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RESEARCH HIGHLIGHT

How I do it: Condylar screws

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Abstract

Background Condylar screws have broadened fixation options for Craniocervical Fusion techniques and are used when occipital squama anchorage is inadequate. They may also outperform barplate constructs in patients with connective tissue disorders.

Methods The condyles are entirely dissected, sacrificing the Posterior Condylar Emissary Vein. An entry 3 mm lateral to the foramen magnum is created. Hand drilling converges 20° medially, aiming toward the basion under fluoroscopy, under continuous hypoglossal EMG monitoring. A 34-mm lag screw is inserted and confirmed by intraoperative CT.

Conclusion Condylar screws provide reliable fixation and are a useful adjunct to contemporary CCF techniques.

Keywords Occipital condyle · Craniocervical instability · Craniocervical fusion

Abbreviations

OC	Occipital Condyle
IOM	Intraoperative Monitoring
CM1	Chiari 1 Malformation

Relevant surgical anatomy

The occipital condyles (OCs) form the lateral boundaries of the foramen magnum and articulate with the C1 lateral masses. The hypoglossal nerve runs within the hypoglossal canal at the superior third of the OC. Posterior-superior and slightly lateral to the OC lies the condylar fossa, within which the posterior condylar emissary vein exits the condylar canal. Key adjacent structures include the clivus (anteromedial), internal jugular vein (anterolateral), and vertebral artery (posteroinferior) (Fig. 1).

The Craniocervical Junction is formed by the bone and ligamentous structures spanning from C0 to C2, is the most mobile joint in the body, and is located at an important and delicate anatomical crossroad of the Central Nervous System: the Cervico Medullary Junction. Whenever surgical stabilization of the craniocervical junction becomes necessary, direct anchoring to the occipital condyles presents distinct biomechanical advantages.

Description of the technique

The head is positioned in traction and forced flexion, to optimize the posterior exposure of OC and C0–1 joint. Establish continuous hypoglossal (XII) EMG monitoring and standard neuromonitoring [7]. Dissecting the posterior condylar emissary vein is achieved by first defining its superior, lateral, and medial margins. The C0-1 joint is entered with a Penfield #4. Bipolar coagulation (keep the tool tangential to the vein) leads to progressive shrinkage of the emissary vein, often resulting in near or complete obliteration, before division with monopolar coagulation at its exit from the condylar canal, which is then packed with bone wax. The lateral edge of the foramen magnum is dissected bluntly all the way to its inferior edge. A small bony prominence marks the transition between the supraocciput and the superomedial edge of the occipital condyle. The venous plexus lateral to

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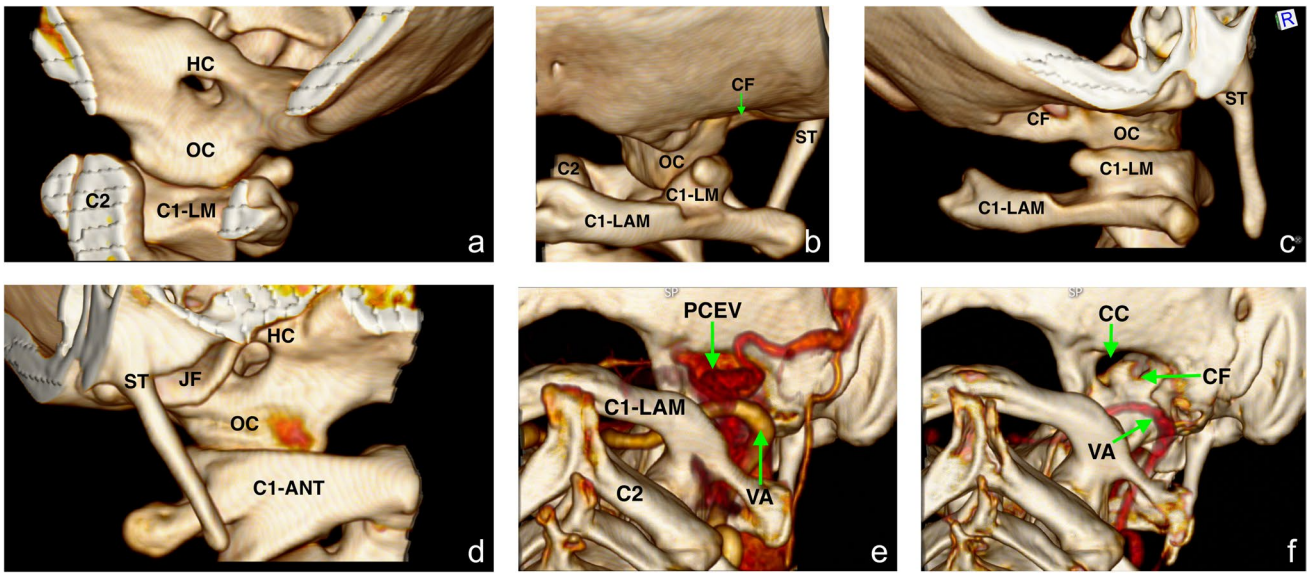

