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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-SI lumbar to pelvic reconstruction/fusion.

Case Study

A middle aged male sustained a multiple storey fall resulting in a left sacral fracutre, 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 lumbosacral 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-sided L4-L5 and right-sided L4-S1 pedicle screws were placed. This was followed by the application bilaterally of double iliac screws, and the placement of bilateral fibula strut allografts filled with BMP/INFUSE placed from the

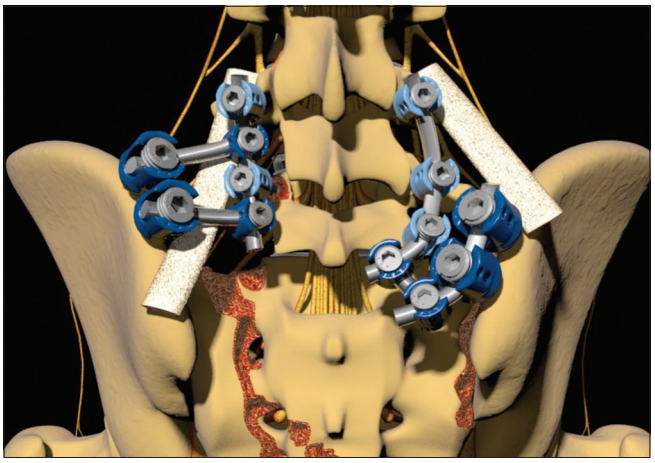


Figure 1: PA Illustration of Bilateral Pelvic Fixation Construct. After a multi-storey fall, a middle aged male sustained a left sacral fracture, and right sacroiliac joint dislocation, He had been operated on twice previously; both attempts resulted in pseudarthroses/failed fusions. Here is the illustration of the repair technique finally perfomed. This consisted of right-sided application of L4, L5, S1 pedicle screws (to address the right SI joint dislocation), and left L4 and L5 pedicle screw fixation (to address left sacral fracture). Additionally, interbody PEEK (polyetheretherketone) fusions at both L4-L5 and L5-S1, the placement of bilateral iliac screws, and the bilateral application of fibula strut allografts filled with BMP/INFUSE were placed over the transverse processes of L4 and L5 down to the sacrum. Rods were then attached along with cross-links.

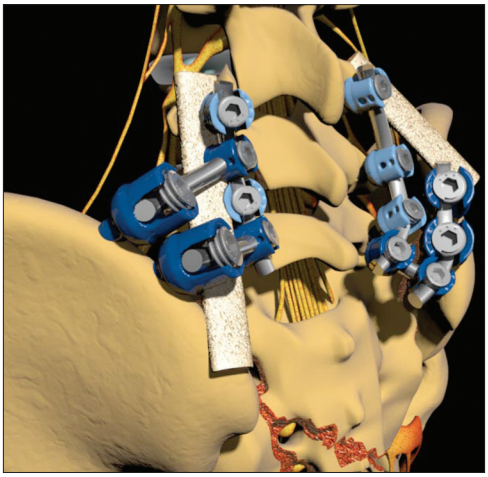


Figure 2: Left Oblique Illustration of Pelvic Fixation Construct For Left Sacral Fracture.

This image clearly shows the left-sided pedicle screws placed in L4 and L5 (not S1), and the two screws placed in the ilium on both sides. Note the completed placement of the rod/cross-link system affixed to the screws. You can also see the fibula strut graft extending from L4 to the sacrum on the left.

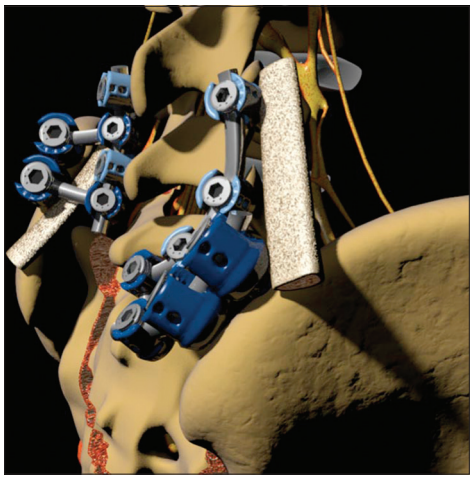


Figure 3: Right Oblique Illustration of Pelvic Fixation Construct for Right Sacroiliac Joint Dislocation.

