



Technical Notes

Occipital condyle screw fixation after posterior decompression for Chiari malformation: Technical report and application

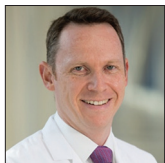
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ABSTRACT

Background: Surgical techniques for stabilization of the occipital cervical junction have traditionally consisted of screw-based techniques applied in conjunction with occipital plating and rods connected to subaxial instrumentation in the form of pars, pedicle, or lateral mass screws. In patients with type 1 Chiari malformation (CM-1) and evidence of occipital cervical junction instability who have undergone posterior decompression, the occipital condyle (OC) represents a potential alternative cranial fixation point. To date, this technique has only been described in pediatric case reports and morphometric cadaver studies.

Methods: Patients underwent posterior fossa decompression for treatment of CM. Subsequently, patients received occipital cervical stabilization using OC screws.

Results: Patients were successfully treated with no post-operative morbidity. Patient 2 was found to have pseudoarthrosis and underwent revision. Both patients continue to do well at 1-year follow-up.

Conclusion: Placement of the OC screw offers advantages over traditional plate-based occipital fixation in that bone removal for suboccipital decompression is not compromised by the need for hardware placement, screws are hidden underneath ample soft tissue in patients with thin skin which prevents erosion, and the OC consists of primarily cortical bone which provides for robust tricortical fixation. These cases demonstrate the novel application of the OC screw fixation technique to the treatment of occipital cervical junction instability in adult patients undergoing simultaneous posterior fossa decompression.

Keywords: Chiari malformation, Occipital condyle screw, Posterior decompression

INTRODUCTION

The occipitocervical junction (OCJ) is a complex anatomical site that poses an operative challenge due to multiple axes of movement and limited available bone surface for fusion. The OCJ consists of the occiput, the atlas, and the axis. Instability of the OCJ may lead to permanent neurological deficits, devastating injury, or death.^[5] Mechanisms of instability include ligamentous laxity, fracture, rheumatoid arthritis, congenital deformity, tumor, and degeneration.^[9,12]

Surgical fixation of pathologies of the OCJ has evolved over time. Methods of fixation include plates and screws, rods and screws, and wire-based techniques.^[5] Recently, occipital condyle (OC)

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screw fixation has been introduced as an effective method as part of correction of OCJ instability.^[17,18,22,23] This technique is especially useful as a salvage technique where other methods of fixation are less feasible.^[22,23] In particular, OCJ stabilization with a condyle screw construct may be a feasible treatment option for patients with Chiari malformation type I (CM-1) who have undergone suboccipital craniectomy with C1 laminectomy. To date, only two pediatric cases have been documented that demonstrate the feasibility of OC screw placement in patients with CM-1 with OCJ instability after posterior decompression.^[2,14] No study, to the best of our knowledge, demonstrates the successful placement of OC screws in adult patients undergoing simultaneous posterior fossa decompression for CM-1, although the cadaveric feasibility has been successfully demonstrated in the literature.^[13]

In the present report, we describe two patients who underwent successful posterior fossa decompression followed in the same operation by OC screw placement for evidence of craniocervical instability. To the best of our knowledge, these are the first documented cases of adults with CM-1 and craniocervical instability who received such treatment.

MATERIALS AND METHODS

Surgical technique

Informed consent was obtained from both patients for all procedures. Patients were intubated carefully given concern for degrees of instability at the cranio-cervical junction, and then placed in the prone position with the head fixed. The imaging guidance system optical camera was placed at the head of the bed and the cranial reference frame was secured to the head clamp for use during screw placement (Medtronic Stealth S8, Minneapolis, MN). A standard posterior fossa Chiari decompression was performed with suboccipital craniectomy, C1 laminectomy, and duraplasty. Subsequently, the lateral masses of C2, lateral masses of C1, and the posterior portion of the OC were exposed. Using navigation, the desired entry point, trajectory, and depth to avoid violating the atlanto-occipital joint and vertebral artery caudally, the hypoglossal canal cranially, or the condylar fossa laterally was identified (Medtronic O-Arm, Minneapolis, MN) [Figure 1]. The OC was then decorticated and drilled using a 3 mm drill bit and a 3 mm threaded tap under real-time navigation bilaterally, and 3.5 mm × 34 mm screws were placed into the OC with the intent to obtain bi-cortical or tri-cortical purchase. The entry points at the posterior aspect of the lateral mass of C1 were also identified and decorticated using navigation and 3.5 mm × 30 mm screws were placed bilaterally. At C2, the same procedure was used to place 3.5 mm × 24 mm C2 pedicle/pars screws.

