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Case Report

A novel technique for precise rod contouring using template rod in minimally invasive spine fixation: a case report

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ABSTRACT

To present an innovative rod templating technique that improves precision in rod contouring and insertion during minimally invasive spine fixation, particularly in cases involving osteoporosis and limited surgical exposure. After insertion of pedicle screws in a 72-year-old osteoporotic patient undergoing delta fixation for high-grade listhesis, an aluminium template rod was passed through the screw tulips and fixed with set screws to capture the spatial configuration of the construct. The contoured template was then used to shape the final titanium rod, which was inserted and secured to achieve in-situ fixation. The templating technique facilitated precise rod contouring, smooth rod passage, and secure fixation without screw backout. The patient experienced significant pain relief and was able to ambulate early. Follow-up at six months showed stable implant positioning with no evidence of screw loosening or pullout. This template-based rod contouring method enhances biomechanical alignment, reduces operative time, and minimises the risk of screw pullout in minimally invasive spine fixation, offering improved surgical efficiency and construct stability in challenging osteoporotic cases.

Keywords: Rod contouring, Minimally invasive spine fixation, Rod templating technique

INTRODUCTION

Fixation techniques are crucial for stabilizing the vertebral column, aiding fusion and restoring spinal alignment in trauma, degenerative conditions, deformities, or tumours.[1] Pedicle screw fixation remains the gold standard for spine fixation due to its ability to provide stability across three columns, effectively correcting deformities, stabilizing the spine and achieving fusion.[2] The development of minimally invasive surgery (MIS) pedicle screw and rod systems represents a significant advancement in spine fixation.[3] These systems were designed to reduce tissue damage and accelerate recovery compared to traditional open techniques.[4] MIS pedicle screw systems utilize smaller incisions, specialised instruments to insert screws and rods percutaneously through muscle-sparing approaches.[5,6] Long-segment minimally invasive surgery (MIS) spine fixation is indicated for conditions necessitating stabilisation across multiple vertebral levels, including carrot stick fractures, complex spinal deformities, multilevel degenerative diseases, trauma, and tumour involvement.[7] Although MIS has several benefits, there are also obstacles to consider.

One unique challenge is rod contouring and insertion within MIS pedicle screw and rod systems, largely due to the limited surgical exposure and restricted working area.[8,9] Unlike open surgery, where direct visualisation and ample access facilitate rod shaping and placement, MIS requires contouring the rod to precise anatomical alignment through smaller incisions and muscle-sparing pathways. This limited access complicates accurate rod bending, increasing the risk of suboptimal fit and screw pull-out, particularly in osteoporotic individuals.[10] To address these issues, we propose an innovative method for precise rod contouring in MIS fixation constructs, which will assist surgeons in achieving enhanced construct stability and potentially improve long-term outcomes.

Ethics statement

This retrospective case report involved analysis of previously collected clinical data. Therefore, it qualifies for exemption from Institutional Review Board (IRB) approval in accordance with applicable ethical guidelines and institutional policies. Patient confidentiality was maintained throughout the study. Written informed consent for surgical treatment and the use of anonymised clinical data was obtained from the patient before surgery.

CASE REPORT

Our patient is a 72-year-old woman experiencing intense lower back pain and pain in both legs. She had previously undergone decompression surgery from L3 to L5 at a different hospital two decades ago. Her current imaging studies indicate grade 5 lytic listhesis at the L5-S1 level. However, prone X-rays showed a correction to grade 3. Her pre-operative DEXA scan (Dual-energy X-ray absorptiometry) was indicative of severe osteoporosis (T-score = - 2.8).

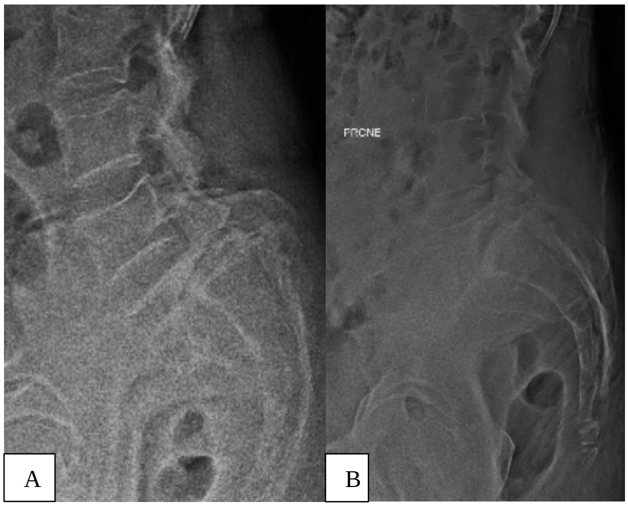

Figure 1: (A) pre-operative standing lateral X-ray image showing L5-S1 grade 5 anterolisthesis and (B) pre-operative prone lateral X-ray image showing reduction of L5-S1 listhesis to grade 3.

