Surgical technique of trans-sacral trans-discal implant insertion: A. Trans-sacral, trans-discal guidewire in place. B. Drilling along the guidewire. C. Trans-sacral trans-discal tract making with reamer. D. Rialto implant in place.

Figure 4. A. CT scan: L5 anterior listhesis. B. MRI: confirms L5 listhesis.
(Figures 5A and 5B), X-Ray confirmed good arthrodesis material positioning (Figure 6), partial reduction of listhesis. Good fusion was proved on CT scan at 2 year and 9 months after surgery (Figure 7), the patient is doing well, presenting no complaint.

**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 (Figures 8A and 8B). The patient was operated on, using the same technique. Also, the postoperative period was uneventful, discharged at eighth day after admission. Postoperative X-ray (Figure 9A), CT scan proved partial reduction (Figures 9B and 9C) and at 2 year and 7 months fusion was confirmed at CT scan (Figure 10).

**Case 3.** 79 years old man operated on in another hospital for high grade L5 listhesis, bilateral transpedicular fixation L2-S, unilateral L5, bilateral TLIF L5-S1. He came to us after sudden onset of intensive lumbar pain and loss of the capacity to walk. On the admission it was confirmed inferior paraparesis, the patient was not able to stand on feet. CT scan revealed pseudarthrosis of L5-S1 with radiolucency around S1 screws bilaterally and marginal S1 fracture (Figure 11). He was selected for trans-sacral fixation with Rialto implant. The implant was positioned using the technique described before, it was positioned in between the TLIF cages (Figure 12), the S1 screws were removed and added S2 SAI screws bilaterally. Postoperative period was uneventful, he recovered gradually his ability to walk, the pain reduced significantly, he is using sporadically pain killers.
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**Figure 9.** A. Postoperative X-Ray. B. CT scan showing Rialto implant in place with partial reduction of listhesis. C. coronal ST scan view.

**Figure 10.** A. Sagittal. B. Coronal CT scan slices confirming fusion at 1 year and 7 months after surgery.

**Figure 11.** A and B. CT scan revealed pseudarthrosis of L5-S1 with radiolucency around S1 screws bilaterally.

**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 as pictured in Figure 13.

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 spinopelvic 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 failure11-13.

The advantages of in situ fusion include a lower risk of neurological deficit, shorter operative times, and less blood loss14,15, however, it is associated with a high rate of pseudarthrosis12.
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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 morbidity 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. 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,

Figure 12. A-C. Postoperative CT scan showing good transsacral implant position.

Figure 13. Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position¹⁰.
even though with similar results, but with increased risks, in our opinion.

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 fixed through a singular incision avoiding the risks of neurologic injury from spondylolisthesis reduction or the morbidity associated with anterior lumbar exposure. The biggest series of 15 cases of trans-sacral fixation for high grade L5 listhesis was published by Bartolozzi et al., and they presumed that all patients, except one with major vascular complications, were extremely or reasonably satisfied with the surgery. All patients showed improvements in radiologic indexes and stable fusion at the final follow-up examination.

This technique is attractive because of direct visualization of neural elements during the surgery, diminishing the risk of neurological damage; avoids vascular, abdominal, sexual complications linked with anterior approaches; it is one stage surgery; Rialto implant is a robust and hollow implant that permits to be filled with substantial quantity of bone graft; the trans-sacral implant is put in the place after inserting the lateral bars, that permits to avoid stretching the L5 roots and diminishes the risk of neurological damage; S2 SAI screws strengthen the stability of the metallic construction. This a challenging pathology that require meticulous preoperative planning, perfect logistic preparation and good execution of planned surgery, followed by physiotherapeutic support and close follow up until definitive fusion proved. This complex of measures makes this technique effective and treatment option.

REFERENCES


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