Fig. 1 **a** Regional anatomy of the Occipital Condyle. Medial view. C1-LM: C1 Lateral Mass; HC: Hypoglossal canal; OC: Occipital Condyle; C2: Second Cervical Vertebra. **b** Regional anatomy of the Occipital Condyle. Posterior View. C1-LM: C1 Lateral Mass; C1-LAM: C1 Lamina; CF: Condylar Fossa; OC: Occipital Condyle; ST: Styloid; C2: Second Cervical Vertebra. **c** Regional anatomy of the Occipital Condyle. Lateral view. C1-LM: C1 Lateral Mass; C1-LAM: C1 Lamina; CF: Condylar Fossa; HC: OC: Occipital Condyle; ST: Styloid. **d** Regional anatomy of the Occipital Condyle. Anterior view. C1-ANT: C1 Anterior Arch; HC: Hypoglossal canal; JF: Jugular Foramen; OC: Occipital Condyle; ST: Styloid. **e** Regional anatomy of the Occipital Condyle. Inferior view with vasculature. C1-LAM: C1 Lamina; PCEV: Posterior Condylar Emissary Vein; VA: Vertebral Artery; C2: Second Cervical Vertebra. **f** Regional anatomy of the Occipital Condyle. Inferior view without vasculature. CF: Condylar Fossa; CC: Condylar Canal; VA: Vertebral Artery

the dural sac often requires gentle bipolar coagulation and careful packing with Surgicel©.

Enter the C0–1 joint using an Adson periosteal dissector to complete the posterior exposure of the OC's. The entry point for the screw is planned 3 mm lateral to the rim of the foramen magnum, slightly below the anatomical equator of the exposed OC [10] (Fig. 2).

After drilling a shallow pilot hole with a C1 Midas Rex© tip, advance the hand drill at a 20-degree medial angulation [5, 10], maintaining a sagittal trajectory directed toward the basion under lateral fluoroscopic guidance, and under continuous XII nerve IOM [7]. Advance until the tip of the hand drill overlaps the signal of the basion on the lateral fluoroscopic imaging, and anterior cortical resistance is felt (Fig. 3a).

Perform a shallow tap and manually insert a 34-mm lag screw using the same coordinates, until resistance of the anterior cortical layer is encountered (Fig. 3b).

Place additional C1 lateral mass and C2 pedicle screws; verify screw positioning with intraoperative CT (Fig. 3c).

Reposition the head in extraction and mild extension; cut and fit two short cobalt-chrome rods onto the screw heads to build a C0–1–2 (minimum) construct (Fig. 4).

When locking the caps, any torquing motion of the Condylar screw head needs to be prevented.

Although we do not routinely use computer-assisted navigation, this technique can be helpful in this setting. However, its margin of error may be problematic, particularly in cases of hypoplastic condyles.

Indications

The prime indication for condylar screws is inadequate or disrupted occipital squama preventing solid and effective barplate fixation, because of congenital, traumatic, or iatrogenic etiologies [1, 4].

Complex Chiari 1 malformation is a subtype of Chiari I malformation in which the mass effect of tonsillar herniation on the brainstem is compounded by the ventral compression

