Technical Notes

Reconstruction of Shattered Lumbo-Sacral Junction/Pelvis Utilizing Bilateral L4-Sacrum Fibula Strut Allograft And Double Iliac Screws Plus Routine Lumbar Pedicle Screw Fixation

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ABSTRACT

Background: A traumatically shattered lumbosacral junction/pelvis may be difficult to repair. Here the authors offer a pelvic fixation technique utilizing routine pedicle screws, interbody lumbar fusions, bilateral iliac screws/rods/crosslinks, and bilateral fibular strut allografts from the lumbar spine to the sacrum.

Methods: A middle aged male sustained a multiple storey fall resulting in a left sacral fracture, and right sacroiliac joint (SI) dislocation. The patient had previously undergone attempted decompressions with routine pedicle screw L4-S1 fusions at outside institutions; these failed twice. When the patient was finally seen, he exhibited, on CT reconstructed images, MR, and X-rays, a left sacral fracture nonunion, and a right sacroiliac joint dislocation.

Results: The patient underwent a bilateral pelvic reconstruction utilizing right L4, L5, S1 and left L4, L5 pedicle screws plus interbody fusions (L4-L5, and L5, S1), performed from the left. Unique to this fusion construct was the placement of bilateral double iliac screws plus the application of bilateral fibula allografts from L4-sacrum filled with bone morphogenetic protein (BMP). After rod/screw/connectors were applied, bone graft was placed over the fusion construct, including the decorticated edges of the left sacral fractures, and right SI joint dislocation. We additionally reviewed other pelvic fusion reconstruction methods.

Conclusions: Here, we utilized a unique pelvic reconstruction technique utilizing pedicle screws/rods, double iliac screws/rods, and bilateral fibula strut grafts extending from the L4-sacrum filled with BMP.

Key words: Bypass lumbar fracture, Fibula allograft, Ischial fusion, Pedicle screws, Reconstruction, Sacral disruption, Sacral fracture, Sacroiliac joint dislocation, Sacral screws

INTRODUCTION

A traumatically shattered lumbosacral junction may be difficult to repair. Here, we present a patient who had sustained a left sacral fracture, and right sacroiliac joint dislocation who had previously undergone two failed attempts at lumbo-sacral junction pelvic fusion. Here, we performed the routine placement of left-sided lumbar L4 and L5, and right-sided lumbar L4, L5, and S1 pedicle...
screws with accompanying interbody L4-L5, and L5-S1 fusions. Further, bilateral double iliac screws were connected to the L4-L5/L4-S1 pedicle screw construct. However, unique in this case was the additional placement of bilateral fibula strut allografts filled with bone morphogenetic protein (BMP) placed from the L4 levels bilaterally to the sacrum.

**Video of Technique to Treat Sacral Fracture (Illustrated File)**

An initial midline lumbo-sacral incision is accompanied by bilateral lateral incisions over both iliac crests. All the soft tissue is then removed from the posterolateral elements between L4, and the pelvis. Using normal anatomical landmarks, bilateral pedicle screws are placed at the L4 and L5 levels, while bilateral iliac screws are placed in the pelvis. Next, the posterolateral elements are decorticated between the L4-L5 levels including the sacral ala. This is followed by the application of bilateral cadaveric fibular strut grafts filled with Bone Morphogenetic Protein (Infuse: Medtronic, Memphis, USA) to create a bridge between the lumbar transverse processes of L4 and L5 with the sacral ala. The fibula struts are secured using bone suture anchors (BSA) and FiberWire (Arthrex: 1370 Creekside Boulevard Naples, Florida). The FiberWire has an ultra-high molecular weight polyethylene multifilament core surrounded by a braided poly-ester jacket with a silicone coating for ease of handling, and knot-tying. This is followed by lumbar pedicle screw placement bilaterally (e.g. L4, L5, S1), and the application of bilateral double iliac screws; rods and cross-links are then appropriately placed, and tightened [Figures 1-4]. Together, this construct creates a bilateral L4-S1 lumbar to pelvic reconstruction/fusion.

**Case Study**

A middle aged male sustained a multiple storey fall resulting in a left sacral fracture, and right sacroiliac joint dislocation. He had previously undergone two failed decompressions with L4-S1 pedicle/screw fusions at outside institutions. When the patient was finally seen in preparation for the third surgery, the CT reconstructed images, MR, and X-rays demonstrated a persistent right sacroiliac joint dislocation, and a left sacral fracture nonunion.

