
4

Occipitocervical Vertex Fixation

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Highlights

The evolution of occipitocervical fixation with advancing technology and progressive construct stability has allowed treatment of more complex craniocervical instabilities with a higher success rate and less cumbersome postoperative immobilization. Initial onlay fusion and simple wire techniques required periods of traction followed by prolonged halo immobilization.¹ Rod and wire constructs were more stable but continued to have difficulty preventing axial loads due to the rods pistoning through the sublaminar wires.²⁻⁵ Plate and screw constructs were the first truly stable types of segmental occipitocervical fixation.⁶⁻¹⁰ Proper screw insertion was often difficult because screw placement was dependent on the fixed hole-hole distances in the plate. Contouring the rigid plates to the occipitocervical junction can be difficult. In addition, these devices do not have a rigid connection of the screw to the plate. The Vertex system is a rod-screw system that allows independent insertion of the screw anchors as well as stable connection to the longitudinal rod.

Indications

The Vertex system is used for stabilization of the occipitocervical junction. The most common causes of craniocervical instability are such inflammatory arthritides as rheumatoid arthritis, and trauma resulting in the disruption of the stabilizing ligamentous structures of the craniocervical junction. Tumors and infections may also cause instability of the occipitocervical junction.

Description of System Components

The components of the Vertex system include:

- 3.2 mm titanium rod (120 mm and 240 mm)
- Medial offset rod-screw connectors

- 3.5 mm cortical occipital screws (6 to 14 mm in 2 mm increments)
- 3.5/4.0 mm titanium, multiaxial, top-loading, cancellous cervical/thoracic bone screws (10 to 24 mm in 2 mm increments)
- 3.5/4.0 mm titanium, multiaxial, top-loading cortical cervical/thoracic bone screws (26 to 52 mm in 2 mm increments)
- Set screw (locks rod to screws)
- Lateral connector (accommodates rod attachment of nonlinear screws and allows increased angle of screw trajectory and/or differences in screw heights)
- 4.5/6.0 mm laminar hooks

Operative Techniques

Anesthesia

General anesthesia is required and an awake fiber-optic intubation is often recommended if severe instability exists. Intraoperative monitoring by motor-evoked potentials and somatosensory-evoked potentials is useful in patients with severe stenosis or profound instability.

Positioning

The patient is positioned prone with a Mayfield pin headrest. Attention to intraoperative positioning is critical to avoid occipitocervical kyphosis. In addition, care must be taken to avoid overdistracted of occipitocervical dissociations.

Surgical Approach

A standard midline incision is made from the occiput to approximately C4. Dissection is carried through the ligamentum nuchae to minimize bleeding. The occiput

is exposed to the external occipital protuberance. Dissection on the cephalad aspect of the posterior aspect of C1 should not extend more than 12 mm lateral to the midline to avoid injuring the vertebral artery, which emerges from the transverse foramen of the atlas and courses medially on the anterior aspect of the superior surface of the posterior ring. The posterior elements of C2 (and C3 if needed) are subperiosteally stripped to the lateral aspect of the facet.

Surgical Technique for Internal Fixation

The C2 screws (pedicle or transarticular C1–C2) are placed first because they are the most technically demanding and anatomically constrained screws of the construct. Next, the subaxial cervical lateral mass screws are placed. The occipital screws should be placed last. The rod or plate is bent to the appropriate occipitocervical sagittal lordotic angle with enough room along the occipital longitudinal member to place three screws. If the rod or plate is to run over the superior nuchal line, a reverse bend should be made to allow it to lie flat on the occiput. If a rod is used, it will want to pivot on its apex at the occipitocervical junction with the cephalad aspect of the rod angling either lateral or medial. Allowing it to angle medially before tightening the connectors in the cervical spine will enable placement of the occipital screws in the thick bone along the external occipital protuberance. If a plate is used, a coronal plane bend can be applied to angle the occipital portion medially.

After the cervical screws are placed, the contoured rod with medial offset occipital connectors or rod plate is seated in the caudal anchors and fixed with set screws. The occipital screws are prepared and placed through the plate or connectors. Occipital screw length ranges from 6 to 14 mm with the average screw measuring 10 mm. The area immediately lateral to the external occipital protuberance will accommodate up to a 14 mm screw. The best zone for screw insertion is up to 20 mm lateral to the external protuberance along the superior nuchal line decreasing to 5 mm lateral to the external protuberance 20 mm inferior to the superior nuchal line. This forms a V-type configuration.

The drill stop should be set to 10 mm and the far cortex felt with the drill at high revolution and drilled through. The hole must be tapped. The occipital cortex is very hard (thus allowing for excellent fixation), but if threads are not tapped into this cortical bone, the screw may not even get started.

Autogenous iliac crest graft is the gold standard. Cement should only be considered in cases where life expectancy is <6 weeks. Bicortical iliac crest autograft is harvested through a longitudinal incision over the posterior superior iliac spine. The occipitocervical spine is decorticated with a high-speed burr. The posterior

cortex of the midline occiput is removed to expose bleeding cancellous bone. This thick area of the occiput has the optimal bone to serve as a foundation for the fusion. The posterior elements of C1 and C2 are also decorticated before the bicortical graft is laid down.

