Cranial Remodeling (Techniques)

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COMPLCATIONS

- cranial remodeling operations are associated with significant blood loss! (transfusion is often required)
  EBL OK < 1/3 of circulating blood volume (70 mL/kg)
  Two large bore IVs + A-line (may not need central line); wax bone edges!
- blood conservation strategies:
  1. Secure at least 3 units of suitable cross-matched blood before surgery
  2. CellSaver
  3. Erythropoietin - 4 doses weekly preop
  4. TXA intraop
- risk of dura, sinus injury → air embolism: HOB down, flood operative field with saline, if has central line – aspirate air
- if prone position, face should be lifted and gently massaged every ≈ 30 minutes by the anesthesiologist to prevent face pressure injuries.

POSITIONING & ACCESS

- depends on which fused suture needs correction:
  a) **SUPINE POSITION** with head supported on neurosurgery horseshoe - access to anterior cranium and frontoorbital region - for **METOPIC** and **UNICORONAL** craniosynostoses.
  b) **PRONE POSITION** - access to occipital area - for **LAMBDOID** craniosynostosis.
  c) **MODIFIED PRONE POSITION** with cervical spine extended - access to both anterior and posterior cranium (i.e. both frontoorbital area and occipital area) – for **SAGITTAL** and **BICORONAL** craniosynostoses:

N.B. ensure proper fixation of endotracheal tube - this position can be dangerous if patient is accidentally extubated during procedure!

- significant midface deformity may be problem for intubation.

MINIMALLY INVASIVE APPROACH (SUTURECTOMY)

- on gel rolls if prone (newborns can go just on Bair Hugger)
- mark with pen suture on scalp skin.
- prep with Betadine (if < 2 mos old) or chlorhexidine.
  Dr. Ritter preps everyone with chlorhexidine (and no need for sponge and alcohol as families do chlorhexidine towels preop at home)
- short incision (10-blade or Colorado Bovie):
  a) perpendicular to suture (e.g. in two places across the middle portion of the sagittal suture)
  b) along suture (e.g. in the middle of coronal suture)
- periosteum is elevated.
- bur hole (matchstick or diamond drill bit):
  a) on both sides of sagittal suture
  b) on suture
- bur hole is enlarged to rectangular shape with width of planned suturectomy:
  a) 7 mm – coronal, metopic
  b) 10 mm – lambdoid
  c) 20 mm – sagittal
- using lighted retractor (± with endoscope), scalp is elevated along entire suture length → pericranium is incised with Colorado Bovie to width of planned **suturectomy**
- make bone troughs with diamond drill bit at planned bone resection lines.
- ± using Storz retractor with endoscope go under bone and inspect for any bridging vessels.
- entire suture is resected with bone scissors (or mastoid rongeur / Lampard rongeur).
- optional - **barrel stave osteotomies** (using bone scissors) like tapering wedges extending laterally perpendicular to midline down to parietosquamous sutures.
- hemostasis is done at every step with Gelfoam, absorbable bone wax, and FloSeal.
- bacitracin irrigation.
- galea is approximated with 4-0 Vicryl in interrupted fashion.
- skin approximated with simple running 4-0 Monocryl → bacitracin ointment.

CRANIOTOMY (OPEN)

- zigzag bicoronal **INCISION** (prevents parting of hair along straight line, and scar tends to spread less because of redistribution of forces) - begins slightly anterior and superior to helix of ear.
  – do not extend incisions too far anterior or inferior (injury to temporal branch of facial nerve).
- *dissection in subgaleal plane* - flaps are developed anteriorly and posteriorly if needed.

- as orbital rims are reached, incision through periosteum is completed (do not injure supraorbital ***neurovascular bundle***, exiting from supraorbital foramen or notch, in medial aspect of superior orbital rim - bundle is translocated forward and out of foramen or notch with coronal flap).
- ***temporalis muscle*** is dissected from bone and reflected inferiorly (access to lateral wall of orbit).
- high-speed craniotomy with small burs, calvarium is carefully elevated from dura.
- if orbital osteotomies are needed, periorbita is separated carefully and ocular globe is retracted with malleable retractor.

REMODELING

FIXATION PRINCIPLES

- **titanium plates** (associated with migration from ectocranium to endocranium → plates and screws came in contact with dura and brain) have been replaced by **absorbable plates** made of *polyglycolic and polylactic acid* (absorb by hydrolysis in 1-3 years).