**Bilateral Fibula Strut Allograft, Bilateral Double Iliac Screws, and L4-S1 Pedicle/Screws**

Though a midline lumbo-sacral incision with bilateral lateral pelvic incisions, the bone edges of the left sacral fracture nonunion, and the right sacroiliac joint dislocation were exposed, and debrided. Next, left-sided transforaminal lumbar interbody fusions utilizing PEEK cages were performed at the L4-L5, and L5-S1 levels. Additionally left-
L4-L5 transverse processes to the sacrum [Figures 1-4]. Once rods/connectors were appropriately affixed, bone graft was laid over the construct bilaterally as confirmed on the postoperative AP/ Lateral X-rays, and CT studies [Figures 5 and 6].

DISCUSSION

Review of other Pelvic Reconstruction Techniques

Multiple other alternative pelvic reconstruction techniques were published between 2014-2016 [Table 1]. In 2014, Padalkar et al. treated a 25 year old male, who for an L5 burst fracture/dislocation with Grade III spondylolisthesis and total comminution of the L5 vertebra, was treated utilizing a...
### Table 1: Various Pelvic Reconstruction Techniques.

| Author/Year | Journal/Year | Cases/Type of Procedure | Data | Data | Data | Data | Conclusions/Outcomes |
|-------------|--------------|-------------------------|------|------|------|------|-----------------------|
| Padalkar[4] | J Orthop Case Rep 2014 | Posterior Only | Reconstruct L5 | Burst Frx- Expandable Cage/Fusion | Paralysis L5/S1 Roots Loss Sphincter Function | TES Reconstruction Techniques | SPF Shift from Trans-Sacral Implants/ Hook to Pedicle/ Iliac Screw-Rod | 25 yo M Heavy Object Fell on Back Burst Frx L5 Grade III Spondyloïdthesis | Disruption Posterior Ligaments L5S1 X-rays 75% Grade III Slip Comminuted Burst Fracture L5 SPF PPRF ASCF | Transforaminal Approach Avoided Anterior Reconstruction of Vertebral Body-Only Posterior Fixation Postop AE Infections, GI, Vascular Higher AE for non-ASCF Group (1.63 vs. 0.7) | Surgery: Used Expandable Cages for Posterior Only Approach Avoided Anterior Surgery |
| Biederman[2] | Eu Spine J 2014 | SPF After SAC Outcome | Mean Age 37; Followed 33 mos | 23 Articles (out of 856) | 43 Patients | TES | Results | 3530 ml Mean EBL | Fractures 8/10 No | 156 Patients Avg age 66.7 | Surgery: Used Expandable Cages for Posterior Only Approach Avoided Anterior Surgery |
| Ayoub[1] | Eur Spine J 2016 | Standalone Percutaneous TP Rx for Vertically Unstable Sacral Frx Type C | Followed Avg 22.1 mos Mean OR Time 43.3 min Incision 4.6 cm Length | 2 ISS Screws TBP TP+1 ISS Screws 5 mm Gap Left Transforaminal Zone Pubic Symphysis Separated 5 mm Stabilized 3.5 mm Plate | Left Hemipelvis Docked to Rigid Base Plate- Loaded onto S1 End Plate Displacement and Coronal Tilt Measured Right Hemipelvis | 42 Cases: 16 with Nerve Root Injuries Preop Subcutaneous 3.5 m, 28 RP Placed Through Vertical Incisions 14 Transvers | Better Outcomes Comminuted Sacral Frx Worse Results | Better TP +1 IS Screw > 5 mm Vertical Displacement vs. 2 IS screws vs. TBP TBP < 5 degrees Coronal Tilt vs. 2 ISS screws vs. TP +1 ISS Screws | Nerve Root Injuries Significant Postop Recovery Conclusion 3.5 mm RP Good Option vs. Percutaneous ISS Screws | Advantages TP Minimal Incision Short OR Time Less Radiation Good Stability < Iatrogenic Injuries |
| Chaiyamongkol[3] | Asian Spine J 2019 | Biomechanical Comparison 3 Posterior Pelvic Fixation Techniques for Vertically Unstable Sacral Fractures 12 Pelvic Models | Lumbar Spine to P/S Group A: 10 Endoprosthesis Combined Reconstruction Mean IS 32.5 mos | 3D Pelvic Models Used CT Studies Trans-Sacral Implants 7.3 mm Diameter Study Safe Zone 12 mm Diameter | Group B: 14 Combined Non-endoprosthetic Reconstruction + Anterior Fusion Group C:SPF- Spino-Pelvic Fixation (8 pts) 51% Pelvis Accommodated S1 Implants with Safe Zone Bilateral IS Screws Placed Possible in S1 | 2 ISS Screws TBP TP+1 ISS Screws | TES Stabilize Lumbar Spine to P/S | TEB Stabilize Lumbar Spine to P/S Group A: 10 Endoprosthesis Combined Reconstruction Mean IS 32.5 mos | Group B: 14 Combined Non-endoprosthetic Reconstruction + Anterior Fusion Group C:SPF- Spino-Pelvic Fixation (8 pts) 51% Pelvis Accommodated S1 Implants with Safe Zone Bilateral IS Screws Placed Possible in S1 | TEB Stabilize Lumbar Spine to P/S Group A: 10 Endoprosthesis Combined Reconstruction Mean IS 32.5 mos | Superiority TP+ 1 ISS Screw for Vertically Unstable Sacral Fractures |
| Wei[1] | Bone Joint J 2019 | Lumbar Pelvic REC 3D Printed SEP 32 TES 2015-2017 Followed Avg 22.1 mos 2015-2017 space Mean EBL 3530 ml | Trans-Sacral Implants for Pelvic Frx- Virtual Implant Positioning 156 Patients Avg age 66.7 | 3D Pelvic Models Used CT Studies Trans-Sacral Implants 7.3 mm Diameter Study Safe Zone 12 mm Diameter | Group B: 14 Combined Non-endoprosthetic Reconstruction + Anterior Fusion Group C:SPF- Spino-Pelvic Fixation (8 pts) 51% Pelvis Accommodated S1 Implants with Safe Zone Bilateral IS Screws Placed Possible in S1 | TEB Stabilize Lumbar Spine to P/S Group A: 10 Endoprosthesis Combined Reconstruction Mean IS 32.5 mos | Group B: 14 Combined Non-endoprosthetic Reconstruction + Anterior Fusion Group C:SPF- Spino-Pelvic Fixation (8 pts) 51% Pelvis Accommodated S1 Implants with Safe Zone Bilateral IS Screws Placed Possible in S1 | TEB Stabilize Lumbar Spine to P/S Group A: 10 Endoprosthesis Combined Reconstruction Mean IS 32.5 mos | TEB Stabilize Lumbar Spine to P/S Group A: 10 Endoprosthesis Combined Reconstruction Mean IS 32.5 mos | Best Results Endoprosthesis Group A >Stability/IS No > Intraop Bleeding or Periop Complications AE : 69% Perforation Sacral Ala and Iliac Fossa 23% Iliac Fossa Perforation 8% Sacral Ala Perforation |

