**Affiliation: Northwestern University, Chicago, IL**

**INTRODUCTION:** While the ideal synthetic material for cranioplasty remains elusive, the use of prefabricated alloplastic implants has many proposed advantages. Custom implants that fit a patient’s specific defect can reduce operative time and improve contour. Polymethyl-methacrylate (PMMA) has a long history of use for large cranioplasty defects. However, advances in 3D printing have led to an increased popularity of polymer alloplastic materials such as polyether-ketone-ketone (PEKK) implants. No direct comparisons of PMMA and PEKK exist in the literature. We present a retrospective analysis of PMMA and PEKK patient-specific implants at a single institution.

**METHODS:** A retrospective chart review was performed identifying patients undergoing patient-specific implant (PSI) cranioplasty at Northwestern Memorial Hospital between January 2013 and July 2017. Medical records were reviewed for patient characteristics, indications, surgical details, implant type, and post-operative complications. Patients were divided into groups based on cranioplasty type (PMMA vs PEKK). Comparisons between groups were made using the student’s t test and Fisher exact test.

**RESULTS:** 74 patients underwent PSI cranioplasty during the study period. Thirty-five (47.3%) had PMMA implants and 39 (52.7%) had PEEK implants. Patients were 51% male with an average age of 44. There were no differences between groups except for follow up length (17 months vs 7 months, p=0.002). Plastic surgery involvement was more common in patients with a history of infectious complications (46% v 26%). The overall failure rate for PSI cranioplasty was 14.3%. There was no difference in failure rate when comparing PMMA to PEKK (14.7% vs 13.9%, p>0.05). There was no significant difference in complications between PMMA and PEKK (41.0% vs 34.3%, P>0.05). Infection rates were equivalent between groups (17.1% vs 16.7%). Delayed wound healing was also equivalent (8.8% vs 13.9%, p>0.05). When reviewing the 10 failures, 7 occurred in patients with prior infection, 5 in patients with a history of radiation, and 3 with both.

**CONCLUSION:** PMMA and PEKK have similar complication profiles for patient-specific implant cranioplasty. Complication rates remain high for both materials, with wound healing and infectious complications and radiation carrying high risk of implant failure.

---

**Age of Cranioplasty and Surgical Risk**

**Presenter: Alexander H. Sun, BS**

**Co-Authors: Kevin Nguyen, MS; Michael Alperovich, MD, MSc**

**Affiliation: Yale School of Medicine, New Haven, CT**

**PURPOSE:** Correction of craniosynostosis has been well-established to be safe and to have sustainable results in infants. Timing of surgery, however, has remained variable based on surgical training and professional biases. This study sought to evaluate the impact of surgical timing on craniosynostosis management utilizing data from the National Surgical Quality Improvement Program (Pediatric NSQIP).

**METHODS AND MATERIALS:** All available Pediatric NSQIP data through 2016 was acquired and cranioplasty cases were selected using current procedural terminology (CPT) codes 61550, 61552, 61556, 61557, 61558, 61559 and 21175. Cases were split by patient age into four-month age intervals: 0 to <4 months, 4 to <8 months, 8 to <12 months, and 12+ months. Perioperative variables were compared between age groups, including comorbidities, total length of stay (LOS), operative time, American Society of Anesthesiologists (ASA) physical status classification, thirty-day readmissions, thirty-day reoperations, and wound infection rate. Data was analyzed in JMP statistical software (SAS Institute, Cary, NC).

**EXPERIENCE:** A total of 3,926 patients were segregated into age groups based on four-month age intervals.

**RESULTS:** There were significant differences between the age groups by ASA class (p<0.0001) and wound class (p<0.0001). A greater percentage of patients younger than 4 months were ASA class I (24.37%) compared to patients who were older than 12 months (8.92%). Conversely, a greater percentage of patients older than 12 months were ASA classes III and IV (37.38%) compared to patients younger than 4 months (20.90%). The operative time varied significantly by age group (p<0.0001 by chi-square); patients younger than 4 months had a mean operative time of 96.6 minutes, and patients older than 12 months had a mean operative time of 259.7 minutes. The length of stay also varied significantly by age group (p<0.0001). The four age groups had significantly different rates of post-operative
morbidity (p<0.0001), transfusion requirement (p<0.0001), and unexpected reoperations (p<0.0001) and readmissions (p=0.037) in the first thirty days by chi-square testing.

