

Shayna Azoulay-Avinoam – Final Report to AAOF

Type of Award – Research Aid Award

Name of Principal Investigator – Dr. Shayna Azoulay-Avinoam DDS MS

Title of Project – Novel Machine Learning Approach to Examine Surgical Outcomes in Patients with Craniosynostosis

Period of Support – 07/01/2019 to 06/30/2020

Amount of Funding – \$5,000

Summary of Abstract –

Craniosynostosis, defined as the premature fusion of cranial sutures, is one of the most common congenital craniofacial defects occurring 1 in 2000 to 2500 live births. Patients with craniosynostosis present with distorted head shape which results from the lack of growth perpendicular to the fused suture/s and compensatory growth at normal sutures. Management of craniosynostosis requires multidisciplinary care teams that include pediatric neurologist, geneticist, plastic surgeon, neurosurgeon, and other specialists ideally in a tertiary healthcare center. Commonly performed surgical techniques include fronto-orbital advancement, open cranial vault remodeling, extended strip craniectomy, spring-assisted cranial expansion, and cranial vault distraction. Patients with craniosynostosis often present with severe maxillary/mandibular skeletal imbalances and malocclusions that require comprehensive orthodontic treatment during the teen years. Nationally representative data documenting the quality of care rendered to patients undergoing surgical corrections of craniosynostosis (this includes craniosynostosis repairs during the first few years of life and orthognathic surgeries during the late teen years) is lacking. Such data would serve to identify pathways to improve process of care and eventual outcomes. We undertook this study to address the following specific aims:

Specific Aim # 1: To examine the association between infectious complications and hospital outcomes such as in-hospital mortality, length of stay in hospital, and hospital charges. The rationale for this aim is that substantial resources are utilized in hospital settings to treat infectious complications and occurrence of these are associated with poor outcomes.

Hypothesis: We will test the hypothesis that occurrence of an infectious complication is associated with longer length of stay in hospital and higher hospital charges.

Specific Aim # 2: To identify risk factors for occurrence of infectious complications. This aim is based on the rationale that certain cohorts of patients and types of hospitals experience higher risks for infectious complications following surgical procedures.

Hypothesis: We will test the hypothesis that a mix of patient and hospital level factors are associated with occurrence of infectious complications.

We used a mix of traditional regression models and Neural Network Models to examine outcomes in those with craniosynostosis who underwent craniotomy repairs and orthognathic surgeries. A total of 8360 craniotomy repairs and 3420 orthognathic surgeries were examined in those with a diagnosis of craniosynostosis. Overall, the in-hospital mortality rates were very low. In the craniotomy repair cohorts, the overall infectious complication rate was 3.3%. Most common were viral (1.2%) and bacterial (1.1%). Six hidden layers were used in the Neural Network model predicting occurrence of infectious

complications. In terms of normalized importance, co-morbid burden (100%) and Race (81%) were strongest predictors of occurrence of infections. The Area Under Curve was 0.83. Overall, our neural network model classified 96.2% of patients accurately (developed or did not develop infection). The mean length of stay in hospital was 4.3 days. 11 hidden layers were used in the Neural Network Model for length of stay. Comorbid burden (100%), type of admission (32.2%), race (21.1%), occurrence of bacterial infections (21%), and occurrence of mycoses (12.7%) were the top 5 variables with highest normalized importance for predicting length of stay in hospital. Those who develop infections were associated with significantly higher hospital charges and length of stay in hospital.

With regards to orthognathic surgeries, a vast majority (close to 90%) were discharged routinely. Overall infection rate was 9.7% with 5.5% experiencing bacterial infections and 3.1% having post-op pneumonia. Length of stay in those with infections was 44 days (compared to 11 days in those without infections). This was significant after adjustment for confounders ($p < 0.001$). Similarly, those with infections tended to have higher hospital charges even after adjustment for confounders ($p < 0.0001$).

In conclusion, we examined hospitalization outcomes in those with craniosynostosis who underwent craniotomy repairs and orthognathic surgeries. Our results indicated that using Neural Network Models, we can accurately predict cohorts that are likely to develop infections. When infections occur, they are associated with significantly high hospital charges and longer length of stay in hospitals. We were able to successfully test our study hypotheses.

1. Were the original, specific aims of the proposal realized?

Yes. The original specific aims proposed for our study were realized.

2. Were the results published?

a. If so, cite reference/s for publication/s including titles, dates, author or co-authors, journal, issue and page numbers

Shayna Azoulay-Avinoam, Richard Bruun, James MacLaine, Veerasathpurush Allareddy, Cory M Resnick, Bonnie L Padwa. An Overview of Craniosynostosis Craniofacial Syndromes for Combined Orthodontic and Surgical Management. *Oral Maxillofac Surg Clin North Am.* 2020 May;32(2):233-247. doi: 10.1016/j.coms.2020.01.004. Epub 2020 Feb 17.

b. Was AAOF support acknowledged?

Yes. We have acknowledged the support of AAOF in the publication.

c. If not, are there plans to publish? If not, why not?

Two more manuscripts are currently being prepared and will be submitted for publication in *Journal of Oral and Maxillofacial Surgery and Cleft Palate/Craniofacial Journal*.

3. Have the results of this proposal been presented?

a. If so, list titles, author or co-authors of these presentation/s, year and locations. Our abstracts were accepted for presentation at the following meetings.

Yes. The following abstracts were presented at the AAO Annual Meeting 2020 (Virtual Session):

Shayna Azoulay-Avinoam, Deepti Karhade, Kyint Chwa, Veerasathpurush Allareddy. Use of Neural Network Artificial Intelligence Modelling to Examine Perioperative Outcomes following Craniosynostosis Surgical Repairs. E-poster presentation at the AAO Annual Meeting 2020.

Leslie Cohen, Shayna Azoulay-Avinoam, Veerasathpurush Allareddy. Orthognathic Surgeries and Facial Bone Repairs in those with Craniosynostosis: Nationwide Profile and Outcomes. E-poster presentation at the AAO Annual Meeting 2020.

b. Was AAOF support acknowledged?

Yes. We have acknowledged the support of AAOF.

4. To what extent have you used, or how do you intend to use, AAOF funding to further your career?

The support from AAOF has been pivotal for me to develop an interest in Cleft and Craniofacial Orthodontics. I have successfully obtained a Fellowship position in the Cleft and Craniofacial Orthodontics program at NYU-Langone Medical Center. I will be joining the program in July 2020. In the long term, my goal is to be affiliated with a Cleft/Craniofacial Team and provide orthodontic care to those with Cleft and Craniofacial anomalies.