(Contd...)
short segment L5-S1 fusion with placement of an expandable cage [Table 1]. From a review of 23 studies (out of 856 found in PubMed: 2014), 43 patients undergoing total sacrectomies were treated with spinopelvic fixation (SPF) or posterior pelvic ring fixation (PPRF), with or without anterior spinal column fusion (ASCF). Notably, more instrument failures were seen in those not receiving simultaneous ASCF (e.g., 4/23 patients (17.4%) without vs. 1/8 (12.5%) with instrumentation) [Table 1]. Of interest, a 2016 study performed “En Bloc” SI fusion for patients with pelvic fractures, Wagner et al. (2019) studied normal CT examinations to formulate the optimal placement of trans-sacral implants (e.g. diameter of 7.3 mm) so that they included safe zones (with/without peripheral safe zones of 12 mm); in 51% of cases, S1 could accommodate bilateral trans-sacral screw implants with “safe zones”, and it was also possible to place bilateral sacroiliac screws in S1 [Table 1]. In 2019, Xu et al. performed “En Bloc” SI (Sacroiliac) joint removal for; 3 primitive neuroectodermal tumors, 3 chondrosarcomas, and 3 osteosarcomas; this was followed by reconstruction of the pelvis. Also in 2019, Santoro et al., within 18 days of admission effectively managed 25 traumatic sacral fractures plus 20 simultaneous spinal fractures utilizing iliosacral screw fixation, and 6 spinopelvic fixation techniques [Table 1]. Finally, utilizing 12 pelvic models, Chaiyamongkol et al. (2019) documented the superior biomechanical advantages of transiliac plating (TP) plus the placement of a single iliosacral screw (ISS) compared with 2 iliosacral screws (ISS), or a tension band plate (TBP) [Table 1].

