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Case Report

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Reconstruction with a 3D-printed Prosthesis and Internal Fixation with Novel Four-Rod Technique After En Bloc Resection of Meningiomas in the Lumbosacral Region (L5-S3) without Rectum/Bladder Function Sacrifice: Technical Case Report

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ABSTRACT

Spinal meningiomas are rare in the lumbosacral region. The best solution is complete tumor resection. However, how to preserve the patient's rectum/bladder function after en bloc resection is still a considerable challenge, even without spinopelvic reconstruction. The use of the three-dimensional (3D) printing technique may simplify it. The final step after restoration is the establishment of rigid fixation. The purpose of this article was to present a case of lumbosacral meningiomas treated by en bloc resection, 3D-printed prosthesis reconstruction, and fixation with pedicle screws and cortical bone trajectory screws.

A 35-year-old woman has suffered from lumbosacral and two legs pain for two months. During the previous month, she limped, and her strength was 4/5 in both legs. Magnetic resonance imaging (MRI) revealed space-occupying lesions from the lumbar 5 (L5) to sacral 3 (S3) vertebral bodies. The previous biopsy confirmed the lesions were spinal meningiomas. The patient underwent an en bloc resection followed by 3D-printed prosthesis reconstruction and internal fixation with a novel technique. The surgery was successful, and the patient recovered well postoperatively according to follow-up examination.

En bloc resection of L5-S3 meningiomas without rectum/bladder function sacrifice is a feasible procedure, and 3D-printed prosthesis provides an alternative method for the reconstruction of the spinopelvic ring. The rigid fixation construct using the novel four-rod technique could develop strong bony fusion.

KEYWORDS: En bloc, Four-rod technique, Rectum/bladder function, Spinal meningioma, 3D-printed prosthesis

ABBREVIATIONS: 3D: Three-dimensional, **ASF:** Anterior spinal fixation, **CT:** Computed tomography, **L:** Lumbar, **MRI:** Magnetic resonance imaging, **PPRF:** Posterior pelvic ring fixation, **S:** Sacral, **SINS:** Spinal instability neoplastic score, **SPF:** Spinopelvic fixation, **WBB:** Weinstein-Boriani-Biagini

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INTRODUCTION

Spinal meningiomas mostly occur in the thoracolumbar spine (11). The current guideline recommends removing the tumor as completely as possible (6). However, en bloc resection often damages nerve roots (3). Spinopelvic structure reconstruction and rigid fixation are necessary.

We report a case of lumbosacral meningiomas treated by en bloc resection, 3D-printed prosthesis reconstruction, and fixation with pedicle screws and cortical bone trajectory screws.

CASE REPORT

A 35-year-old woman had suffered from lumbosacral and two legs continuing discomfort and pain and perineal bulge sensation for two months. During the past month, she hobbled and felt worsened pain after activity. The patient also experienced a change in bowel habits, specifically dry stool. Upon physical examination, her strength was 4/5 in both legs. Magnetic resonance imaging (MRI) showed expansive destructive lesions located from L5 to S3 level of her spine and iso-T1 and iso-T2 signal shadows with local protrusion into the intervertebral foramen, osteolytic destruction of the adjacent lumbosacral vertebral body and appendages, and morphological disturbance of the cauda equina nerve. She had undergone a local resection biopsy at a local cancer hospital, indicating spinal meningioma (WHO Grade II). Before surgery, the patient underwent angiogram and selective arterial embolization to reduce surgical blood loss (Figure 1A-C).

Based on the preoperative imaging data, we identified the osteotomy planes and determined the shape of the bone defect. Then we designed a titanium alloy prosthesis with 3D modeling software (Siemens NX, version 10.0, Plano, TX, USA) and printed with a 3D printer (BLT-S310, Xi'an Bright Laser Technologies Co. Ltd, China). The 3D-printed prosthesis weighed 119.9 g. It was 134.9 mm in length, 39.7 mm in height, and 50.6 mm thick (Figure 2A-C).

