SURGICAL TREATMENT OF OCCIPITOCERVICAL INSTABILITY

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OBJECTIVE: Instability of the occipitocervical junction can be a challenging surgical problem because of the unique anatomic and biomechanical characteristics of this region. We review the causes of instability and the development of surgical techniques to stabilize the occipitocervical junction.

METHODS: Occipitocervical instrumentation has advanced significantly, and modern modular screw-based constructs allow for rigid short-segment fixation of unstable elements while providing the stability needed to achieve successful fusion in nearly 100% of patients. This article reviews the preoperative planning, the variety of instrumentation and surgical strategies, as well as the postoperative care of these patients.

RESULTS: Current constructs use occipital plates that are rigidly fixed to the thick midline keel of the occipital bone, polyaxial screws that can be placed in many different trajectories, and rods that are bent to approximate the acute occipitocervical angle. These modular constructs provide a variety of methods to achieve fixation in the atlantoaxial complex, including transarticular screws or C1 lateral mass screws in combination with C2 pars, C2 pedicle, or C2 translaminar trajectories.

CONCLUSION: Surgical techniques for occipitocervical instrumentation and fusion are technically challenging and require meticulous preoperative planning and a thorough understanding of the regional anatomy, instrumentation, and constructs. Modern screw-based techniques for occipitocervical fusion have established clinical success and demonstrated biomechanical stability, with fusion rates approaching 100%.

KEY WORDS: Fusion, Instability, Instrumentation, Occipitocervical

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Instability at the occipitocervical junction results from a myriad of disorders and can lead to severe neurological morbidity or mortality if left untreated. Because of the challenging anatomic and biomechanical characteristics of this region, surgical stabilization can be difficult, and early attempts were met with high rates of failure (32). Evolution of fixation constructs, however, has led to increasingly successful outcomes. Modern segmental screw-based constructs allow for rigid short-segment fixation of unstable elements and provide the stability needed to achieve successful fusion in almost 100% of patients (46, 58). Fusion success is nearly universal with these techniques, despite the difficulty in implementing them and the potential for serious complications. In this article, the authors describe their preferred technique for stabilizing the occipitocervical junction and provide brief reviews of the most common pathological entities requiring treatment and of the evolution of surgical constructs.

CAUSES OF OCCIPITOCERVICAL INSTABILITY

Occipitocervical instability can result from a myriad of disorders, including congenital cranial settling, trauma, rheumatoid arthritis and other inflammatory arthropathies, neoplasm, infection, or iatrogenic response to surgical decompression (11, 46). Patients may present with progressive myelopathy, pain, lower cranial nerve dysfunction, or deformities of the craniocervical region (11, 46).

Atlanto-occipital dislocation, or traumatic dislocation of the occipital condyle and C1 lateral mass (O–C1 joint), is the most common acute presentation of instability at the occipitocervical junction. Although numerous radiographic measures have been described to aid in detection, atlanto-occipital dislocation can be difficult to diagnose, and the diagnosis was missed in as many as 75% of trauma patients on initial radiographic examination (5, 7). Unfortunately, devastating consequences, including tetraplegia and death, can result if the diagnosis is missed, because these injuries are highly unstable (26). Although successful treatment of this condition with O–C1 stabilization alone has been reported, dislocation at this joint may also involve disruption of the alar ligaments, tectorial membrane, and transverse atlantal ligament, with resultant rotational and translational instability of C1–C2 (14, 16). Because atlantoaxial injury is an associated finding in up to 55% of patients, O–C1–C2 fusion is the most commonly accepted method of treatment for traumatic dislocation at this joint (26, 27, 49). Every attempt at rapid surgical treatment should be made, as improved neurological outcome is associated with early diagnosis and spinal stabilization (2, 5).

Rheumatoid disease is the most commonly seen inflammatory arthropathy affecting the high cervical spine, although the region can also be affected by Reiter syndrome, psoriatic arthritis, inflammatory bowel disease-associated arthritis, and calcium pyrophosphate deposition disease (42). Rheumatoid arthritis is chronic and progressive, and presenting patients may be elderly or in poor physical condition. Although atlantoaxial and subaxial instability is more common in rheumatoid arthritis, O–C1 instability can also occur and manifest as cranial settling and gross instability (40, 44). Rheumatoid arthritis patients with craniocervical instability who are treated conservatively have an extremely grave prognosis, with the vast majority of patients becoming bedridden and succumbing to their illness. The associated mortality with medical management alone has been reported to be up to 100% at 8 years (38, 41). In contrast, surgical stabilization has been shown to have beneficial long-term results, including a more than 2-fold increase in the 5-year survival rate, with long-term survival, pain reduction, and improvement of myelopathy in the majority of patients and increased long-term functional outcome (39, 45).