This image clearly shows the pedicle screws placed on the right side at the L4, L5, and S1 levels, plus the two screws placed in the ilium. Note the completed placement of the rod/cross-link system affixed to the screws. You can also see the fibula strut graft extending from L4 to the sacrum.

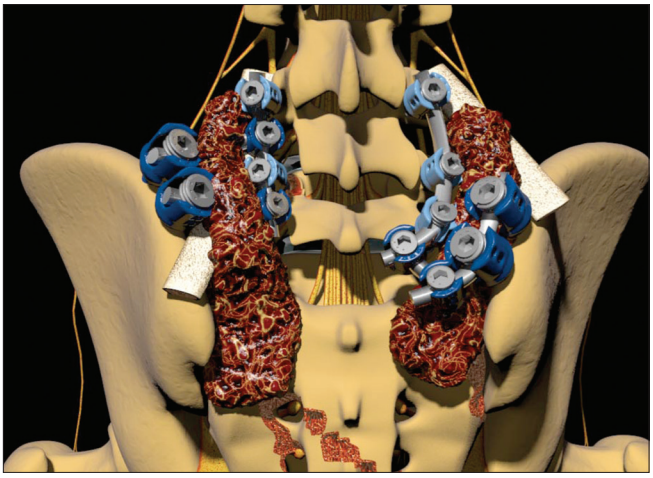


Figure 4: PA Illustration of Bilateral Fixation Construct.

The PA illustration of the bilateral pelvic fixation shows the bone graft placed along the left sacral fracture, and right S1 joint dislocation.

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 reconstrucdtion techniques were published between 2014-2016 [Table 1].[1,2,4] In 2014, Padalkar *et al*. treated a 25 year old male, who for an L5 burst

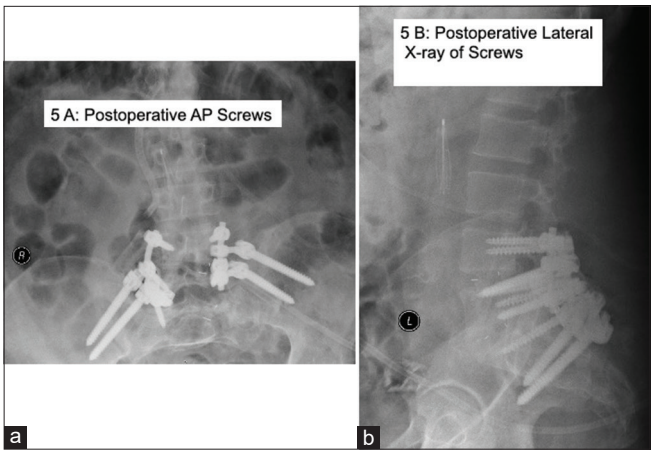
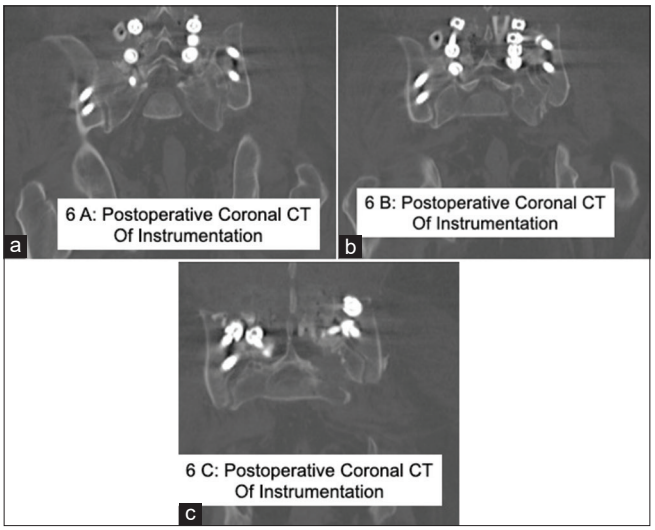


Figure 5: (a and b) Postoperative AP and Lateral X-rays Showing Pelvic Construct.