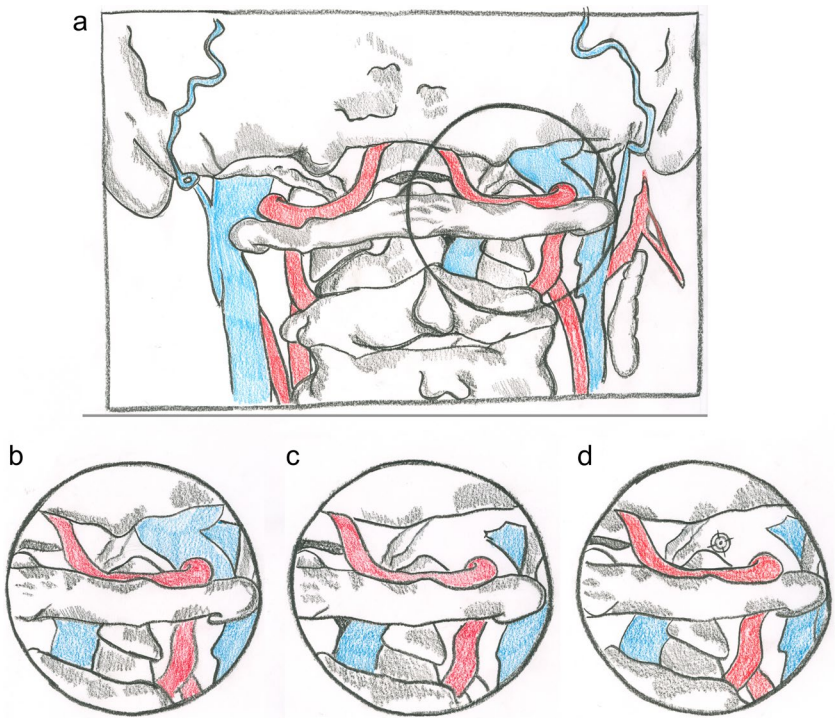

Fig. 2 **a** Artist rendering of the surgical anatomy. Overall view. **b** Artist rendering of the surgical anatomy. Focused view, before dissection. **c** Artist rendering of the surgical anatomy. Focused view, after sacrificing the Posterior Condylar Emissary Vein. **d** Artist rendering of the surgical anatomy. Focused view, defining the entry point for the Condylar Screw)

exerted by an abnormal craniocervical anatomy (e.g. retroflexed odontoid or basilar invagination). In selected patients, Complex Chiari 1 malformation may require craniocervical fusion as a staged or combined procedure with posterior fossa decompression. In these cases, the post-decompression parasagittal suboccipital squama is frequently thin and suboptimal for solid barplate fixation. Condylar screws enable secure fixation without compromising the extent of Chiari decompression, thereby avoiding a trade-off between decompression and fusion stability [2].

Craniocervical instability in patients affected by connective tissue disorders presents unique biomechanical problems, resulting in higher stress on the conventional barplate constructs, contributing to an increased rate of painful profile, next level disease, and metal fatigue (up to the point of occasional fracture of the midportion of the barplate), with the suboptimal congenital bone metabolism as a compounding factor [6, 8]. Condylar screws permit the use of a short straight bar that is deeply seated within the screw heads, with screws of uniform length and orientation, providing stabilization directly adjacent to the target joints (Fig. 5).

Limitations

Absolute contraindications include condylar destruction or instability from fracture, neoplasm, infection, or inflammatory disease [3]. Relative challenges include hypoplastic condyles; despite seeing these in approximately ⅓ of our patients, this anatomical variation has never prevented us from using this technique [9].

How to avoid complications

Maintain continuous hypoglossal nerve EMG; specify alarm criteria, 2.8 mA threshold and pause to reassess vector if triggered [7]. Intraoperative CT scan verification of the screw placement is highly recommended. Hypoplastic condyles present additional challenges that require specific precautions to reduce the risk of complications. Following complete dissection of the anatomical landmarks, the portion of the supraocciput immediately above the screw entry point should be carefully drilled down and thinned, as it may otherwise obstruct the trajectory and compromise optimal screw placement. In some cases, the superior edge of the C1 lateral mass can be shaved with a Kerrison upcut punch or drill to improve