Instability requiring stabilization at the craniocervical junction may also be caused by infection, neoplasm, or iatrogenic response to surgical decompression of the foramen magnum or high cervical spine (4, 56). Occipitocervical fusion may also be indicated in cases in which there is irreducible subluxation of C1 on C2, when the lateral masses of C1 are anatomically inadequate or unsuitable for the acceptance of screws, as in the case of fracture or significant erosion, or when significant anterior decompression of an anteriorly situated pannus has been undertaken (42, 43).

Finally, various congenital and developmental defects may be seen at the occipitocervical junction and may lead to instability. Occipitocervical instability is commonly seen in patients with Down syndrome and may require fusion at a young age (8). Additionally, because of the complex embryology of the area, numerous developmental anomalies may necessitate fusion owing to instability or neural compression (9).

DEVELOPMENT OF SURGICAL STABILIZATION

The unique and complex anatomic and biomechanical characteristics of the occipitocervical junction have made the development of surgical techniques for stabilization challenging. Instability in this region was considered inoperable and often fatal in the early part of the 20th century. The first attempt at surgical fusion of the occipitocervical junction was by Foerster (17) in 1927, who used a fibular strut graft. Since then, advancements in the understanding of the biomechanical and anatomic characteristics of this region have led to remarkable advancements in the techniques and technology available for surgical stabilization. Newer techniques, although technically demanding, allow for rigid fixation of the region with nearly universal fusion success (11, 57).

The difficulty in operative stabilization of the occipitocervical junction is attributable to the unique biomechanical characteristics of the region, with O–C1 responsible for approximately 15 degrees of flexion and extension of the cervical spine, and C1–C2 allowing more than 45% of the axial rotation (29, 48, 67). Constructs must be fixed at both occipital and cervical ends to restrict motion in all axes of rotation, including flexion-extension, rotation, lateral bending, axial loading, and distraction. Instrumentation must not only oppose forces along these vectors but must also overcome the long moment arm generated by the acute angle at the occipitocervical junction and provide for strong fixation to the relatively thin occipital bone (64).

Early techniques involved the use of stand-alone onlay bone grafting, which was advanced to include the use of wires to secure bone grafts and add stability to motion segments posteriorly (65). Because sufficient stabilization is not conferred until full arthrodesis, however, these techniques necessitated the use of postoperative halo fixation, which is not only uncomfortable but also hinders early rehabilitation and is associated with potentially serious complications (18). Furthermore, wiring techniques are associated with a pseudoarthrosis rate of up to 30%, and they often require extended fusion constructs that eliminate motion over multiple subaxial segments (23, 33, 55).

The development of semi-rigid fixation using rod-and-wire techniques in combination with bone grafting provided greater immediate stability and demonstrable improvement in fusion rates with respect to earlier techniques (Fig. 1) (34, 37, 60). In these constructs, rods are bent or preformed into a U shape, contoured to fit the occipitocervical angle, and secured to the occiput and laminae of the cervical spine with threaded wires. Although rod-and-wire constructs are still in use, they have been shown to be biomechanically inferior to rigid screw-based techniques, often require postoperative halo immobilization and fusion of additional mobile segments for adequate strength, and are associated with complications arising from

FIGURE 1. *Early semi-rigid fixation devices using preformed rods that are secured by suboccipital and sublaminar wires. An example with the Ransford loop (Surgicraft, Ltd., Worcestershire, England) is shown.*

the passage of sublaminar or suboccipital wires, including dural lacerations and neurological injuries (28, 34, 61, 62).