(a) The postoperative AP X-ray shows the entire pelvic construct. On the right you can see the pedicle screws in L4, L5, and S1 while on the left, pedicle screws were found only in L4 and L5. Bilateral double iliac screws were placed, and you can see the rods, and rod/screw connectors. Also the fibula strut was clearly visualized on the left extending over the transverse processes from L4-L5 to the sacrum; this was not so clearly seen on the right. (b) The lateral X-ray confirmed the construct as outlined above.



Figures 6: (a,b, and c) 2D Bone Window CT Reconstructed Images of Final Construct.

Here are three 2D Bone Window-CT postoperative reconstructed images. (a) This coronal bone window CT demonstrated the right pedicle screws in L4, L5, and S1, the left pedicle screws in L4 and L5, and bilateral iliac screws (only partially visualized). (b) This second coronal bone window CT image taken slighlty more dorsally showed some of the rod on the right side. (c) Even further dorsally, this coronal CT bone window image showed the bilateral iliac screws.

fracture/dislocation with Grade III spondylolisthesis and total comminution of the L5 vertebra, was treated utilizng a

Table 1: Various Pelvic Reconstruction Techniques.

Author Journal Year	# Cases/Type of Procedure	Data	Data	Data	Conclusions and Outcomes
Padalkar[4] **J Orthop Case Rep 2014**	Posterior Only Reconstruction L5 Burst Fx- Expandable Cage/Fusion Paralysis L5/S1 Roots Loss Sphincter Function	25 yo M Heavy Object Fell on Back Burst Fx L5 Grade III Spondylolisthesis	Disruption Posterior Ligaments L5S1 X-rays 75% Grade III Slip Comminuted Burst Fracture L5	Transforaminal Approach Avoided Anterior Reconstruction of Vertebral Body-Only Posterior Fixation	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 Reconstruction Techniques SPF Shift from Intrapelvic Rods/ Hooks to Pedicle/ Iliac Screw-Rod	SPF PPRF ASCF Separated Patients With or Without ASCF Anterior Surgery	Postop AE Infections, GI, Vascular **Higher AE For non-ASCF** Group (1.63 vs. 0.7)	Instrument Failure 1/8 (12.5%) with ASCF vs. 4 of 23 (17.4% No-ASCF
Ayoub[1] **Eur Spine J 2016**	Standalone Percutaneous TP Rx for Vertically Unstable Sacral Fx Type C Followed Avg 22.1 mos Mean OR Time 43.3 min Incision 4.6 cm Length	42 Cases: 16 with Nerve Root Injuries Preop Subcutaneous 3.5 m, 28 RP Placed Through Vertical Incisions 14 Transvers	Assessed Hannover Outcome Scores 14 Excellent 16 Good 6 Fair 6 Poor Younger Patients Better Outcomes Comminuted Sacral Fx Worse Results	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	**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	**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	**Superiority TP+ 1 ISS Screw for Vertically Unstable Sacral Fractures**
Wei[7] **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	TES 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)	Outcome: 9/10 Walked 8/10 No Pain 3 Implant Failures: Broken Screws/Rod 1 Reop Local Recurrence (Bone Solid)	Best **Results Endoprosthesis Group A >Stability/IS No > Intraop Bleeding or Periop Complications**
Wagner[6] **Arch Orthop Trauma Surg 2019**	Trans-Sacral Implants for Pelvic Fx- 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	51% Pelvis Accommodated S1 Implants with Safe Zone Bilateral IS Screws Placed Possible in S1	**All had Safe Zone for Trans-Sacral Implant** S2/78% Safe Zone also S1	AE : 69% Perforation Sacral Ala and Iliac Fossa 23% Iliac Fossa Perforation 8% Sacral Ala Perforation

(Contd...)