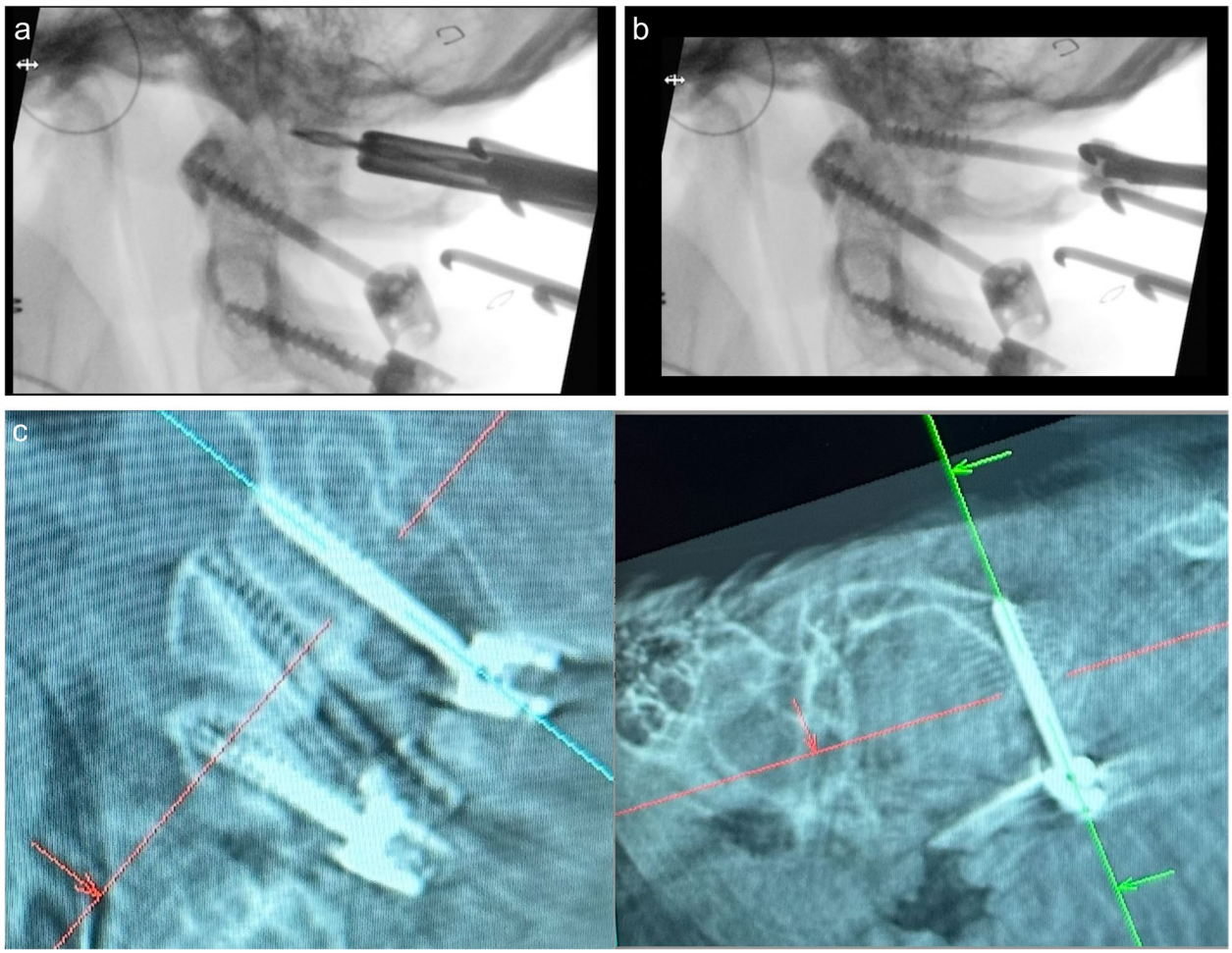

Fig. 3 **a** Intraoperative Imaging. Digital Fluoroscopy, lateral view, during hand drilling. **b** Intraoperative Imaging. Digital Fluoroscopy, lateral view, during screw insertion. **c** Intraoperative Imaging. Intraoperative CT, sagittal and axial views

exposure of the condylar surface. When the screw trajectory is particularly acute, a small "landing zone" may be created within the condyle itself. This provides a stable entry site and prevents slippage of the hand drill from the pilot hole, ensuring a controlled and accurate trajectory.

Specific information for the patient

Condylar screws provide a reliable method of craniocervical fixation when the bone at the base of the skull (supraocciput) is weakened by fractures, thinned from birth, removed during prior surgery, or disrupted after the failure of standard barplate techniques.

The procedure is performed under continuous fluoroscopic guidance with intraoperative neuromonitoring, and screw placement is confirmed with an intraoperative CT scan.

Risks include injury to the hypoglossal nerve, vertebral artery compromise, bleeding, construct failure, displacement, infection, and the usual risks of craniocervical fusion surgery.

Key points summary

Condylar screws provide a reliable method of craniocervical fixation when the supraocciput is mechanically compromised by fractures, craniectomies, congenital thinning, prior surgical removal, or failure of standard barplate constructs.

This method is particularly valuable as a salvage option when conventional barplate fixation is anatomically impossible or biomechanically insufficient.

Successful placement requires meticulous regional dissection and identification of anatomical landmarks.

