Occipitoaxial spinal interarticular stabilization with vertebral artery preservation for atlantal lateral mass failure

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The treatment of craniocervical instability caused by diverse conditions remains challenging. Different techniques have been described to stabilize the craniocervical junction. The authors present 2 cases in which tumoral destruction of the C-1 lateral mass caused craniocervical instability. A one-stage occipitoaxial spinal interarticular stabilization (OASIS) technique with titanium cages and posterior occipitocervical instrumentation was used to reconstruct the C-1 lateral mass and stabilize the craniocervical junction. The ipsilateral vertebral artery was preserved.

The OASIS technique offers single-stage tumor resection, C-1 lateral mass reconstruction, and stabilization with a load-sharing construct. It could be an option in the treatment of select cases of C-1 lateral mass failure.

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KEY WORDS craniocervical instability; C-1 lateral mass reconstruction; titanium cages; vertebral artery preservation; technique

MANY techniques have been described for posterior occipitocervical fixation in the treatment of regional instability.^{1,5,6,16,17,20} Contemporary techniques use rigid screw-based systems between the occipital bone and the upper cervical spine, which provide immediate stability.^{1,20,21} Extensive destruction of load-bearing elements of the cervical spine by neoplastic lesions places additional biomechanical loads on a posterior construct,^{2,14,22} and this can be offset by anterior reconstruction with a cage or structural graft in the subaxial spine. At the level of C-1 (atlas), destruction of the lateral mass can lead to load-bearing failure and clinical instability. Alternatively, a longer construct extending from the occiput into the subaxial spine without C-1 lateral mass reconstruction can be used. Surgical access to replace the C-1 lateral mass is gained from a lateral or posterior approach.^{3,8,12,19} The use of a load-bearing implant to replace the lateral mass of the atlas may allow the use of a shorter posterior occipitocervical construct. We describe 2 cases in which the latter technique has been used. This occipitoaxial spinal interarticular stabilization (OASIS) technique involves the use of a single titanium cage or stacked titanium cages (Corridor, Globus Medical) placed between the occipital condyle and the superior facet of the axis (C-2). Mobilization of the vertebral artery (VA) with its proximal control is a prerequisite to obtain adequate exposure of the articular surface

of the occipital condyle, as well as the superior articular surface of C-2, and to avoid VA injury during cage placement.

Case Reports

Case 1

History and Examination

A 48-year-old woman presented with a 1-year history of progressive intractable neck pain, localized to the left suboccipital area, which was maximized when in an upright position and relieved when lying down. Her neurological examination was normal. A visible and palpable mass was noted in the upper posterior paraspinal region on the left side, just below the occiput. She had a left-sided head tilt in the resting position, and she had very limited range of motion because of pain.

Magnetic resonance imaging revealed a large paraspinal mass in the left suboccipital region with complete destruction and collapse of the left lateral mass of C-1. The mass contained small areas of calcification on CT. Because of the risk of VA injury or intralesional bleeding, given the lesion's close relationship to the left VA, which was completely encased at the distal V3 segment (Fig. 1), and because the lesion was attached to the dura mater under the C-2 lamina, we did not attempt a biopsy. Both VAs

ABBREVIATIONS CVJ = craniocervical junction; OASIS = occipitoaxial spinal interarticular stabilization; SINS = Spine Instability Neoplastic Score; VA = vertebral artery.

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FIG. 1. Case 1. Preoperative MR images (**A and B**) with an arrow demonstrating the completely encased V3 segment. Computed tomography scans (**C and D**) showing a large suboccipital mass with bone destruction of the left C-1 lateral mass.

filled equally with contrast and were of the same diameter; that is, there was no visible VA dominance. We performed CT studies of the thorax and abdomen to look for other lesions, but the findings were normal. The Spine Instability Neoplastic Score (SINS) was calculated as 14, indicating craniocervical instability.⁷

Given the need to gain access for instrumentation, the proximity of tumor to the spinal canal, and the additional need to make a histological diagnosis, resection and craniocervical stabilization were offered to the patient.

