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HOW I DO IT - PEDIATRICS

How I do it. 3D endoscopic treatment of metopic craniosynostosis through a single incision

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Abstract
Background Endoscopic approaches for craniosynostosis are a growing field in pediatric neurosurgery. In metopic synostosis, previous reports for complete fronto-orbital remodeling have proposed an intervention with multiple incisions (bregmatic, tarsal, and preauricular) to open frontonasal and frontoethmoidal synostotic sutures, and orbital roof.
Methods We propose a technique to complete all these osteotomies with a unique incision anterior to the bregmatic fontanel under 3D endoscopic vision, and review possible complications, limits, and pitfalls.
Conclusions Under endoscopic assistance, a complete fronto-orbital remodeling could be completed with a unique incision without mayor drawbacks.

Keywords Endoscopic surgery · Craniosynostosis · Trigonocephaly · Metopic suturectomy

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Relevant surgical anatomy

Trigonocephaly, a premature closure of metopic suture, seems to present a higher incidence in the last few years, being in some series the second most frequent single-suture craniosynostosis after scaphocephaly [1, 6]. When performing a metopic suturectomy, the main objectives are to avoid a future hypotelorism, normalize interpupillary distance, allow a bifrontal and bitemporal expansion, with an adequate shape of anterior fossa and a satisfactory fronto-orbital contour, presenting a proper esthetic result [3, 4]. This could be achieved either by open or endoscopic techniques. In this context, the main anatomic landmark, on one hand, is the frontonasal and frontozygomatic sutures, which articulates the lowest part of both frontal bones with the superior part of nasal bone and with frontal process of the zigoma, respectively; on the other hand, it is the frontoethmoidal suture, joining the ethmoidal and frontal bones (Fig. 1). Previously, some authors have described a tarsal incision to approach the frontomaxillary joint, cribriform plate, orbital roof, lateral orbital wall and pterion, and in some cases with another preauricular incision [2, 3].

Description of the technique

Positioning and skin incision

The child is placed in supine position on a horse headrest to enable the movement of the head. In our case, all patients are operated assisted with a 3D endoscope. After shaving the hair,

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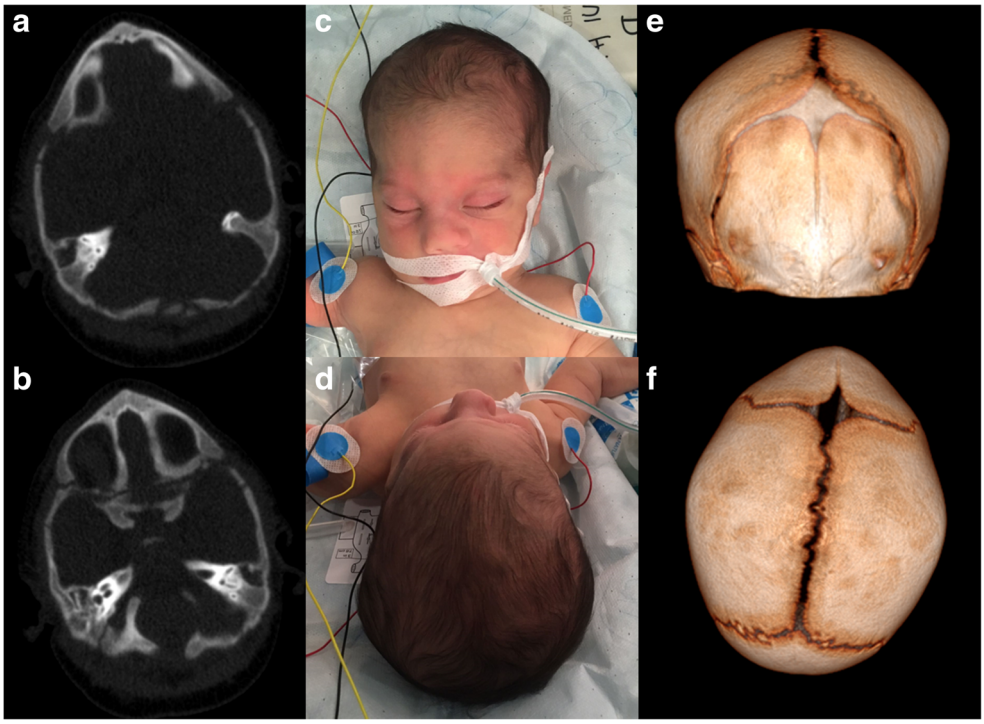