The patient was placed in a prone position, and an inverted Y incision was made extending along the midline to separate the muscles and ligaments. At this point, the spinous process lamina was gradually freed to L5 transverse processes and sacroiliac joints. A complete laminectomy of L5 and sacrum was performed by rongeur to allow exposure of the dural sac and sacral nerve roots, which were largely embedded in the tumor. Next, the L5 nerve roots and left S1 nerve root were identified and preserved. Then the bilateral sacroiliac joints were freed. A urinary catheter was introduced along the periosteum, and a T-saw was passed through to cut bilateral sacroiliac joints near the iliac crest. The L4–L5 disc was freed and a T-saw was introduced to free the disc from the ventral side to the posterior longitudinal ligament. The posterior longitudinal ligament was cut with scissors. The right S1 nerve root and the dural sac below S1 were ligated and divided. The free sacrum, L5 vertebral body, and the tumor mass were gradually inverted and resected in one piece with an adequate margin, and the left S1 nerve root was isolated during inversion. The specimen was a piece of dark red and yellow mass measuring 15 x 8 x 5.5 cm in size and had the

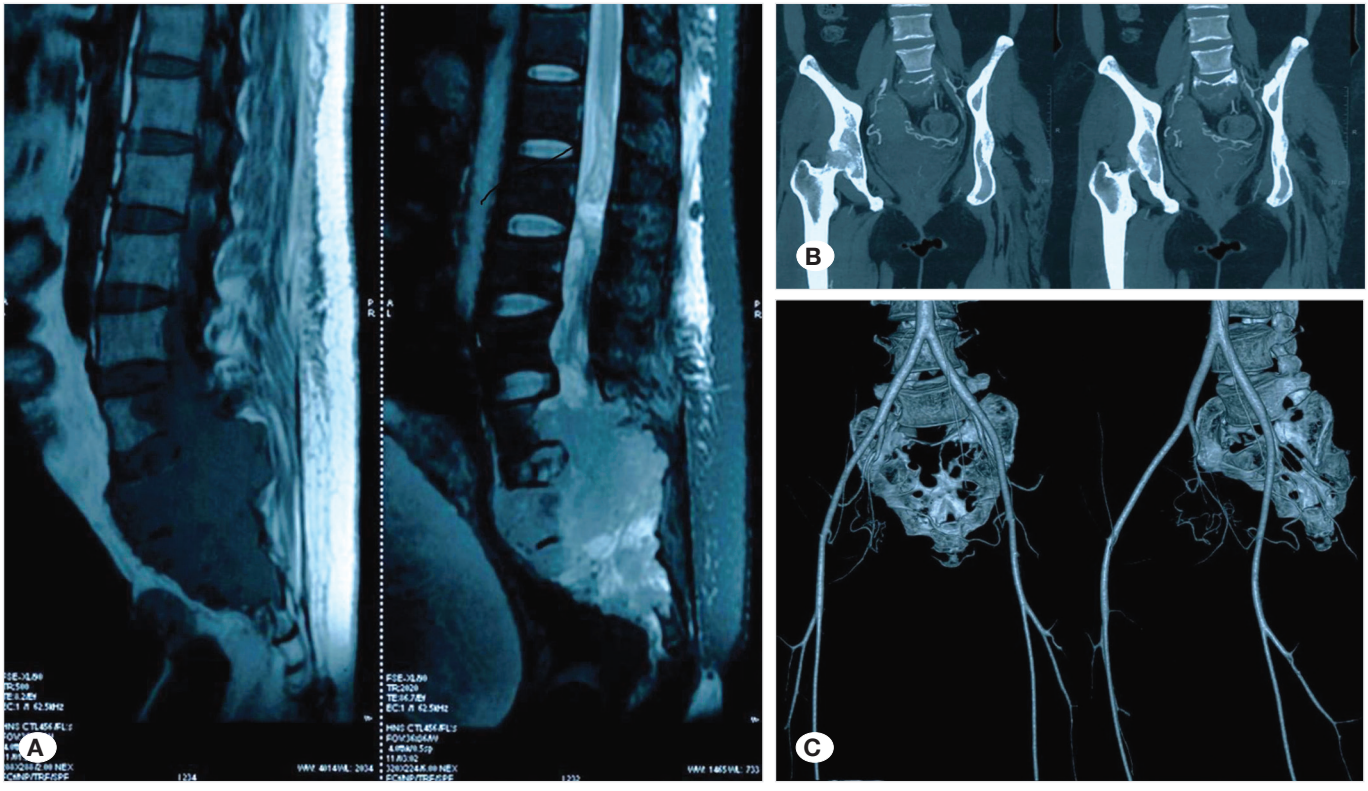

Figure 1A-C: Radiology before surgery.

