osteogenesis in 8 patients (2 of whom had been referred from other institutions) or after autologous mandibular reconstruction in 4 patients. Follow-up was 12.6 ± 6.6 years. On average, patients had 9 (range, 2–19) mandibular operations. Adjusting for length of follow-up, patients having their first mandibular operation at a younger age had more frequent reoperations. Mandibular reconstruction involved costochondral grafts in 4 patients, iliac crest in 1, and microvascular free fibula transfer in 2. Gap arthroplasties were performed in 9 patients, interpositional arthroplasties in 5, and coronoidectomies in 7. One patient underwent alloplastic joint replacement. Overall improvement in mean interincisal opening was 24.8 ± 6.4 mm. Ankylosis occurred in 73.3% of cases (3 congenital and 8 iatrogenic) and necessitated on average 3 operations (range, 1–8). Tracheostomy dependence persisted in 6 (40%) patients and gastrostomy dependence persisted in 7 (46.7%). Decannulation was successful in 5 patients. Recurrence of bilateral ankylosis necessitated repeat tracheostomy in 1 patient. Tracheostomy was successfully prevented in 3 patients.

CONCLUSION: TMJ ankylosis in the setting of craniofacial microsomia reconstruction is associated with high recurrence rates requiring multiple reoperations, despite improvement in initial postoperative mean interincisal opening. In patients with craniofacial microsomia, younger age at initial mandibular surgery and number of operations seem to be associated with an increased risk of TMJ ankylosis and tracheostomy and gastrostomy dependence.

Holographic Surgical Planning and Telementoring for Craniofacial Surgery

**Presenter:** Ki-Hyun Cho, MD, MSc

**Co-Authors:** Jeff Yanof, PhD; Graham S. Schwarz, MD; Karl West, MS; Bahar Bassiri Gharb, MD, PhD; Francis A. Papay, MD

**Affiliation:** Cleveland Clinic, Cleveland, OH

**INTRODUCTION:** As the complexity of the craniofacial (CF) surgery increases, cases become more challenging for less-experienced surgeons to perform advanced procedures. Surgical teleconsulting/telementoring by an expert physician, as a subset of telemedicine, can provide real-time guidance to inexperienced surgeons at remote medical centers. Mixed reality head-mounted displays like HoloLens (Microsoft, Seattle, WA)—modern, untethered, a network-enabled headset which “augments” computer-generated 3-dimensional virtual image/information to the real physical environment/surgical site—are potentially easier to use than the conventional high-cost 2-dimensional telemstrator-based systems.

**OBJECTIVE:** To validate that a collaborative surgical planning application developed for HoloLens meets ease-of-use criterion on a system usability scale (SUS) criteria (mean Likert scale ≥ 3.0 with P ≤ 0.05; 1: strongly disagree; ≥ 5: strongly agree), whereas 2 plastic surgeons, in the roles of mentor and mentee, use shared interactive annotation and linear measurement tools on CF holograms.

**METHODS:** To demonstrate the use of mixed reality headsets for telementoring in CF surgery, HoloLens was utilized to evaluate its usability. Teleconsulting/telementoring application with CF surgical planning tools was developed for HoloLens. Seven adult dry human skulls with several main types of facial fractures were selected. Computerized tomographic imaging data were acquired, bone structures were segmented, and resulting surface mesh files were loaded onto HoloLenses. Ten surgeons (ranging from second-year residents to experienced surgeons [>300 surgeries]) were enrolled in the study. Each session consisted of 2 surgeons at different geographical locations wearing HoloLenses networked via an internet connection. A set of interactive dimensional measurements was performed on disfigured holographic skulls to evaluate the CF defect for collaborative surgical planning. A previously verified distance measurement tool calibrated with a holographic phantom for HoloLens was used. Optimal reconstructive options were discussed via a Voice over Internet Protocol and holographic annotation. The SUS was evaluated using a Likert scale questionnaire and analyzed with a Student’s t test. The latency of interaction was evaluated by comparing the navigation of shared holographic cursors from the 2 participants.

**RESULTS:** Holograms provided enhanced visualization of 3-dimensional spatial relationships and depth perception within and between anatomic structures which could not be observed by the conventional 2-dimensional display monitors. Mean SUS score of overall participants was 3.92 ± 0.73 (P ≤ 0.05, 1-sided). Surgeons evaluated the defects and shared surgical plans using interactive holographic annotations and linear measurements facilitating discussion of bone reduction direction, incision, and osteotomy design in true 3-dimensions. Latencies were acceptable for both shared holograms and Voice over Internet Protocol.