Given her age, high-grade listhesis, osteoporosis, obesity and several health issues, a plan was made to perform an in-situ delta fixation at L5-S1 and interbody bone grafting, connected with L3 and L4 MIS pedicle screws and rods. After administering general anesthesia, the patient was positioned prone with careful padding on her face, chest, pelvis, and knees.

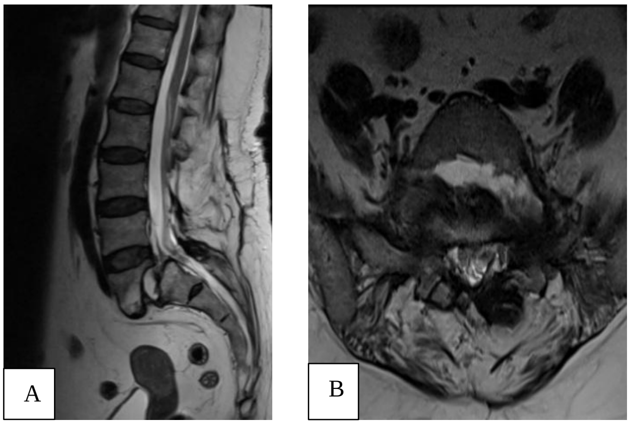

Figure 2: Preoperative MRI images showing L3-5 postoperative fibrosis with S1 lamina impinging on the thecal sac: (A) sagittal cut and (B) axial cut.

Her hips were extended to achieve a preoperative reduction of the listhesis to grade 3. The patient was then draped and prepped for surgery. Guide wires were first inserted bilaterally into the L3 and L4 pedicles using a Jamshedi needle (J-needle) under fluoroscopic guidance.

Next, the S1 pedicles were marked, and the J-needle was inserted from the S1 pedicle into the L5 body for delta fixation, and a guide wire was passed through it. MIS pedicle screws of appropriate sizes were then inserted over the guide wires. A small incision was made along the midline to carry out a partial S1 laminectomy for decompression. The excised lamina was morselized and utilised as bone graft in the L5-S1 disc space to facilitate fusion. The subsequent task of shaping and inserting the rod presented a significant challenge.

Technique

Step 1: MIS pedicle screw insertion: Insertion of percutaneous pedicle screws at the L3, L4 and L5-S1 delta screw was done.

Step 2: initial rod contouring and placement: Contour a titanium rod roughly to approximate the spinal curvature. Insert this rod through the tulips of the pedicle screws within the submuscular plane to establish a preliminary path.

Step 3: template rod application: Pass a malleable aluminum rod template through the screw tulips, following the path created by the initial titanium rod.

Step 4: template rod contouring: Tighten the set screws over the aluminium template rod to secure it in place. This step allows the template rod to mold precisely to the spine's shape.

Step 5: template rod removal: Carefully remove the aluminium template rod while preserving its contoured shape.

Step 6: final rod contouring: Use the accurately contoured template rod as a guide to contour the final titanium rod precisely.

Step 7: final rod placement and fixation: Pass the final contoured titanium rod through the pedicle screw tulips and tighten the set screws to secure the construct, achieving stable in-situ fixation.

Step 8: verification: Confirm proper placement and fixation with a final C-arm image, ensuring no screw backout or malposition.

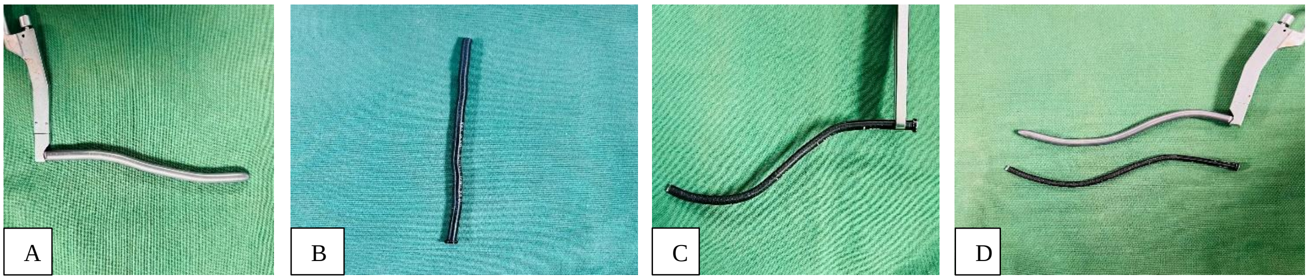

Figure 3: Rod contouring steps: (A) roughly contoured titanium rod to make a path inside the tulips, (B) straight template rod used for contouring, (C) template rod contoured according to the construct, and (D) final titanium rod contouring done according to the contoured template rod.