Further developments have led to the creation of biomechanically superior segmental screw-based constructs (28, 47, 51). Early screw-based constructs consisted of lateral mass plates modified to extend to the occiput either as separate bilateral constructs (Fig. 2A) (57, 59, 64) or as preconformed "Y" occipitocervical plates, such as the Axis Y-plate (Medtronic Sofamor Danek, Memphis, TN). These constructs, while providing increased stability and better outcomes when compared with prior instrumentation, also had limitations. Separate bilateral plates required securing the occiput lateral to midline, where the bone is thin and pullout strength is substantially decreased (15, 54, 69). These plates are constructed with slots or holes for screw placement, limiting screw entry points and trajectories, which can lead to frustration when trying to plan transarticular screw trajectories in a manner that safely secures C1 and C2 and also passes through the predetermined slots. Because the screws used in these constructs are not locked rigidly to the plate, they can only be considered semi-rigid and may offer slightly less biomechanical stability when compared with completely rigid systems. To correct the problem of midline fixation, preshaped rods connected by a plate that allowed for midline occipital fixation were manufactured (OMI U-loop; Ohio Medical Instruments Co., Inc., Cincinnati, OH) (Fig. 2B). However, screw placement sites were still limited, and this factor, in combination with the fact that these plates are difficult to contour, increased the technical difficulty of occipitocervical fusion and often led to fusion of the occipitocervical junction in a suboptimal position.

The latest generation of fixation devices (Fig. 3) has eliminated most of the shortcomings of the previous generation of occipitocervical plates. Current constructs use polyaxial screw heads and 3.5- or 4.0-mm rods, which can easily be bent to accommodate varying screw trajectories and approximate the appropriate occipitocervical angle. Furthermore, current modular systems allow for independent placement of occipital and cervical fixation, which can then be linked and secured with contoured rods. Occipital plates can be applied to the midline of the occiput, where the thick midline keel provides the highest resistance to pullout, and then attached independently to the atlantoaxial screws (54). This stepwise mode of instrumentation has increased the ease of occipitocervical fusion. Some of these constructs can, however, occupy valuable bony surface needed for fusion, and care must be taken to ensure that an adequate surface area exists for fusion to ensue. The additional stability of modern constructs has reduced the need for external orthoses and increased fusion rates to near 100% while allowing for the fusion of unstable segments only (20, 30, 46).

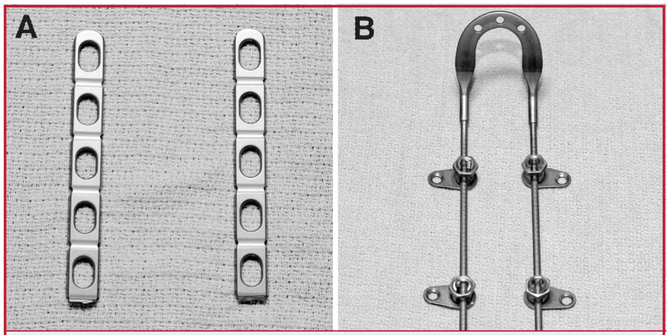

FIGURE 2. *The development of screw-based constructs for occipitocervical instrumentation increased biomechanical stability and fusion rates. Examples include lateral mass plates (A) and the OMI U-loop (B) (Ohio Medical Instruments Co., Inc., Cincinnati, OH).*

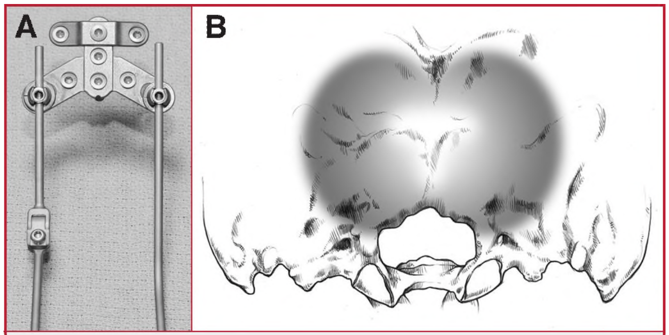

FIGURE 3. A, *current occipitocervical instrumentation allowing for midline fixation to the occiput and placement of polyaxial screws in the cervical spine. Rods connect occipital and cervical instrumentation. An example with the Mountaineer occipital plate (DePuy Spine, Inc., Raynham, MA) is shown.* **B**, *graphic illustration of the occiput in which whiter areas indicate optimal locations for placement of occipital screws based on bony thickness.*

Upper Cervical Instrumentation

Although there have been reports of successful occipitocervical stabilization with fusion of only the atlas to the occiput using atlanto-occipital transarticular screws, and through anterior approaches with custom-designed plates that attach to the clivus and the anterior C2 body, these reports are few, and extensive experience is lacking (10, 13, 16). These techniques may be better suited for rare salvage cases in which sufficient bone does not exist for traditional screw purchase, or if posterior instrumentation has failed. Bilateral posterior O–C1–C2 screw-rod constructs provide superior stabilization. There are 3 main screw-based constructs available to achieve this (Fig. 4).