characteristics of local invasive growth according to the postoperative pathological results.

For reconstruction, two cortical bone trajectory screws and two pedicle screws were placed in L3 and so was done in L4, and the 3D-printed titanium alloy prosthesis was placed in the defect area precisely. The prosthesis was fixed to the ilium with four iliac screws. Four rods were bent to suit the lumbosacral lordosis. The rods were connected to the iliac screws, pedicle screws, and cortical bone trajectory screws, and a lumbopelvic fixation was obtained from L3 to the pelvis. The duration of the operation was 8 h, and the total blood loss was about 4000 mL (Figure 3A-C).

Intravenous antibiotic was administered. The patient started to move with lumbar support at three days postoperatively. The patient was discharged 14 days after her surgery. At 4.5-month of follow-up, X-ray, computed tomography (CT) scan, and MRI showed that the lumbopelvic structure was stable (Figure 4A-C). The patient could walk short distances with crutches, and the rectum/bladder function was in good condition.

DISCUSSION

Most spinal meningiomas are benign, although in rare cases they can be cancerous. Complete resection of spinal meningiomas is the first choice. For lumbosacral meningiomas, an extended sacrectomy may reduce the local recurrence (9). But such a resection carries a high risk of complications, which generally involves three steps: an anterior approach, a posterior approach with en bloc resection of the sacrum and other structures involved, and reconstruction of the lumbopelvic structure. Admittedly, the Weinstein-Boriani-Biagini (WBB) staging system should be integrated to consider how to approach the sacral lesions for surgery (2), and not all diseases should be used in a combined anterior/posterior approach. However, en bloc resection can preserve the patient's ambulatory mobility and rectal and bladder function, so the posterior approach alone can significantly reduce the incidence of complications (14).

Generally speaking, total sacrectomy often sacrifices all sacral nerve roots. Patients then experience rectal and bladder dysfunction. It has been reported that preserving the S1 nerve root could maintain the patient's rectal and bladder function (7). In the preoperative conversation, we informed the patient and her family about the risks and benefits of the surgery. Intraoperatively, we found that only the left S1 sacral nerve root had not yet been eroded by the tumor and did our best to preserve it. Qin et al. reported a case in 2014 (10). The patient underwent a partial en bloc sacrectomy (partial S1 and completely below), and her bilateral S2 nerve roots were killed. Luckily, urinary and bowel functions were restored through exercise. According to a systematic review by Zoccali et al. in 2016, patients who spared both L5 and one or both S1 had major bladder problems in 97.7% of cases and minor problems in 2.3%; major bowel problems in 96.4% of cases

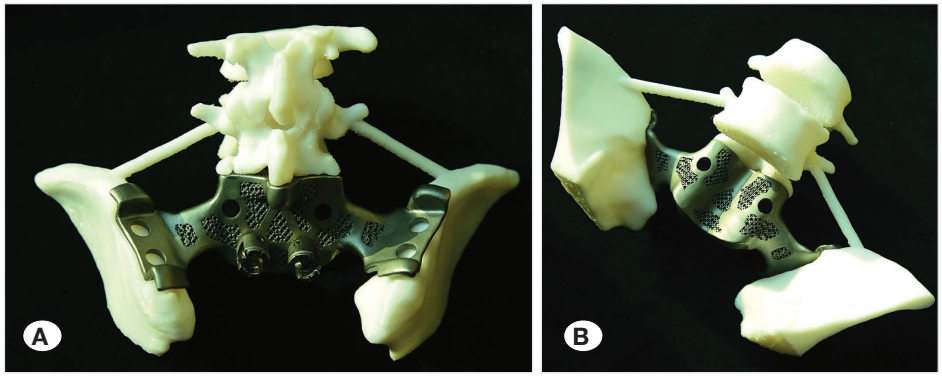

Figure 2: A) 3D-printed prosthesis for reconstruction suited to the bone defect precisely. **B)** The front view of 3D-printed prosthesis.