Table 1: *(Continued).*

Author Journal Year	# Cases/Type of Procedure	Data	Data	Data	Conclusions and Outcomes
Xu[8] **Orthop Surg 2019**	**9 Patients** **En Bloc** **Pelvic Ring REC** **Primary MBT SI Joint** 2009-2017 5 M , 4 F Average Age 35 (Rg 16-63)	Reconstruct Pelvic Ring Longitudinal Half Sacrum, SI Joint with Iliac Bone Block and Screw/Rod System with Bone Graft	23 PNET 3 ChS 3 OsteoS 45 Min EBL Avg 3111 ml; Followed Avg 24 mos 3 yr Survival 57%	3 Local Recurrence 3 No Tumor Recurred 5 Died: 4 Lung mets. 1 Brain Mets	AE; 4 Bone Graft Not Heal 5 Healed 6.2 mos 1 Deep Infection 1 Skin Necrosis 2 Failed Fusion-Displaced Rods No Rod Fx
Santoro[5] **World Neurosurg 2019**	**Traumatic Sacral Fx** **Navigation** Used Fusion 2015-2017 25 Sacral Fx 12 (48%) Severe TL Trauma	12 Pelvic Trauma (48%) 7 (28%) External Fixation 80% Spinal Fractures with Sacral Fx Mean Time to Surgery 18 days (Rg 8-31)	Surgery: **19 (76%)** **Iliosacral Fixation** **6 (24%)** **Spinopelvic Fixation** Mean # Screws 9.67 (Rg 6-17)	Mean OR Time 323.67 Min (Range 247-471) Iliosacral Osteosynthesis Avg Screws 1.37 (1-3 Rg) Surgical Time 78.93 min	Postop CT Confirmed Adequate Screw Placement AE 2 Infections-Vac Closure 1Sacral Screw Removed

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=Secretory, AE=Adverse Events, Entrap=Intraoperative, L=Lumbar, LS=Lumbosacral SI=Sacroiliac, F=Females M=Males, Rg=Range, PNET=Primitive Neuroectodermal Tumors, Chas=Chondrosarcoma, Osteons=Osteosarcoma , Avg=Average, EBL=Estimated Blood Loss, Mets=Metastases, Fix=Fracture, REC=Reconstruction, MBT= Malignant Bone Tumor, TL=Thoracolumbar, ISS=Ileocecal Screw, TP=Trans iliac Plating, TBP=Tension Band Plate, Fix=Fractures

short segment L5-S1 fusion with placement of an expandable cage [Table 1].[4] 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).[2] 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].[2] Of interest, a 2016 study documented the efficacy of percutaneously placing transiliac stand-alone 3.5 mm plates (TP) for managing 42 vertically unstable sacral fractures (all type C) vs. percutaneous iliosacral screws [Table 1].[1]

Five other studies employed additional techniques for lumbar pelvic ring reconstruction addressing various pathologies [Table 1].[5-8] Following total "En Bloc" sacrectomy (TES), Wei *et al.* (2019) compared a 3-D printed sacral endoprosthesis vs. other lumbar-pelvic ring/junction reconstruction technqiues. They found that the 20 endoprostheses (Group A) resulted in better reconstruction results/outcomes vs. the 14 patients (Group B) who received posterior non-endoprosthetic reconstructions with anterior spinal fixation, vs. the 8 patients (Group C) undergoing spinopelvic fixation (SPF) alone [Table 1].[7] Further, to create safe trans-sacral implants 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].[6] 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. [8]. They utilized; "...longitudinal half sacrum, sacroiliac joints, and partial iliac bone block excision and (a) screw-rod system combined with bone grafting" [Table 1].[8] 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 spino-pelvic fixation techniques [Table 1].[5] 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].[3]

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

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 additonally 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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Nil.

Conflicts of interest

There are no conflicts of interest.

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