Transarticular screw fixation, as described by Magerl and Seeman (36), has been the most prevalent method of fixing the atlantoaxial articulation. Cervical screws can then be connected to the occipital end of the construct with plates or rods. This method has been demonstrated to be biomechanically stable and superior to rod-and-wire-based constructs (28, 47, 51), with a fusion rate of nearly 100% (28, 47, 51, 57). Drawbacks of the technique include the technically demanding nature of the procedure, risk of vertebral artery injury, and necessity of achieving reduction before screw insertion. Moreover, between 5.9 and 23% of patients may have unfavorable anatomy that places the vertebral artery at increased risk for injury and, therefore, precludes the placement of transarticular screws (6, 19, 35, 50).

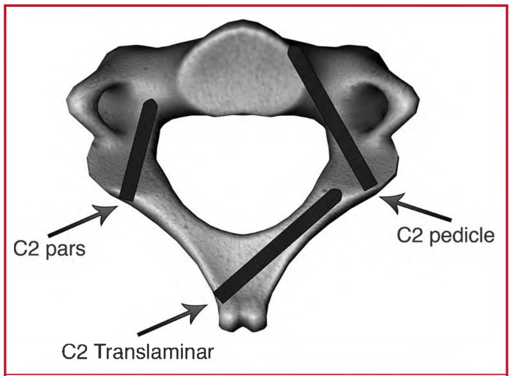

FIGURE 4. *Illustration showing trajectories for the C2 pars screw, C2 pedicle screw, and C2 translaminar screw.*

An alternative to transarticular screw fixation in the stabilization of the atlantoaxial joint is the placement of C1 lateral mass screws and C2 pars or pedicle screws (Fig. 4) (20, 24). This construct can be extended with rods and an occipital plate to stabilize the occiput and has recently been shown to be of similar biomechanical strength to the transarticular construct in the destabilized cadaveric craniovertebral junction (52) (MA Finn et al., unpublished data). Familiarity with this technique is valuable in cases in which transarticular screw insertion is precluded because of unfavorable anatomy. The method also has the added benefit of allowing for reduction maneuvers to be performed after screw placement. This construct, however, is not universally applicable, as approximately 9% of patients have anatomy that precludes safe instrumentation at the C2 pedicle (53).

The translaminar technique is a third method that has recently been described in which screws are placed in the lamina of C2 in a crossed trajectory and connected with rods to C1 lateral mass screws (Fig. 4) (68). The technique has the advantage of eliminating risk to the vertebral artery, although there may be a risk of spinal cord injury with ventral lamina penetration. It also has the advantage of simplicity, as the C2 lamina is the largest in the cervical spine and all elements at risk are visualized directly during insertion, thus eliminating the need for navigation. Although this construct has been shown to be biomechanically equivalent to the Harms construct in the stabilization of the atlantoaxial joint, additional biomechanical data show significant inferiority of the translaminar technique to both occipital-transarticular and occipital-C2 pedicle constructs, a factor that may be attributable to the acute bend needed in the rods connecting the cervical screws to the occipital plate used in our study (21) (MA Finn et al., unpublished data). In addition, the prominence of the screw head on the lateral aspect of the spinous process limits the available contact area for bone grafts, limiting the use of the technique to those cases with extremely unfavorable C2 anatomy.

OCCIPITAL INSTRUMENTATION

Numerous variations in instrumentation have been described that are intended to obtain secure attachment of cervical constructs to the occiput. Suboccipital wire-based techniques are biomechanically inferior to screw-based techniques, especially in resisting cranial settling and axial rotation, and have been associated with significant neurological morbidity (28, 34, 63). The newest constructs offer the ability to fix the occiput in the midline (Fig. 3A), where the keel provides the greatest bony depth and resistance to pullout (Fig. 3B) (54). Some plates offer the option of both midline and lateral fixation. This may be beneficial because it has been shown that lateral fixation may be better suited to resist lateral bending moments, and midline fixation may be better suited to resist axial rotation moments (1). These differences, however, are of uncertain clinical relevance.