First Operation

A standard midline posterior approach with ipsilateral hockey-stick extension along the superior nuchal line was performed. Intraoperatively, the mass was highly vascular and firm with infiltration of the adjacent paraspinal muscles. There was extensive bone destruction of the lateral mass of C-1. Gross-total resection was performed. The tumor was firmly attached to the dura, which appeared to be intact. The left VA was dissected free, mobilized at the V3 segment, so it could be transposed medially to facilitate total resection of the left C-1 lateral mass (Fig. 2).

To fill out the occipitoaxial gap, which was greater than 10 mm, two of the largest cages (10 mm, Corridor, Globus Medical) were stacked and positioned between the left occipital condyle and the superior facet of C-2. Small holes were countersunk into the condyle and C-2 lateral mass articular surfaces to help anchor the cages, which were filled with polymethylmethacrylate (PMMA). The VA was then repositioned behind the cages. Normal blood flow in the VA was confirmed using micro-Doppler. Occipitocervical fixation (C0–3) with bilateral isthmus screws at C-2 and bilateral lateral mass screws at C-3 was performed. Image guidance (O-arm, Medtronic) was used as an adjunct for precise implant placement.

FIG. 2. Case 1. **A:** A large tumor mass covering the suboccipital space after dissection from surrounding soft tissue. The ring indicates the occipital bone; asterisk, the spinous process of C-2; and arrows, the extent of the tumoral mass. **B:** After tumor resection. The vascular loops allow free mobilization of the VA, which can be transposed medially and laterally during resection and cage implantation. The ring indicates the occipital bone; asterisk, the spinous process of C-2; cross, the dura covering the spinal cord free from tumor and completely decompressed; and double-sided arrow, the destroyed C-1 lateral mass. The tip of the right aspirator is placed on the C1–2 right joint. Figure is available in color online only.

First Postoperative Course

Compression was applied across the cages using a posterior construct to hold them in place (Fig. 3). No postoperative MRI was performed. The patient was mobilized without a collar and discharged home on the 6th postoperative day. She was pain free and had no neurological deficits. Histological analysis revealed a Grade III angiosarcoma. The patient was scheduled for local radiotherapy following multidisciplinary discussions.

Three weeks postoperatively, the patient was hospitalized with new-onset cervical pain. A neurological examination revealed signs of cervical myelopathy. Imaging confirmed local aggressive tumor recurrence with spinal cord compression.

Second Operation

The patient was taken to the operating room, and during surgery we found recurrent tumor traversing the dura and compressing the spinal cord intradurally. The left VA, having been macroscopically tumor free at the end of the first surgery, was again encased in tumor. The dura and the intradural mass were partially resected, leaving a portion of tumor adherent to the spinal cord.

FIG. 3. Case 1. Postoperative cervical CT scans (**A and B**) and radiograph (**C**) showing lateral mass reconstruction and occipito-cervical stabilization.

Second Postoperative Course

Postoperatively, the patient's pain and neurological status improved. She remained hospitalized and began local radiation therapy. She died suddenly 9 days later, following an acute cardiopulmonary arrest. At the request of the family, no autopsy was performed.

Case 2

History and Examination

A 54-year-old man presented with a 3-month history of severe neck pain. Initial conservative treatment did not provide any relief. His neurological status was normal. A CT scan followed by MRI of the cervical spine revealed a mass centered on the right C-1 lateral mass with extensive bone destruction (Fig. 4). There were additional osteolytic lesions in the subaxial cervical spine and thoracic spine as well as other skeletal lesions. The suspicion of multiple myeloma was confirmed by elevated IgG κ and the bone marrow biopsy showing infiltration with atypical plasma-cytes. The SINS was again calculated, with a score of 12 indicating impending instability.⁷ Because of the clinical signs of instability at the craniocervical junction with mechanical pain localized to the right suboccipital area, we elected to perform craniocervical stabilization.