Fig. 1 Preoperative images of trigonocephaly. **a**, **b** Axial CT demonstrating metopic craniosynostosis. **c**, **d** Positioning of patients with frontal (**c**) and superior (**d**) vision of trigonocephaly. **d**, **e** 3D reconstruction of preoperative CT in frontal (**d**) and superior (**e**) view

skin is prepared in a sterile fashion with 2% aqueous chlorhexidine and a 2–3 cm incision is marked anterior to the bregmatic fontanel at the hair line after skin infiltration. Finally, the skin is infiltrated with a solution of SSF, 25% bupivacaine, and adrenaline 1:1 (Fig. 2a).

Metopic suturectomy

An incision is made with an ultra-sharp microdissection needle to avoid blood loss and coagulate the galea to approach the pericranium and frontal bone. A burr hole is performed with a

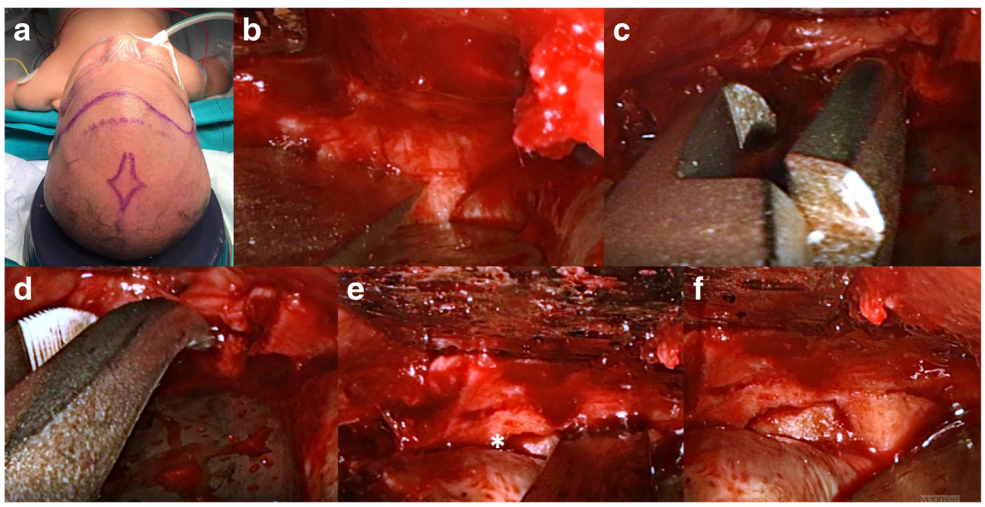

Fig. 2 Endoscopic orbitotomy operative procedure. **a** Positioning of the patient after skin preparation. Landmarks are prepared before skin infiltration; the *continuous line* indicates the hairline and the *pointed line* indicates the incision anterior to bregmatic fontanel. **b** 3D endoscopic view of frontonasal junction that is liberated with a chisel after dural retraction and separation from bone. **c**, **d** After opening of the frontonasal and frontoethmoidal joints, it is recommended to widen the distance between both orbits in order to reduce hypotelorism in the future. **e** Once the dura mater is dissected from the orbital roof, an orbitotomy (*) is done with a chisel under endoscopic control from medial to lateral until the superolateral part of the orbit and the pterional fontanel. **f** Greenstick fracture at the union between the orbitotomy at the superolateral end of the orbit and pterional fontanel

high-speed drill at both sides of the metopic suture. After dural exposure, this is separated with a Penfield dissector and bone is removed to approach the bregmatic fontanel. Then with the assistance of a rigid 0° 3D endoscope (VisioSense™), dura is detached below the closed suture until the exposure of the anterior part of cribriform plate. In the same way, the endoscope is used to pull apart the skin above the synostosis. Once this is completed, curved Metzenbaum scissors are introduced to perform suturectomy, which could be ended up with rongeurs to reach the frontonasal suture at the nasion (Fig. 3a).