SURGICAL TECHNIQUE

Planning

Presurgical planning always involves the acquisition of high-resolution computed tomography with coronal and sagittal reconstructions for optimal understanding of individual regional anatomy. Particular attention is paid to the course of the vertebral arteries and the thickness of the keel of the occipital bone. For challenging anatomy, we use a 3-dimensional computer navigation system (StealthStation Treon image guidance system; Medtronic, Minneapolis, MN) for image reconstruction and trajectory planning. The trajectory views can be particularly helpful in planning a path that avoids penetration of the vertebral foramen when anticipating the use of transarticular screws. Although the use of stereotactic guidance in this application has been described and is regularly used by some practitioners, it is no substitute for a thorough understanding of individual anatomy and surgeon experience (66). Navigation techniques tend to be cumbersome because of physical interference with the reference arc, which must be placed in the center of the operative field. Additionally, stereotactic techniques in which the reference array is placed on the spinous process of C2 do not account for intraoperative motion between C1 and C2, making the technique inaccurate in cases requiring significant reduction of the C1–C2 joint.

If preoperative traction is necessary for reduction, it is maintained during patient transfer to the operating room and during anesthetic induction. Alternatively, the patient can be placed in a halo for reduction before surgery; this has the added benefit of allowing for preoperative mobilization and assessment of the adequacy of positioning (Fig. 5). On occasion, we allow patients who have undergone reduction to walk and eat while stabilized in a halo vest the day before the procedure to ensure that there will be no issues with line of sight or swallowing, which can occur with poor positioning. In cases of significant instability, awake fiberoptic intubation is used.

Preoperative Setup

The patient's head is secured with rigid cranial fixation or left in the halo ring, if halo immobilization is used preoperatively, and the patient is carefully turned to the prone position on bolsters or a Jackson table. During rotation into the prone position, careful man-

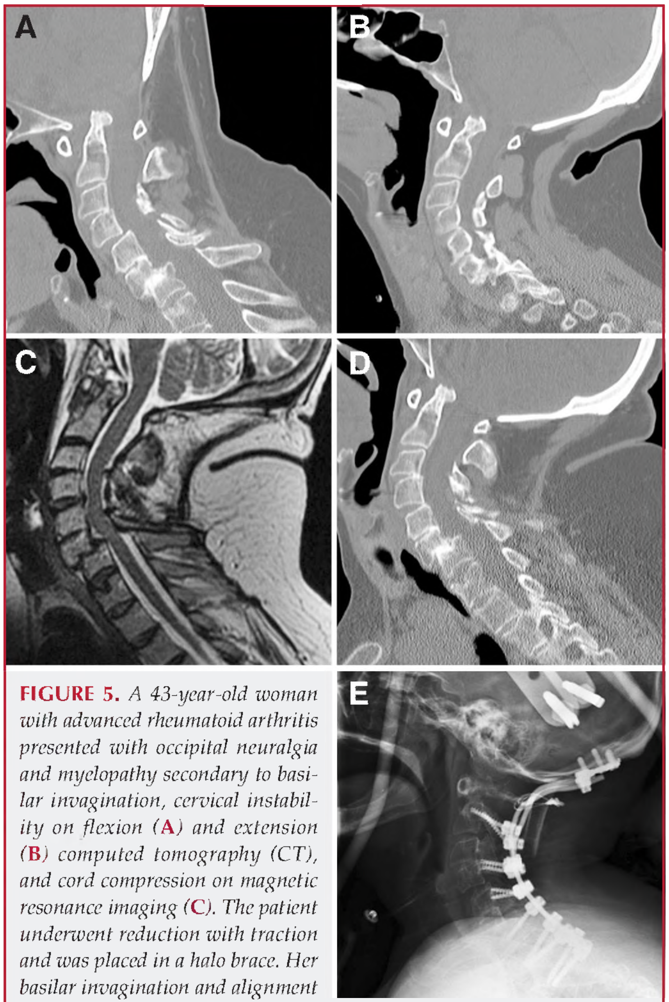

FIGURE 5. *A 43-year-old woman with advanced rheumatoid arthritis presented with occipital neuralgia and myelopathy secondary to basilar invagination, cervical instability on flexion (**A**) and extension (**B**) computed tomography (CT), and cord compression on magnetic resonance imaging (**C**). The patient underwent reduction with traction and was placed in a halo brace. Her basilar invagination and alignment improved on CT (**D**) after halo placement and remained stable with activity and walking. She then underwent occiput-to-T2 fusion while in the halo vest. Postoperatively, the patient's basilar invagination and alignment remained improved (**E**), and her occipital neuralgia and myelopathy had improved significantly on follow-up examination.*

ual traction is maintained if the patient is not in a halo device while the patient is positioned in the rigid headholder. The head is placed in the neutral position with a slight military tuck. Too much military tuck can lead to postoperative swallowing difficulty. The operative table is positioned in slight reverse Trendelenburg position to aid venous drainage from the operative site, and the patient's back and legs are slightly elevated. Adequacy of positioning and maintenance of reduction are confirmed with lateral fluoroscopy and visual inspection, ensuring that the lateral masses align perfectly and that the patient's ears are parallel to the floor.