Operation

A standard midline posterior approach was performed. After deep muscle dissection, the operative microscope

was brought into the surgical field. The VA with its surrounding venous plexus was carefully dissected in a subperiosteal fashion from the transverse process of C-1. The C-2 nerve root was dissected microsurgically and divided along with its venous plexus to give wide access to C1–2 articulation. The VA was mobilized and transposed between the C-2 transverse foramen and its intradural entry point, facilitating access to the lateral mass of C-1 and to the occipitoatlantal joint.⁸ Gross-total resection of the C-1 tumor mass was then performed. An appropriately sized titanium cage (Corridor) was placed between the occipital condyle and the superior articular surface of C-2. Contralateral opening of the C1–2 joint was performed along with the subsequent placement of a 5-mm intraarticular cage (Corridor), as described in the literature.^{4,9,10} No bone graft was used. Posterior fixation (C0–2) was performed using image guidance (O-arm) as an adjunct for precise implant placement. The C-2 pedicle screws were used as the terminal fixation points of the construct.

Postoperative Course

Compression across the posterior construct was performed prior to the final tightening. The patency of blood flow in the VA was confirmed using micro-Doppler. The postoperative period was uneventful. The patient went home on the 6th postoperative day free of pain and without any neurological deficit.

At the 14-month follow-up, he was asymptomatic aside from limited head rotation. A follow-up cervical CT scan

FIG. 4. Case 2. Preoperative CT scans (**A and B**) and MR image (**C**) showing complete destruction of the C-1 lateral mass by tumor.

and flexion-extension radiographs showed bone regrowth between C-0 and C-2 across the cages without any detectable motion (Fig. 5).

Discussion

Occipitocervical fixation is well established for instability of the craniovertebral junction (CVJ). It can be used for neoplastic lesions of the upper cervical spine causing instability at the CVJ.¹³ The complex anatomy and biomechanics of the region require careful planning for reconstruction, taking into account anticipated biomechanical loads. Our 2 cases presented such challenges. Two other reports on the use of a cage to replace a destroyed C-1 lateral mass have been described in literature.^{3,19} In both of those cases, however, the VA on the same side as the tumor was sacrificed using an endovascular technique because of bleeding concerns. The risk of neurological deficit following VA sacrifice is reported as 6% in the literature.¹⁸ In our 2 cases we performed an intralesional resection with preservation of the VA by transposing it out of the direct surgical field. This avoids the risk of ischemic stroke, as mentioned above, and enables unrestricted instrumentation of C-2, which would be contraindicated on the side opposite to an occluded VA.

The goals of occipitocervical stabilization, local disease control, and pain relief were achieved using the OASIS technique, notwithstanding the very limited survival of the first patient for extraneous reasons.

To our knowledge, no biomechanical studies have con-

sidered lateral mass reconstruction of the atlas and its impact on posterior occipitocervical constructs. However, it is possible that OASIS reconstruction may shield the posterior construct and provide more robust reconstruction to support the weight of the head.^{11,15} Destruction of the C-1 lateral mass reduces support of the head and may add to CVJ instability by rendering the transverse ligament incompetent at its insertion point on the medial aspect of the lateral mass of C-1.

The OASIS technique increases the integrity of the construct to ensure an acceptable outcome. Biomechanical studies are needed to verify this.

The reconstruction between C-0 and C-2 with titanium cages offers two advantages to the construct. First, it serves as a load-bearing implant and by itself limits movement between the areas of contact.⁴ Second, it offloads to some extent the posterior construct and may make it more durable, and therefore less prone to failure.

Conclusions

The OASIS technique as described can be used in conjunction with a posterior construct in patients with cranio-cervical instability. Vertebral artery transposition greatly facilitates surgical exposure, and VA sacrifice was not necessary in our 2 cases. The advantage of the OASIS technique is that it offers a direct approach for resection, reconstruction, and stabilization without sacrifice of the VA, providing a robust construct. It may be an option for treating select patients with CVJ instability due to C-1 lateral mass failure. To our knowledge, this is the first technique involving C-1 lateral mass reconstruction using a titanium cage together with ipsilateral VA preservation.

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FIG. 5. Case 2. Follow-up cervical CT scans (**A and B**) and flexion-extension radiographs (**C and D**) obtained 14 months after surgery, showing evidence of solid bone regrowth across the cages and lack of visible motion.

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Author Contributions

Analysis and interpretation of data: Bobinski, Duff. Critically revising the article: Bobinski, Duff. Reviewed submitted version of manuscript: all authors. Administrative/technical/material support: Levivier. Study supervision: Bobinski, Duff.

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