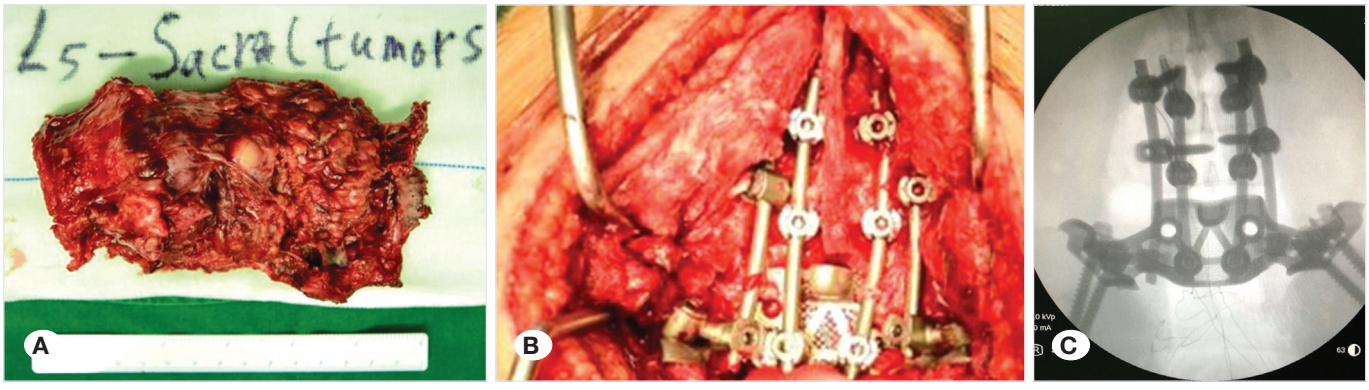

Figure 3: A) Resected tumor specimen. **B)** Image showed prosthesis was settled. **C)** Radiology in surgery.