Neural monitoring is used in all patients who have significant instability, neural compression, or myelopathy (25, 31). Motor evoked potentials and somatosensory evoked potentials are measured after induction of anesthesia while the patient is in the supine position and again after rotation into the prone position. A significant change in motor or somatosensory evoked potentials during positioning mandates returning the patient to the supine position and undertaking a neurological examination with the patient awake if potentials do not return to baseline levels. Somatosensory evoked potentials are measured throughout the procedure, whereas motor evoked potentials are checked after significant maneuvers, such as removal of laminae, reduction of deformity, and placement of screws.

Procedure

Antibiotics with coverage for common skin organisms are administered beginning 30 minutes before skin incision. A strip of hair is shaved from above the external occipital protuberance to the hairline, and an incision is marked in the midline from the inion to the level of the C3 spinous process. If the use of transarticular screws is planned, a long straight instrument held over the planned screw trajectory is visualized under fluoroscopy, and the exit site through the skin is marked, as described elsewhere (3). The incisions are infiltrated with 1% lidocaine with epinephrine 1:100 000 to aid in hemostasis and then are opened sharply. Dissection is performed to the fascial layer with monopolar electrocautery, followed by Cobb dissection to splay the soft subcutaneous tissues off the fascial layer. This aids in securing tight fascial closure at the end of the procedure. At this stage, we also use monopolar electrocautery to create a horizontal incision in the fascia and musculature approximately 2 cm inferior to the inion. This provides a cuff to attach the remaining paracervical muscles during closure and improves fascial closure at the superior end of the incision. It also eases identification of the midline avascular raphe through which dissection of the paraspinal musculature will proceed.

The midline plane is developed until the occiput and spinous processes of C1, C2, and C3 are identified. Subperiosteal dissection on the occiput is performed to the medial edge of the mastoids and along the spinous processes and laminae of C1 and C2 until the lateral masses of each are visualized. Lateral dissection around the C2 nerve and C1 lateral mass is performed with bipolar cautery and sharp dissection to minimize the risk of injury to the vertebral artery. We then remove the soft tissue between the occiput and ring of C1 with tenotomy scissors, and the bony edges of the foramen magnum and ring of C1 are defined with curettes. If the use of a Songer cable to secure the bone graft is planned, curved curettes are used to dissect the soft tissues gently off the C1 ring. The surgeon should be cognizant of the intimate relationship between the vertebral artery and the ring of C1 during this maneuver. The dura mater should be visualized upon completion of the dissection. The soft tissues are then removed between C1 and C2 in a similar fashion. Curettes are again used to dissect the ligamentum flavum from bony attachments until the bony edges are well developed and the dura is visualized. The soft tissues between C2 and C3 are left intact. The pars interarticularis of C2 is the critical landmark for the placement of screws and must be fully exposed to the C2–C3 articulation. Venous bleeding may occur during exposure of the C2 pars or C1 lateral mass. Floseal (Baxter Healthcare, Deerfield, IL) or Gelfoam powder (Pfizer, Inc., New York, NY) mixed with thrombin and the gentle application of bipolar electrocautery are all adjuncts to obtaining hemostasis in this area. When C1 lateral mass screws are used, we dissect the inferior medial surface of the C1 lamina using small straight curettes. The dissection continues ventrally until the C1 lateral mass is identified. An entry site directly in the lateral mass is visualized to avoid placement of a screw too laterally into the vertebral foramen. After all screw entry sites and landmarks are exposed, screws are inserted along the planned trajectories.

Instrumentation

As mentioned above, a variety of screw combinations exist to secure C1 and C2. Our preference is to use either transarticular screws or C1 lateral mass and C2 pedicle screws when feasible, although the use of C2 pars screws in conjunction with C1 lateral mass screws is used if the vertebral artery has a course that runs medially and precludes the placement of pedicle screws. In the rare instance that both pedicle and pars screw placement is prevented, C2 laminar screws may be considered. The planning of trajectories and the placement of screws for each of these constructs have been described elsewhere and are illustrated in Figures 4 and 6 (3, 22, 24, 68).