Frontonasal and frontoethmoidal detachment

Once frontonasal and frontoethmoidal joints are reached, they could be liberated with rongeurs or a high-speed drill to reach both sutures. Then, using a chisel, nasal and ethmoidal from frontal bone and posteriorly to obtain a wide detachment is recommended to separate them with the aid of Kocher tongs (Fig. 2b–d; Fig. 3b–c). Bone bleeding is treated with hemostatic collagen matrix and pressure.

Lateral and orbital roof approach

Similar to as previously described, through the same incision, dura is dissected equally with the endoscope, until the anterolateral fontanel in exposed. This allows visualization, which allows visualization during the introduction of dissection scissors to perform the osteotomy. Again, in the frontal region and guiding the procedure with endoscopy, an osteotomy is performed at the orbital roof with the chisel and hammer until the supero-lateral region of the orbit (Figs. 2e and 3d). Finally, a greenstick fracture is performed to accomplished the connection between the orbit and pterional fontanel (Figs. 2f and 3e).

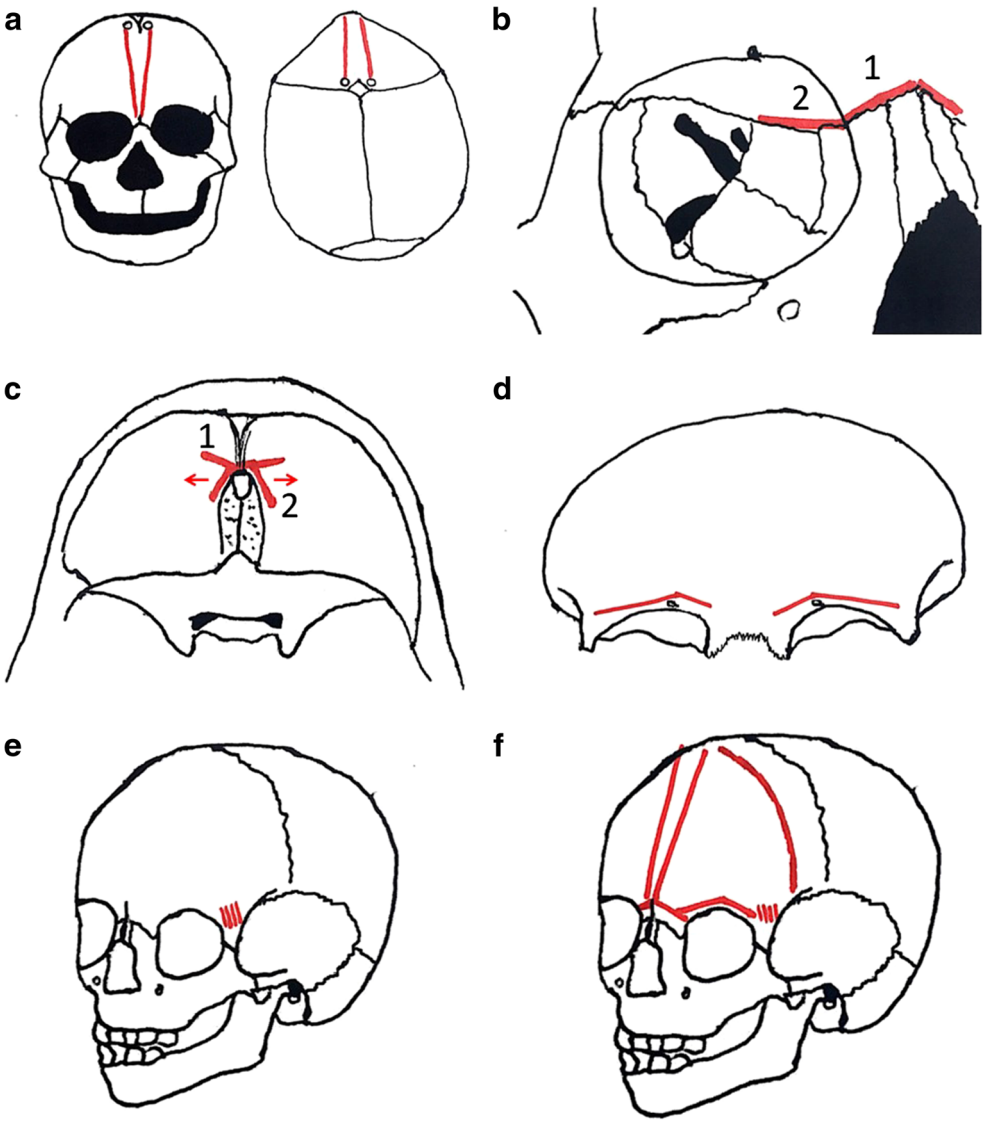

Fig. 3 Schematic planning of the osteotomies. **a** Burr holes and metopic suturectomy after dural dissection under endoscopic vision. **b**, **c** Frontonasal (1) and frontoethmoidal (2) joint liberation though osteotomies with chisel and hammer and separated with Kocher tongs (**c**). **d** Fronto-orbital liberation through an osteotomy over supraorbital hole to the lateral edge. **e** Green-stick fracture to connect orbital superolateral wall and pterional fontanel. **f** Compilation of all the osteotomies of the procedure, including osteotomy from the bregmatic to pterional fontanel

Indication

There are no differences in the indication for this technique, and the endoscopic assistance of metopic craniosynostosis, so every patient diagnosed with trigonocephaly under 4–6 months of age [5] could be a candidate, with the advantage of a unique superior incision behind the anterior fontanel.

Limitations

There are few limitations towards this technique, the most important being age, because patients over 3 months would require a more aggressive complete fronto-orbital remodeling with open technique that could be assisted with endoscopy.