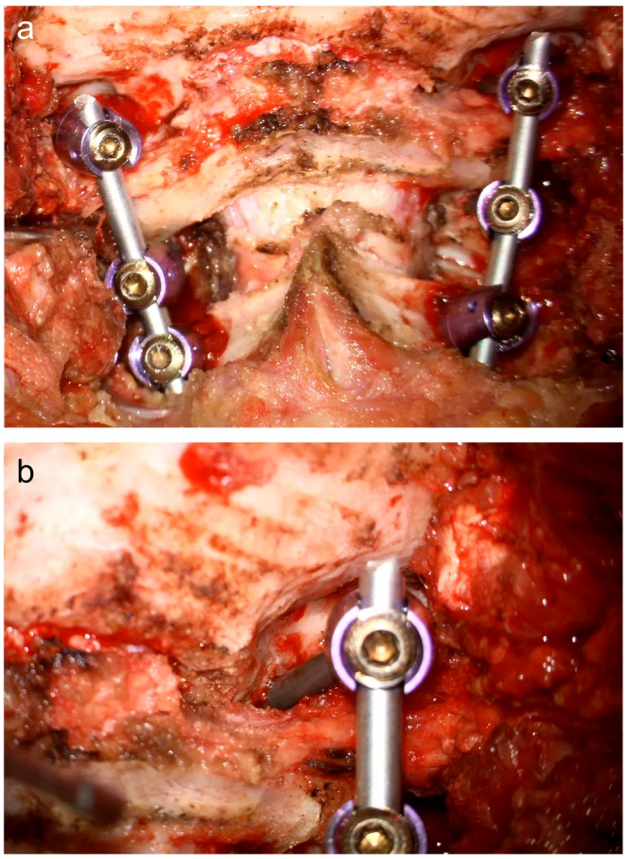

Fig. 4 **a** Intraoperative anatomy. General view. **b** Intraoperative anatomy. Detail of the Condylar screwhead

Flexion of the Craniocervical Junction facilitates both condylar dissection and screw insertion. Intraoperative repositioning into distraction and mild extension is required once the screws are in place.

Continuous intraoperative neuromonitoring of the hypoglossal nerve is essential to minimize the risk of iatrogenic injury.

A stimulation threshold of 2.8 mA is considered the lowest acceptable limit.

Digital fluoroscopy and intraoperative CT scans are necessary standard tools.

Computer-assisted navigation can aid placement; however, its potential error margin warrants caution, particularly in patients with hypoplastic condyles.

Thinning the supraocciput just rostral to the condyle may improve screw trajectory and facilitate secure placement.

Care must be taken during locking of the screw caps to minimize/prevent torquing forces on the screw heads.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00701-026-06861-z.

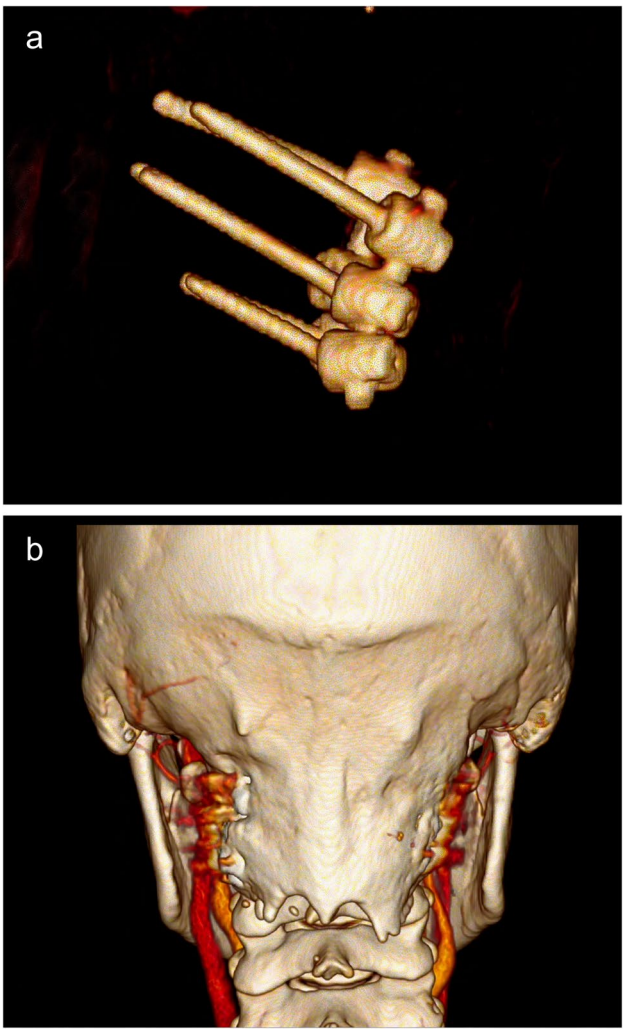

Fig. 5 **a** Late postoperative imaging. Final Construct on 3DCT. **b** Late postoperative imaging. 3DCT Angiogram 12 months after the surgery

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate All procedures performed in this study were conducted in accordance with the 1964 Helsinki

declaration and its later amendments or comparable ethical standards. All patients provided informed consent.

Consent for publication We provide consent for publication to Acta Neurochirurgica (an open access journal).

Dual publication The results/data/figures in this manuscript have not been published elsewhere.

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