After placement of screws to secure the atlantoaxial articulation, attention is turned toward the occipital end of the construct. As discussed above, numerous devices are available for occipital fixation. We prefer a design that offers the option of midline screw placement, because it takes advantage of the added bone depth at the midline keel. Surface irregularities of the occipital bone are evened with a high-speed burr, and the plate is placed to ensure a flush fit. The most superior screw is prepared first. A power drill with a stop set at 6 mm is used to bore the initial hole, and the drill stop is increased in 2-mm increments until the ventral cortex is penetrated. The pilot hole is probed at each depth to ensure that only the ventral bone and not the dura is penetrated. A 4.5-mm-diameter blunt cortical screw of the appropriate length is secured after tapping through the entire depth of the pilot hole. One or 2 additional screws are then placed in a similar fashion.

Once the occipital plate is secured, 3.5-mm rods are shaped to fit the screw heads and the plate. The rods are secured tightly with set screws once anatomic alignment is assured. After instrumentation is secured, the bone graft is prepared. Of specific note, harvesting autologous bone grafts for fusion constructs in this patient population, particularly those with rheumatoid arthritis, has been reported to be unnecessary, and avoiding this procedure may help reduce morbidity (45). We use tricortical iliac crest allograft for most fusions, although consideration is given to the use of autograft in smokers. A V-shaped notch is made in the inferior part of the graft to fit snugly over the spinous process of C2 and in the anterior aspect to accommodate the lamina of C1. The superior portion is shaped to rest flush against the occiput. All contact points between the graft and the native bone are decorticated with a high-speed burr before final placement. Demineralized bone matrix is packed into the contact surfaces of the graft, which is then wired into place with a Songer cable around the ring of C1 and spinous process of C2 (12). If the ring of C1 is incompetent or has been damaged or removed, we have had success in wiring the graft directly to the rods. We also place a screw through the upper end of the graft into the occiput to ensure apposition of the superior portion of the graft with native bone.

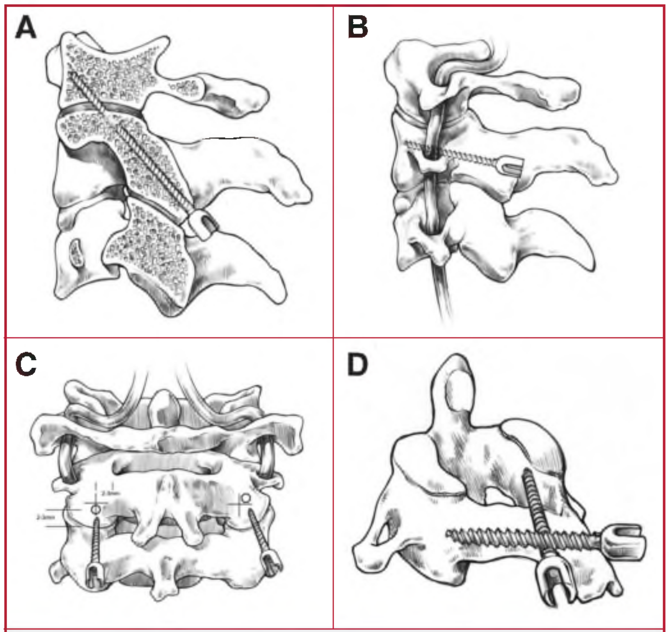

FIGURE 6. A, *sagittal rendering of the transarticular screw fixation (TASF) and axial pars screw. These screws take similar trajectories, with the pars screw ending before the C1–C2 articulation. Common screw lengths are typically 36- to 44-mm and 18-mm length, respectively.* **B**, *sagittal rendering of the axial pedicle screw trajectory. Note the pedicle screw cephalocaudad angle is less than that of the TASF/pars screw.* **C**, *atlantoaxial rendering indicating entry sites for TASF/pars screw (left) and axial pedicle screw (right), with the crosshairs indicating the midline. The TASF/pars screw enters approximately 2 to 3 mm cephalad to the inferior margin of the lateral mass and takes a trajectory 0 to 10 degrees medial and 40 degrees cephalad. The pedicle screw enters in the upper, outer quadrant of the pars and takes a more medial (20-degree) and flat trajectory (20 degrees of inclination).* **D**, *superior oblique view of the axis with cross-laminar screws.*

The wound is then copiously irrigated with bacitracin and closed in layers, with special attention to the fascial closure, which we close with a running 0 Vicryl suture (Ethicon, Inc., Somerville, NJ). The muscle is also closed in layers, with the superior aspect attached to the cuff that was left attached to the cranium at the beginning of the procedure. Skin closure is completed with a running nylon suture.