How to avoid complications

One of the main complications in relation to surgery is bleeding, which in our case is avoided with the use of monopolar cautery (Colorado needle) and hemostatic collagen matrix (Floseal™), showing a scarce rate of transfusion. Also, dural sinus tears and cerebrospinal fluid leaks are prevented with a gentle dissection between bone flap and dura and with good endoscopic vision.

Specific perioperative considerations

All patients diagnosed with metopic craniosynostosis are studied with a 3D CT before the intervention. After surgery, patients are admitted and monitored in the ICU for a night. In our case, we do not recommend the use of helmets or orthesis, and patients are followed up once a week for removing staples and sutures and look after the wound.

Specific information to give to the patient about surgery and potential risks

Although endoscopic approach is considered a minimally invasive technique, swelling of frontal subcutaneous tissue and tarsal puffiness would be important in the first postoperative days. Also, wound-healing problems or injury to the supraorbital nerve should be explained.

Key points

1. 3D CT should be obtained preoperatively.
2. Unique frontal incision anterior to bregmatic fontanel.
3. Close dissection of dura mater assisted with 3D endoscopy.
4. Exposure of frontonasal and frontoethmoidal sutures at the cribriform plate.
5. Liberation of both sutures with a chisel and hammer (Fig. 3b and c).
6. Widening of joints with Kocher tongs (Fig. 3c).
7. Lateral osteotomy trough the same incision to the pterional fontanel after dural dissection (Fig. 3f).
8. Orbital roof osteotomy with chisel and hammer under endoscopic vision (Fig. 3d).
9. Greenstick fracture between orbital superolateral wall and pterional fontanel (Fig. 3e).
10. No need of helmet for good aesthetic results.

Compliance with ethical standards

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Informed consent was obtained from all individual participants included in the study.

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