**CONCLUSION:** The novel telementoring application met usability acceptance criteria and enabled effective holographic telementoring during collaborative CF surgical planning. Future telementoring studies will include spatially registering and augmenting patient-specific holograms on the physical surgical site to provide real-time intraoperative guidance. This will improve educational access to surgeons to enhance surgical competency and patient safety in addition to facilitating the teaching of advanced surgical skills worldwide.
Craniosynostosis on Posterior Quadrants

Presenter: Michelle V. Zaldana, MD
Co-Authors: Brendan J. Cronin, BA; Meera Reghunathan, BS; Daniel Vinocur, MD; Amanda A. Gosman, MD
Affiliation: University of California, San Diego, San Diego, CA

Purpose: Craniosynostosis results from premature fusion of the cranial sutures and leads to distortion of normal calvarial anatomy. It has long been understood that this distortion is a direct result of growth restriction adjacent to the synostotic suture with compensatory growth of adjacent structures; however, there has been a paucity of data regarding volumetric assessment, by quadrant, of calvarial asymmetry. This study aims to characterize cranial vault asymmetry in patients with unicoronal craniosynostosis focusing on posterior cranial vault volumetric changes. Additionally, we will quantify the effect of distraction osteogenesis (DO) on established cranial asymmetry.

Materials and Methods: Retrospective chart review at Rady Children’s Hospital identified 17 patients with unilateral craniosynostosis who underwent cranial vault reconstruction by internal DO. Pre- and postdistraction computerized tomography scans were analyzed using ITK-SNAP volume segmentation software. These 3-dimensional reconstructions were bisected into hemispheres by a midsagittal plane from nasion to occipital crest, and into anterior and posterior quadrants based on a coronal plane between the anterior take off of the petrosal ridges. Quadrant and hemispheric volumes were compared pre- and post-DO using paired Student’s t tests.

Results: Seventeen patients were analyzed (4 males, 13 females, age 6–32 months) over a 5-year period. Before DO, the synostotic posterior quadrant (SPQ) contained 1.9% less volume as a proportion of total intracranial volume (ICV) compared to the nonsynostotic posterior quadrant (NSPQ) (27.3% versus 29.2%; P = 0.039). Likewise, the synostotic anterior quadrant (SAQ) contained 4.3% less volume than the nonsynostotic anterior quadrant (NSAQ) (19.6% versus 23.9%; P = 0.0019).

There was no significant difference in the proportion of hemispheric volumes before or after surgery (synostotic: 48.5% versus 51.4%, P = 0.2; nonsynostotic: 43.5% versus 51.5%; P = 0.1). Following cranial distraction, total ICV increased by 27.5% (95% confidence interval, 14.9%–34.6%) with an absolute mean volume increase of 216.5 cm³ (848.5 versus 1,065 cm³). ICV change after distraction was more significant in the SAQ (mean, 34.8%) and SPQ (27.6%) compared to the contralateral quadrants (NSAQ 18.3% and NSPQ 19.4%). Despite this fact, when assessing the change in volume as a proportion of total ICV, there was no significant difference between pre- and post-DO volumes in the SPQ (27.3% versus 26.6%; P = 0.57), NSAQ (23.9% versus 23.6%; P = 0.81), or NSPQ (29.2% versus 27.9%; P = 0.21). The SAQ did show a statistically significant increase of 1.2% (19.6% versus 21.8%) following DO with a relative increase of 11.2% (P = 0.036). Postdistraction, the SAQ and SPQ contained 1.8% (48.5% versus 51.4%; P = 0.2) and 1.3% (48.5% versus 51.5%; P = 0.1) less volume than the NSAQ and NSPQ, respectively.

Conclusions: Unilateral coronal craniosynostosis leads to ICV restriction in the ipsilateral posterior quadrant in addition to the expected restriction in the SAQ, resulting in ICV asymmetry of both the anterior and posterior cranial vault. After DO, there is an increase and redistribution of ICV that is most notable in the quadrants ipsilateral to the fused coronal suture. This redistribution results in an overall improvement in cranial vault symmetry; however, minor restriction in growth of the SAQ and SPQ persists as compared to their contralateral counterparts.

Single-stage Adipofascial Turnover Flap as an Alternate Option for Large Nasal Defects Usually Requiring 2-stage Forehead Flap

Presenter: Thomas Mitchell Gallagher, MD
Co-Authors: Albert Y. Truong, BS; Anthony Capito, MD, FACS
Affiliation: Virginia Tech Carilion, Roanoke, VA

Background: Large nasal defects involving the tip, ala, and/or columella with denuded cartilage have traditionally required a 2-stage forehead flap for coverage. As many Mohs patients are presenting older with more medical comorbidities than in the past, an alternative, single-stage adipofascial turnover (AFT) flap with a full-thickness skin graft was developed by the senior author. The authors hypothesize that the AFT flap would have similar success rates, fewer complications, and less operative expense than the traditional forehead flap.