SAGITTAL SYNOSTOSIS

- frontal, parietal, and occipital **bones are removed** and transferred to side assembly table.
- **radial osteotomies** are performed on each bone to normalize contours.
- shortening of AP dimension is accomplished by **ostectomy of sagittal suture**.
- **out-fracturing base of temporal bones** aids in increasing lateral dimension of calvarium.
- **bones are molded** into shape and subsequently **replaced** into position.
- **fixation of bones** with absorbable plates & sutures.

ANTERIOR SYNOSTOSES

Dr. Fuhs (Duke University): all anterior synostoses (metopic, coronal) need:

1) bicoronal incision
2) supraorbital bar advancement
3) bifrontal bone flap → cut in half sagittally → rotate and swap pieces and put back together (so metopic edges lay in coronal position)

BICORONAL SYNOSTOSIS

- **FRONTO-ORBITAL ADVANCEMENT** - increasing volume of constricted anterior cranial fossa and reducing exorbitism:

1) independent ***mobilization*** of ***supraorbital (s. frontoorbital) bar*** with series of facial osteotomies (in appropriate sites of medial, superior, and lateral orbital walls and frontal bone);
2) subsequent ***advancement and stabilization*** of ***supraorbital bar*** in new more anterior position (so that supraorbital rim is 3 mm ventral to vertical plane of cornea);
3) lower border of frontal bones is resected (decrease in vertical dimension of calvarium and reduction of turricephaly)
4) new forehead is reconstructed with frontal bone flaps (simple resection and remolding).
5) fixation is achieved at nasion, pterion, and frontoorbital junction.

Variations (differ mainly on alternative fixations of lateral ends of supraorbital bar on adjacent temporal or zygomatic bones):

a) **"floating forehead" technique** - completely disconnects supraorbital bar and forehead from temporal bones (with goal of allowing complete freedom of growth of forehead from skull base).
b) **"tongue-in-groove" technique** - purposely attaches supraorbital bars to adjacent temporal bones with internal fixation (with goal of maintaining synchrony of growth between realigned forehead and skull base).

UNICORONAL SYNOSTOSIS

- correction of asymmetry within frontoorbital bar, frontal bone, and orbits.

- frontal bone is removed by performing craniotomy 10 mm above supraorbital rim, thus separating it from orbital bar.
- advancement of ipsilateral frontoorbital bar is accomplished by first creating osteotomy across floor of anterior cranial fossa and roof of orbit:
  - osteotomy begins at pterion and extends across midline anterior to crista galli and onto pterion on other side.
  - externally, osteotomy is made across lateral wall of orbit and onto frontozygomatic suture.
  - frontoorbital bar is then excised.
- each orbit is remodeled and shaped to create symmetry:
  - bar is fixed at nasion with absorbable plates.
  - frontoorbital bar is advanced on ipsilateral side (position rim ≈ 3 mm ventral to vertical plane of cornea).
  - small bone grafts may need to be used as interposition grafts if overall advancement is large.
  - ipsilateral orbital rim is cephalad compared with uninvolved side; bone is removed from frontozygomatic and frontonasal sutures to correct this asymmetry; in addition, bone is added to contralateral side to aid in symmetry; bone is also added to ipsilateral orbit rim width and removed from contralateral rim width to correct transverse discrepancy.
- symmetric replacement of frontal bone, after molding, is completed.
- absorbable plate fixation - plates are positioned at lateral orbital rim at its junction with temporal bone, frontonasal junction, and on frontal bone at its junction with frontoorbital bar, parietal bones, and temporal bones.

METOPIC SYNOSTOSIS

- increase in bifrontal diameter, increase in anterior cranial fossa volume, normalization of frontal bone shape.

- frontal bones and frontoorbital bones are excised and transferred to side assembly table.
- frontoorbital bar is advanced to create appropriate brow position.
- interdacryon distance is increased by placing bone graft between 2 halves of frontoorbital bars.
- bone is placed in tenon-and-mortise fashion to enhance stabilization.
- lateral aspects of orbital rims are also advanced.
- fixation via absorbable plates placed at lateral orbital rims at their junction with temporal bones + fixation at frontonasal junction.
- frontal bones are fixed to one another so that bifrontal diameter is increased.

CLOSURE

- ***temporalis muscle is repositioned*** - temporalis is resuspended using absorbable sutures secured to previously placed fixation plate - provides cephalad suspension of muscle as it heals in place.
- ***coronal flaps are reapproximated***, and galeal layer are sutured.
- hemostasis is paramount!

- resorbable sutures close **skin layer**.
- *suction drain* is recommended to reduce subcutaneous blood collection.
- firmly applied head dressing is secured in place with burn netting.

BIBLIOGRAPHY for ch. "Developmental Anomalies" → follow this LINK >>