Postoperative Orthosis

Postoperative orthosis can be used at the discretion of the surgeon. If intraoperative stability and screw purchase are satisfactory, we often choose not to use postoperative external orthosis. Trauma patients and those with poor bone quality are often managed with a hard cervical collar, although we occasionally use halo vests in exceptional cases. Cervical collars may also be used to serve as an activity-limiting reminder in unreliable or extremely active patients.

CONCLUSION

There are a myriad of surgical options available for the treatment of occipitocervical instability. Modern screw-based techniques have been demonstrated to be the most biomechanically secure of these options and have established clinical success, with fusion rates approaching 100%. These techniques are technically challenging and require meticulous preoperative planning and thorough familiarity with the regional anatomy, instrumentation, and constructs.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

In this review article, Finn et al. provide an overview of the surgical approach to the occipitocervical region and share their insights. Their discussion includes commentary on the common pathologies in this region, a brief historical perspective, and a review of current types of instrumentation, followed by an extensive discussion of the technical nuances of surgery in this area, from preoperative planning to intraoperative decision-making and postoperative patient care. As an adjunct to their extensive discussion, the authors have included a number of illustrations to demonstrate important technical points as well as a case presentation.

The development of occipitocervical instrumentation over the past 2 decades has led to much more consistent and successful posterior surgery in this region. This article provides an excellent overview, for neurosurgical trainees and general neurosurgeons alike, of both the indications for and technical details of these procedures.

Sarah Woodrow
Michael Y. Wang
Miami, Florida

This is a contemporary review of an operative procedure that I have enjoyed performing and have struggled with for 20 years. Advances in craniocervical internal fixation devices have made the 80th procedure I accomplished much easier, and likely more effective, than the first dozen I performed. From stainless steel bent rectangles and wire, to titanium rods that we contoured into bent U-shapes secured with braided cables, to lateral mass plate systems wired to the thin, more lateral cranium, to the contemporary midline cranial fixation systems/cervical screw fixation methods described in this text…all have worked. The newer systems are easier to use, safer, more rigid, and much less potentially frustrating to the surgeon. They are probably more likely to result in successful arthrodesis across the craniocervical junction (the goal of the procedure), as compared with earlier techniques and devices, but, to my knowledge, this has not been studied. The authors report nearly 100% fusion success with the use of contemporary systems. The youthful optimism of the authors is appreciated. The newer devices do take up more surface area of the cranium, further emphasizing the importance of meticulous fusion techniques once the hardware has been placed.

New systems or not, several key principles have been consistent (and, in my view, critical), throughout my years of experience, for optimizing patient outcome. I therefore take minor issue with the authors over these points: 1) Preoperative halo ring-vest immobilization, and, preferably, preoperative reduction with immobilization. This is not only safest for the patient, but, in many cases, it allows anatomic reduction of the pathology/dislocation to occur and helps to control the instability with positioning throughout surgery. 2) Meticulous surgical techniques are needed to avoid neural and vascular injury and to maximize bone surface area for fusion across a difficult span to achieve bony healing. 3) Autologous iliac crest bone should always be used. Allograft bone has a higher failure rate when used dorsally as an onlay graft, and the patient's own crest can be harvested and sculpted (cortical side down, cancellous surface up) to perfectly fit the contour of the dorsal craniocervical junction to facilitate bony fusion/bridging across this challenging span. Image-guided navigation systems and intraoperative monitoring should be used if a surgeon feels that they will optimize individual surgeon abilities/improve patient outcomes, but they are not routinely necessary, essential, or required.

Mark N. Hadley
Birmingham, Alabama

The authors briefly review various types of occipitocervical stabilization techniques and then detail their personal technique. They also emphasize preoperative evaluation of diagnostic studies, especially thin-cut computed tomography, that focus on the anatomy of the vertebral artery before occipitocervical fixation is performed. They rightfully note that recent contemporary screw techniques for occipital fusion have achieved high fusion rates. However, they also emphasize that the management of instability at the occipitocervical junction is a challenging surgical problem because of the unique anatomic and biomechanical characteristics of this region.

Volker K.H. Sonntag
Phoenix, Arizona

The authors provide a comprehensive review of the management of occipitocervical junction instability. At this point in time, there is little support for the use of semirigid fixation with wires and rods. Rigid fixation has proven to be significantly more efficacious in both a biomechanical and clinical sense.

Vincent C. Traynelis
Iowa City, Iowa

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