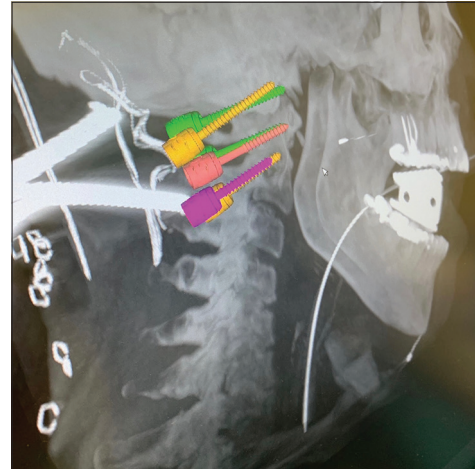


Figure 1: 3D representation of screw trajectory of screws in the occipital condyle and lateral masses of C1 and C2 using Stealth navigation (Medtronic Stealth S8, Minneapolis, MN).

Once all the screws were placed, a second intraoperative computed tomography (CT) scan was obtained to confirm screw placement without breach [Figure 2]. Subsequently, the head of the patient was repositioned into a neutral position and 30 mm titanium rods were bent into slight lordosis, placed, and secured. The cortical bone and joint capsule were then removed from the posterior aspect of the O-C1 and C1-C2 joints bilaterally and autograft was placed into the joint space for fusion. The remaining autograft and allograft were then used to perform postero-lateral fusion from the occiput to C2.

RESULTS

Patient 1

A 53-year-old woman with history of hypothyroidism and cervical spondylosis presented with suboccipital headaches for several years which worsen with exertion and bilateral paresthesia in her hands. Work-up revealed CM-1 with 1.5 cm of tonsillar ectopia, and cervical imaging revealed cervical spondylosis and a pannus behind the odontoid suggesting chronic craniocervical instability. Despite lack of obvious movement on flexion and extension lateral X-rays [Figure 3a and b], the presence of pannus suggested chronic instability which can be worsened by removing the lamina of C1 and interruption of the posterior ligamentous complex [Figure 3c]. Alternative surgical considerations included standard decompression and close follow-up or pre-emptive short-segment occiput-C2 fusion following decompression. After extensive discussion with the patient, the decision was made for surgery, and a suboccipital craniectomy and C1 laminectomy for CM-1 decompression and immediate occiput to C2 posterior instrumented fusion with OC screws