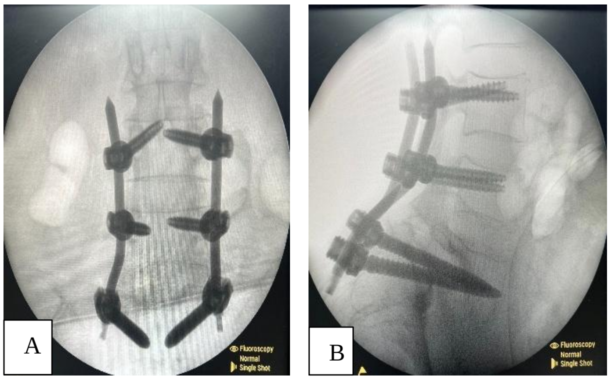

Figure 4: Intra-operative C-arm image of delta fixation showing an accurately contoured titanium rod: (A) AP view and (B) lateral view.

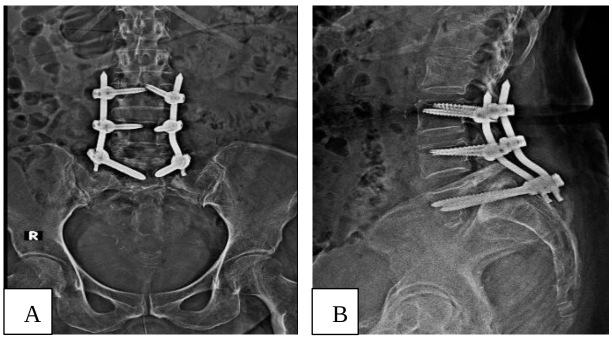

Figure 5: Post-operative 6 months follow-up X-ray showing implants in good position: (A) AP view and (B) lateral view.

This stepwise workflow ensures precise rod contouring and optimal spinal alignment with reproducible fixation outcomes. The patient's pain was relieved, and ambulation started from the next day. A 6-month follow-up X-ray showed the implants in a good position with no screw backout or loosening noted.

DISCUSSION

Osteoporotic bones pose difficulties in spinal fixation due to diminished screw hold and a greater likelihood of screw loosening or pullout.[11] This issue is particularly significant in MIS techniques, where the presence of osteoporosis requires careful attention to rod contouring and insertion, as a poor fit can cause screw pull-out at the time of set screw tightening, compromising construct stability and increasing failure rates.[12]

Charles et al outlined a method for executing in-situ rod contouring during open surgery on thoracolumbar fractures. This technique enables the adjustment of kyphosis at the site of the fractured vertebrae and the corresponding disc by enhancing lordosis and extending the anterior column.[13]

Sardi et al found in their research that surgeons often overbend rods beyond the intended angle when not using a template, but their performance significantly improved with the use of a template guide. This overbending tendency notably affected patient outcomes and increased the risk of proximal junctional failure.[14] In a separate study, Lee et al introduced an innovative method for creating patient-specific prebend rods before surgery by utilising three-dimensional (3D) printing technology in a case involving a percutaneous pedicle screw system in minimally invasive spine surgery (MISS).[15]

Consequently, innovations like the use of rod templates, as discussed, aim to tackle these fixation challenges by enhancing the precision of rod shaping and alignment, thereby reducing the risk of screw pullout and improving overall biomechanical stability in an osteoporotic spine. Our method avoids repeated rod re-contouring, which can cause weakening of the titanium rod due to reduced rod yield strength and stiffness.

Additionally, this technique aids in the smooth insertion of the rod in a single attempt, preventing soft tissue damage caused by multiple attempts of rod contouring and re-insertion. By passing the template rod through the pedicle screw tulips within the submuscular plane and fixing the template rod with set screws, surgeons can accurately replicate the spatial configuration of the fixation construct before final rod contouring.

This approach reduces intraoperative guesswork, allowing for a rod that fits precisely to the patient's anatomy. Moreover, this technique offers particular benefits in MIS long-segment fixation constructs, especially in patients with challenging anatomical features such as osteoporosis, obesity, listhesis, carrot stick fractures, etc., when in-situ fixation is the goal.

The rod template serves as a reliable guide that respects the intricate three-dimensional orientation of the fixation points, facilitating smoother rod passage. This not only reduces operative time but also minimizes tissue trauma. Consequently, the improved procedural efficiency and enhanced construct stability contribute to superior immediate surgical outcomes and promote better long-term spinal function and patient recovery.

CONCLUSION

The technical note presents an innovative rod contouring technique using an aluminium template rod that enhances precision during minimally invasive spine fixation, particularly in complex cases like delta fixation involving osteoporosis and limited surgical exposure.

By accurately capturing the spatial configuration of pedicle screw constructs through a template rod, this method reduces intraoperative guesswork, decreases operative time, improves biomechanical alignment, and minimises the risk of screw pullout in cases where in situ fixation is the goal.

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