If a large area of the midline occiput is resected or if a laminectomy of C1 and C2 is performed, then the bicortical plate cannot be used. Cancellous autograft slush is placed laterally over the atlantoaxial joint extending cephalad onto the lateral aspect of the occiput. This bone graft is applied underneath and lateral to the plate or rod. A major advantage of screw–rod constructs is the extensive area available for the graft.

The bicortical iliac crest autograft plate is placed against the bleeding cancellous surface of the midline occiput between the two plates or rods. The caudal end of the graft is notched to allow it to straddle the posterior spinous process of the C2. A bicortical occipital screw is drilled in the midline cephalad to the graft (just caudal to the superior nuchal line and underlying transverse sinus). A cable or wire is wrapped around the midline screw (two revolutions from being fully seated) and around the C2 posterior spinous process. The cable or wire is tightened over the bone graft plate to keep it in position. The midline occipital screw is then fully seated producing the final tightening of the construct. The midline occipital screw may alternatively be placed directly through the bone graft plate.

After the bone graft is secured, the set screws are tightened using a screwdriver and counter torque device.

Complications and Avoidance

Improper patient positioning and malreduction can lead to improper screw placement and catastrophic outcomes. Malreduction of the atlantoaxial joint will put the vertebral artery at risk during placement of a transarticular screw. Overdistraction in patients with occipitocervical dissociation can cause catastrophic neurologic demise.

If transarticular screws or C2 pedicle screws are to be utilized, the anatomy of the vertebral artery in the axis must be studied because up to 10% of the population have anatomic variants that preclude safe placement of these screws.^{11,12} Placement of transarticular screws that are too long may cause injury to the hypoglossal nerve or internal carotid artery.

Inadequate occipital thickness may be a pitfall. This usually occurs if screws are attempted too close to the foramen magnum. In addition, in this position it is difficult to place the screw perpendicular to the plate or rod because of the steep angle necessary to drill, tap, and screw close to the foramen magnum. Thus, make sure the occipital screws are positioned closer to the

superior nuchal line. If cerebrospinal fluid is encountered during preparation of bicortical occipital screws, just place the screw and the leak will stop.

If a significant amount of the occiput is resected for decompression or destroyed for other reasons, placement of three screws below the superior nuchal line may not be possible. Screws may be applied cephalad to the superior nuchal line, but the transverse sinus must be considered. This venous sinus is usually just deep to the superior nuchal line. If this venous sinus is encountered, simply place the screw. Attempting to repair this sinus formally is fraught with complications.

When a suboccipital decompression is performed, it is important to assure the bone graft plate does not drop into the laminectomy defect because this may cause neurologic compromise. The graft must be well seated on stable cancellous occipital bone and caudally onto solid lamina and the posterior spinous process of the C2. As the cable or wire is tightened down on top of the bicortical bone graft, the graft–host interface must have a large surface area and be very stable cranially and caudally. If the graft is unstable or not long enough to span the defect, do not leave this potentially dangerous piece of bone over the dura. Morselize the bone graft plate and pack the cancellous graft over the decorticated host bone safely, lateral to the spinal canal. As long as the occipitocervical instrumentation provides a stable environment, the morselized graft will heal.

When lateral connectors are used to connect the rod to the screws, special attention must be given to the final set screw tightening process. The close proximity of the lateral connector to the screw collar often prevents seating of the countertorque device. In this situation it is imperative to meticulously tighten the set screw. We have experienced loosening of the caudal set screw with dissociation of the rod in follow-up likely due to inadequate final tightening when the countertorque device was not able to be engaged.

Discussion

Rigid screw fixation of the occipitocervical junction is biomechanically superior to wiring and combined wire–rod techniques. The rigidity of this fixation permits less postoperative external immobilization while increasing fusion rates. Occipital screws at the cephalad end of a fusion may limit problems associated with occipital fixation. Occipital wire and rod constructs are less stable, especially under axial loads.^{13–16} In conditions with significant occipitocervical instability where axial forces must be neutralized, such as vertical migration of the odontoid, occipital screw plate or rod instrumentation is optimal. The ideal site of occipital fixation is at or just inferior to the external occipital

protuberance along the midline where the occiput is thickest.^{17,18} The strength of fixation in this region can be stronger than the strength of the screws.^{19,20} When placing bicortical screws, care must be taken not to injure the venous sinuses, which lay opposite the external protuberance at the superior nuchal line. In the cervical spine transarticular screws, C2 pedicle screws, and lateral mass screws are considered the best forms of fixation. The use of rods with medial offset connectors in the Vertex system promotes easier paramedian placement of six bicortical screws in the thick bone near the external occipital protuberance. The rods also easily connect to top–loading screws in the cervical spine that have been placed in their optimal orientation. This construct provides multiple points of fixation in multiple planes in the strongest part of the occiput.

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