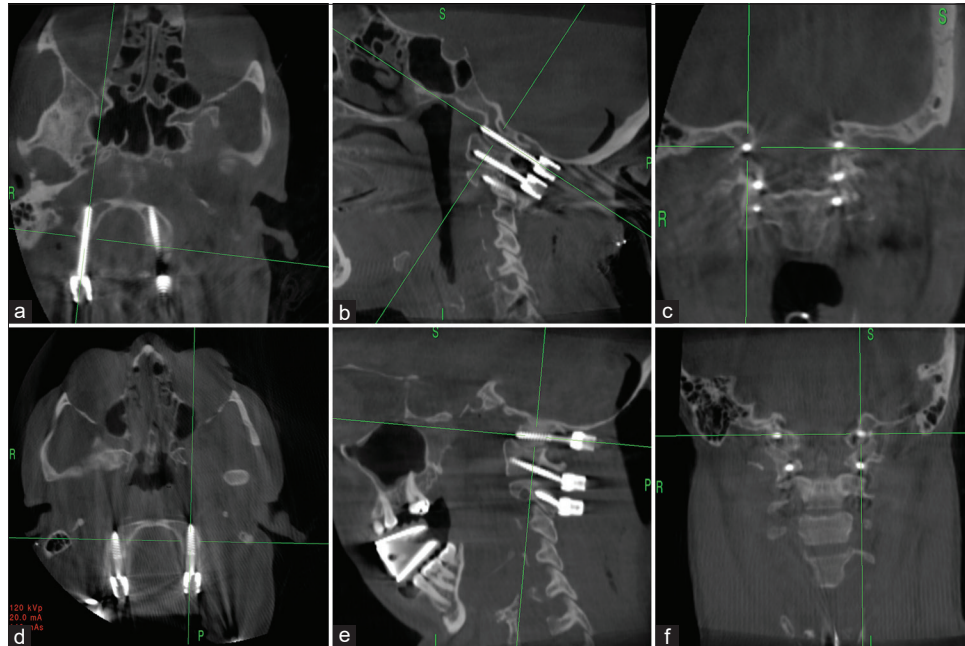


Figure 2: (a-c) Axial, sagittal, and coronal views of intra-operative computed tomography showing secure screw placement in the occipital condyle, C1 and C2 of patient 1; and (d-f) Axial, sagittal, and coronal views of intra-operative computed tomography showing secure screw placement in the occipital condyle, C1 and C2 of patient 2.



Figure 3: (a-b) Flexion and extension X-ray of patient 1 film showing no evidence of instability and (c) C-spine magnetic resonance imaging of patient 1 showing pannus formation at C1 and (d) sagittal upright X-ray of patient 1 at 1-year follow-up demonstrating secure screw placement and stability of C-spine.

for OCJ instability was performed. The patient continued to do well at one-year follow-up, and upright X-ray film showed secure screw placement and no hardware failure [Figure 3d].

Patient 2

A 31-year-old woman with a history of Factor V thrombophilia, neck pain with intermittent right arm paresthesia, and post-tussive headaches was found to have CM-1 with 9.4 mm of tonsillar ectopia. Conservative management with two separate neurologists failed to relieve her headaches. Further workup revealed a small amount of pannus formation behind the dens [Figure 4a], and dynamic X-rays showed 4 mm of motion at the C1-C2 level between flexion and extension [Figure 4b and c]. After extensive discussion with the patient, the patient's neurologist, and members of the neurosurgery team, the decision for posterior fossa decompression with OC screw fixation was made. The patient was found to have pseudoarthrosis of the C2 screw at follow-up, and underwent C2 screw revision with placement of new screws at C3. She continues to do well at 1-year follow-up with upright X-ray film showing secure screw placement and no hardware failure [Figure 4d].

DISCUSSION

We discuss two novel cases of successful OC fusion with OC screws following posterior decompression for two adults with CM-1 and OCJ instability. CM-1 is a syndrome that presents with headache, paresthesia, or cerebellar symptoms due to ectopic presence of cerebellar tonsils below the foramen magnum.^[16] OCJ instability is often found in patients with CM-1 but is not always symptomatic nor



Figure 4: (a-b) Flexion and extension X-ray of patient 2 showing signs of instability and (c) C-spine magnetic resonance imaging of patient 2 showing pannus formation at behind dens of C2 and (d) sagittal upright X-ray of patient 2 at 1-year follow-up demonstrating secure screw placement and stability of C-spine.

requires OCJ fusion.^[26] This association is thought to result from morphometric differences in the ligaments located in the OCJ among patients with CM-1.^[11]

Posterior fossa decompression is the standard surgical treatment in patients with CM-1, and its use has been shown to improve outcomes.^[4,16] However, this approach makes subsequent stabilization of the OCJ more challenging for surgeons due to loss of available purchase in the occipital bone. The use of OC screws in OCJ stabilization is useful in this situation, because surgeons can use the OCs for surgical fixation, negating the need for purchase in the occipital squamosal or midline keel as is needed in standard occipital plating systems.^[2] Careful patient selection, anatomical consideration, and pre-surgical evaluation are the cornerstones of successful OC fusion among this population.