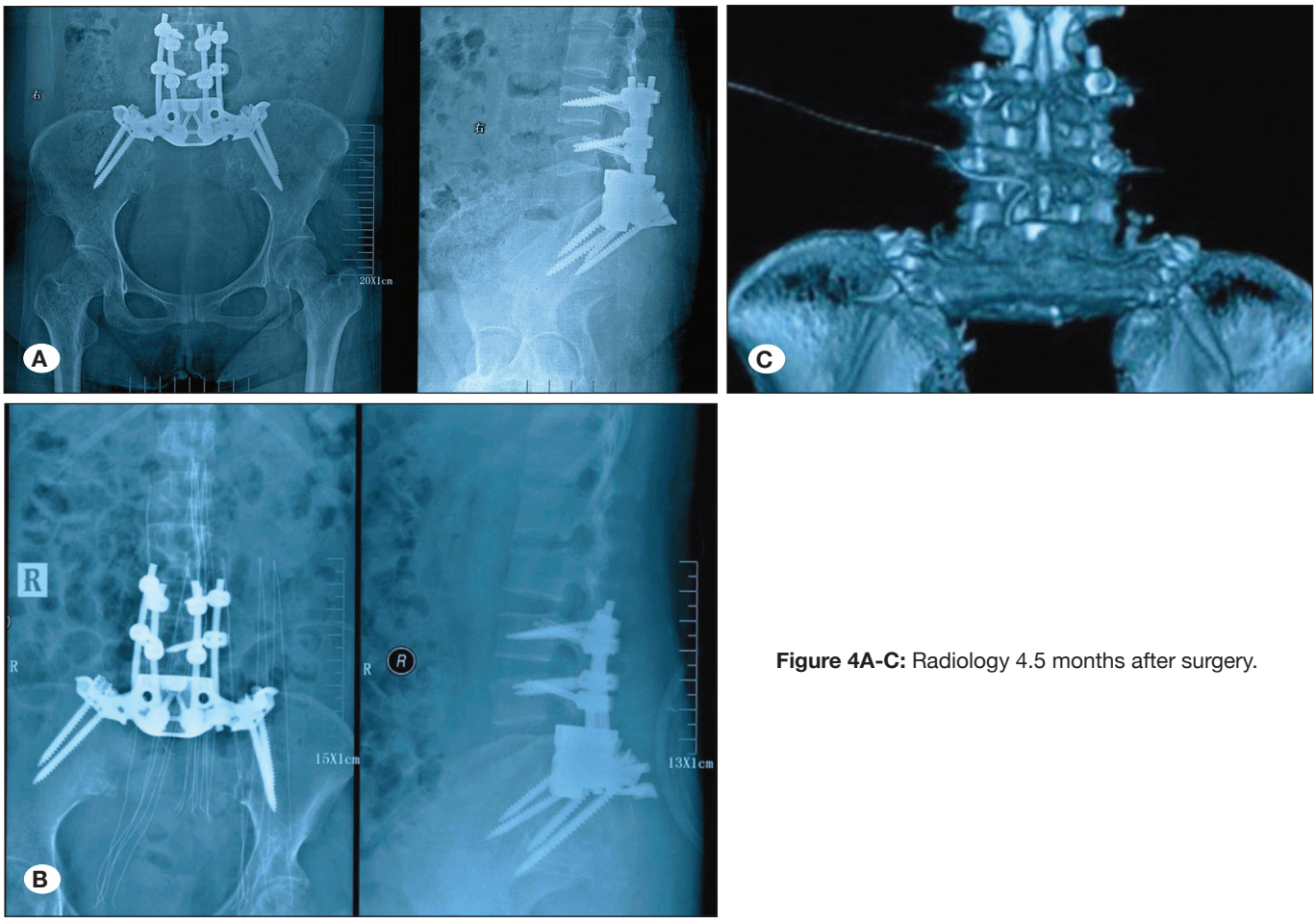

Figure 4A-C: Radiology 4.5 months after surgery.

and minor in 3.6% (15). Minor problems are here defined as problems not requiring invasive procedures and major problems as anything necessitating invasive procedures. The patient in our study also started early rehabilitation on the third day after surgery. The specific mechanism needs to be further studied.

There is no gold standard for reconstruction of spinopelvic stability. There are three types of fixation: spinopelvic fixation (SPF), posterior pelvic ring fixation (PPRF), and anterior spinal fixation (ASF). Galveston performed spinopelvic fixation first by implanting the L-rods into the iliac crest with pedicle screws (1). As for posterior pelvic ring fixation, one is a triangular frame reconstruction technique (8), and the other is a modification of the former published by authors from Johns Hopkins Hospital (5). The anterior spinal fixation technique can add the anterior support to the lumbar spine.

Three dimensional printing technology has been widely used in spinal surgery (14). The contour of the 3D-printed prosthesis is ideally suited to bone defects. The 3D-printed prosthesis is relatively simple to use, meeting the needs of personalized treatment.

Rigid fixation is essential. The patient had a score of 12 based on the Spinal Instability Neoplastic Score (SINS) (4). In such cases, unbalanced lumbopelvic alignment after surgery increases the risk of early prosthesis failure. The novel four-rod technique is a modification of the four-rod (FRR) or double-rod double iliac screw system (12). The novel four-rod technique has better support than the four screws in a single vertebra (two pedicle screws and two direct vertebral body screws) technique (13), because it divides the load of each vertebral body more evenly onto four rods.

CONCLUSION

En bloc resection of L5-S3 meningiomas with preservation of rectal and bladder function is feasible. A 3D-printed prosthesis provides an optimal reconstruction of the lumbopelvic ring. The novel four-rod technique described here provides the necessary rigid fixation to foster bone fusion.

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