### CONCLUSION

In the case presented, the patient had previously undergone two failed attempts to fuse the lumbar spine to the sacrum following a multi-storey fall. The trauma had resulted in

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**Table 1: (Continued).**

| Author Journal Year | # Cases/Type of Procedure | Data | Data | Data | Conclusions and Outcomes |
|---------------------|---------------------------|------|------|------|--------------------------|
| Xu<sup>4</sup> | En Bloc Pelvic Ring REC, Primary MBT SI Joint | 9 Patients 2009-2017 5 M, 4 F Average Age 35 (Rg 16-63) | Reconstruct Pelvic Ring | 23 PNET 3 ChS 3 OsteoS 45 Min | Mean OR Time 323.67 Min (Range 247-471) | AE: Bone Graft, No Heal |
| Santoro<sup>5</sup> | Traumatic Sacral Fusion | 12 Pelvic Trauma (48%) 7 (28%) External Fixation 80% Spinal Fractures with Sacral Fix | 19 (76%) Iliosacral Fixation 6 (24%) | Mean OR Time 323.67 Min (Range 247-471) | Iliosacral Osteosynthesis Avg Screws 1.37 (1-3 Rg) | AE: Bone Graft, No Heal |
| | 12 Sacral Fx | 12 Pelvic Trauma (48%) 7 (28%) External Fixation 80% Spinal Fractures with Sacral Fix | 19 (76%) Iliosacral Fixation 6 (24%) | Mean OR Time 323.67 Min (Range 247-471) | Iliosacral Osteosynthesis Avg Screws 1.37 (1-3 Rg) | AE: Bone Graft, No Heal |
| World Neurosurg 2019 | 12 (48%) Severe TL Trauma | 12 Pelvic Trauma (48%) 7 (28%) External Fixation 80% Spinal Fractures with Sacral Fix | 19 (76%) Iliosacral Fixation 6 (24%) | Mean OR Time 323.67 Min (Range 247-471) | Iliosacral Osteosynthesis Avg Screws 1.37 (1-3 Rg) | AE: Bone Graft, No Heal |

SEP=3D Printed Sacral endoprosthesis, REC=Reconstruction, TES=Total En-Bloc Sacrectomy, P=Pelvis, S=Sacrum, pts=Patients, SPF=Spino-Pelvic Fixation, mos=Months, Rx=Treatment, PPRF=Posterior Pelvic ring Fixation (PPRF), ASCF=Anterior spinal Column Fixation. Avg=Average, Reop=Reoperation, IS=Implant Survival, Rg=Range, Period=Perioperative, SAC=Secretary, AE=Adverse Events, Entrap=Intraoperative, L=Lumbar, LS=Lumbosacral SI=Sacroiliac, F=Females M=Males, Rx=Range, PNET=Primitive Neuroectodermal Tumors, Chas=Chondrosarcoma, Osteos=Osteosarcoma, MBT=Malignant Bone Tumor, SEP=3D Printed Sacral endoprosthesis, REC=Reconstruction, TES=Total En-Bloc Sacrectomy, P=Pelvis, S=Sacrum, pts=Patients, SPF=Spino-Pelvic Fixation, mos=Months, Rx=Treatment, PPRF=Posterior Pelvic ring Fixation (PPRF), ASCF=Anterior spinal Column Fixation. Avg=Average, Reop=Reoperation, IS=Implant Survival, Rg=Range, Period=Perioperative, SAC=Secretary, AE=Adverse Events, Entrap=Intraoperative, L=Lumbar, LS=Lumbosacral SI=Sacroiliac, F=Females M=Males, Rx=Range, PNET=Primitive Neuroectodermal Tumors, Chas=Chondrosarcoma, Osteos=Osteosarcoma, MBT=Malignant Bone Tumor, TL=Thoracolumbar, ISS=Ileocecal Screw, TP=Trans iliac Plating, TBP=Tension Band Plate, Fix=Fractures.
a left sacral fracture, and a right-side dislocation of the sacroliliac joint. The authors successfully fused the lumbar spine to the sacrum, by first combining a lumbar (left L4, L5) and lumbosacral (L4, L5, S1) pedicle/screw/rod fixation technique with L4-L5 and L5-S1 interbody fusions. They additionally placed bilateral double sacral screws (affixed with rods/cross-links), and uniquely applied bilateral fibula strut allografts from L4-S1 filled with BMP.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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