The OCJ is a complex anatomical region, the navigation of which has challenged surgeons for decades. It is comprised the atlanto-occipital joint and the atlanto-axial joint. The vertebral arteries also pass through the OCJ, coursing superiorly from the subclavian artery to pass through the OCJ and wrapping around the OCs as they enter the dura near the foramen magnum.^[6] In addition, the hypoglossal canal, jugular bulb, and carotid artery are all in close proximity to the OC and must be taken into careful consideration during surgery.^[15] Due to the complex anatomy of the OCJ, success

of OC fusion is predicated on the surgeon's understanding of these anatomical relationships.^[19]

OC fusion is performed in cases of trauma, rheumatoid arthritis, congenital deformities, tumors, and degenerative disease.^[9,12] The goal of OCJ fixation is to provide cervical stability while minimizing neurological deficits and the need for external support.^[24] OC fusion was first described in 1927 and then consisted solely of bone graft.^[7] However, this method alone did not confer adequate stability of the OCJ, so patients required external neck support.^[25] The advent of biomechanical constructs, including screw and rod, rod and wiring, and rod and plates, paved the way for superior rates of OC fusion and adequate, immediate stability.^[5] For all combined techniques, fusion is achieved in 69% of patients, with neurological improvement in 64.5% of patients.^[27] The difficulty in obtaining fusion in this area is significantly hampered by lack of bony surface area on which to place graft for fusion.

OC screw fixation for OCJ instability was first described by Uribe *et al.* in 2008 as a salvage technique for a surgeon's armamentarium.^[23] Since then, multiple studies have documented the feasibility of OC screw placement for OCJ stabilization.^[1,2,8,14,17,22] Two studies have specifically documented the utility of OC screw placement for OCJ instability in pediatric patients with CM-1 who first received posterior fossa decompression.^[2,14] Many morphometric studies have been conducted on the OCs to better understand optimal screw length and trajectory so as to minimize injury to surrounding structures while maximizing screw purchase and integrity of OC fusion.^[3,10,13,18-21,28,29] A morphometric analysis specifically analyzing adult patients with CM-1 found that average dimensions for screw placement for their cohort differed significantly from dimensions of the average population.^[13] The same study retrospectively estimated feasibility of screw placement in the right and left OCs for adults with CM-1 to be 81.3% and 90.6%, respectively.^[13] The use of real-time intraoperative navigation with O-arm allows for screw size selection based on the patient's anatomy and the achievable angles. It also allows for avoidance of the hypoglossal canal and safe placement of screws with tricortical purchase. We have also found this technique to be useful in patients with thin skin or atrophy of the cervical musculature as there is no risk of the occipital plate eroding through the skin.

We also hypothesize that use of OC screws may allow for better fusion rates as the technique leads to placement of hardware at each level and decortication of the joint spaces for bony fusion. Placement of autograft or allograft into the decorticated joint spaces allows for increased surface area and compression over the area to encourage fusion. Conventionally, with occipital plating, it is often impossible to instrument the C1 level due to the angle of the rods.

Placement of occipital fixation at the condyle allows for use of a short straight rod without a significant bend, eliminating this point of weakness.

Based on this study and results of our own patients, we suggest that OC screw placement for OCJ stabilization is a safe and feasible option for CM-1 patients who have undergone posterior decompression who either develop instability over time, or have degrees of radiographic evidence preoperatively indicating the possible need for fusion at the same time as the decompression.

CONCLUSION

OC screw fixation is a viable treatment for OCJ instability in patients who have undergone posterior fossa decompression. This technique may be especially applicable to patients with CM-1 receive posterior fossa decompression and who either have preoperative or postoperative evidence of OCJ instability as well.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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