Patients younger than four months had lower risks of tracheostomy (p<0.0001), better sterility (p=0.0048), and a greater percentage of patients in ASA classes I and II (p<0.0001) compared to patients older than four months. As expected, the patients younger than four months of age also had shorter operation times (p<0.0001) and shorter lengths of stay (p=0.0008). Postoperatively, patients younger than four months had fewer unexpected reoperations (p=0.0008), readmissions (p=0.0377), and complications (p<0.0001), including fewer bleeding complications (p<0.0001).

CONCLUSION: Patients receiving surgery at younger than four months of age tended to have lower ASA class, with shorter procedures, less post-operative morbidity, and shorter lengths of stay. Patients older than twelve months had significantly higher ASA class, more comorbidities, longer operations and lengths of stay, and higher thirty-day reoperation and readmission rates. After a multivariate analysis, age was the single most important factor for craniosynostosis complications, increased length of stay, and readmission. Parents of patients greater than 12 months of age should be counseled about the increased risk profile in this population.

Does Autologous vs. Alloplastic Cranioplasty Affect Cranial Growth Patterns?

Presenter: Robert Thomas Nevitt, MD

Co-Authors: Greg Heuer, MD, PhD; Philip B. Storm, MD; Jesse A. Taylor, MD; Scott P. Bartlett, MD; Phuong Nguyen, MD

Affiliation: Mercy Catholic Medical Center, Darby, PA

BACKGROUND: While cranioplasty reconstructive strategies in adults include autologous bone grafts, bone substitutes, and alloplastic materials, there remains a hesitation to reconstruct pediatric cranial defects with synthetic material when paucity of autologous bone graft exists. Pediatric cranioplasty incurs challenges of increased bone resorption, timing, cranial growth, limited donor allograft, and longer exposure to foreign materials as a nidus for infection. Effect on cranial growth after cranioplasty in children is not fully elucidated. Herein, we review the cranial growth of pediatric patients who underwent cranioplasty at our institution.

METHODS: After IRB approval, a retrospective single institution review was conducted from a database of pediatric patients who underwent cranioplasty from 2000 to 2017. Patients without pre-operative, short-term (< 3 months) post-operative, and long-term (>11 months) post-operative imaging were excluded. Patients were divided into alloplastic vs. autologous reconstruction cohorts. Demographics, co-morbidities, age at surgery, etiology and size of cranial defect, type of reconstruction, time of initial surgery to reconstruction, and complications were assessed. 3D surface models were created from CT data and set to the Frankfort horizontal line, which allowed for calculation of cephalometrics pre and post-operatively including cranial growth. These cohorts were then compared to an age-specific database of 3D cranial imaging in normal subjects for assessment of growth patterns. Statistical analysis was performed using SPSS version 22.0.

RESULTS: Thirty-two patients met inclusion criteria for reconstructive cranioplasty (8 mos – 18 years, mean 9.6 years). Cephalic length, width, and 3D measurements were obtained to calculate the cephalic index at varying time points. Etiology of cranial defects included trauma (50%), neoplasm (12.5%), cerebral vascular accident (12.5%), epilepsy (9%), congenital cranial defect (9%), and herniation (4%). Twenty-three patients underwent autologous bone flap reconstruction, 7 underwent alloplastic reconstruction, and 2 underwent a combination of both. In long-term follow up, 3 alloplastic implants were lost to infection. Five autologous bone flaps were lost to infection and replaced with alloplastic materials. An additional 3 autologous bone flaps were revised due to nonunion or resorption. A total of 8 autologous and 3 alloplastic cranioplasties failed respectively. Cranial index at pre-operative, post-operative, and long-term follow up did not significantly differ between autologous vs. alloplastic cranioplasties at each age group (p=0.05 – 0.89). When compared to normative CI means, there was also no significant difference at each age group (p=0.08–0.99).

CONCLUSION: Both autologous and alloplastic cranioplasty do not appear to affect cranial growth patterns in children as compared to normative data. There was a higher failure rate in autologous cranioplasty compared to alloplastic cranioplasty. There does not appear to be a significant difference in cranial growth between autologous and alloplastic cranioplasty.