AAO Foundation Award Final Report

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Award Type	Biomedical Research Award
Project Title	Craniofacial Surface Mapping: Moving Toward a 3-Dimensional Normative Model of the Human Skull
Project Year	2012-2013
Institution	UCLA
Summary/Abstract (250 word maximum)	Objectives: Existing analyses of 3D CBCT images rely upon 2D linear and angular measures to assess facial disharmony. As CBCT technology becomes more prevalent, the orthodontic and surgical community must develop tools necessary to accurately study true 3D skull morphology. The overall objectives of this project are to introduce novel methods to map the surface of the human skull in 3D, compute a 3D normative model based upon multiple patient samples, and demonstrate the utility of this technology by creating a color-coded map of surface deviation and dysmorphology of a single patient. Methods: Active patient files in the UCLA Section of Orthodontics were reviewed for the presence of a NewTom ® 3G CBCT scan. The search resulted in 67 patient scans that met the inclusion criteria for the study. CBCT files in DICOM format were first uploaded into a Beta version of Dolphin Imaging ® 11.5 Software. The surface was then segmented and topology of each skull was corrected using a principal axis star map. Shapes were mapped to a sphere and were then registered using a spherical patch mapping approach. Finally an average was created using 7-parameter procrustes alignment. Results: Size-standardized and non-size standardized average skull models were successfully created for the 67 patient sample. Color-coded displacement maps were generated for a sample patient to demonstrate the potential clinical applicability of this protocol. Conclusions: The results of this investigation suggest that it is possible to average multiple shapes of highly variable topology such as the human skull. The most immediate application of this research will be rapid and detailed diagnostic imaging analysis for orthodontic and surgical treatment planning, particularly in complex cases involving congenital facial anomalies, facial asymmetry, and trauma. There is also great potential for application to areas outside orthodontics such as anthropometrics and genomics.

Were the original, specific aims of the proposal realized?	The specific aims of this project were to: 1. Apply and modify advanced technology used in brain mapping research to accurately and efficiently map the skull surface in 3-D. 2. Apply and modify existing mathematical functions to find the average of multiple skull surfaces. 3. Develop protocol for superimposing sample skulls on the averaged skull model, yielding a color-coded map of surface deviation and dysmorphology. All of these specific aims were realized. This study developed the protocol necessary to segment the surface of the human skull, correct the topology, and register skulls of highly variable topology utilizing a spherical patch mapping approach. 67 skulls from patients with varying demographic and skeletal characteristics were then successfully averaged using 7-parameter Procrustes alignment. A sample patient skull was superimposed on this average, creating a color coded displacement map and illustrating the potential clinical utility of this protocol in diagnosis and treatment planning of patients with complex skeletal conditions. Further research efforts will focus on integrating the protocol described here with other advanced 3-dimensional imaging techniques in an attempt to develop a comprehensive analysis of craniofacial form.
Were the results published? If not, are there plans to publish? If not, why not?	A draft manuscript is currently under review and will be submitted to AJODO for consideration of publication.
Have the results of this proposal been presented? If so, when and where? If not, are there plans to do so? If not, why not?	This results were presented at the following conferences: - IADR: Oral Abstract Presentation (September 2012) - AAO Philadelphia: Posterior Presentation (April 2013) - UCLA Scientific Research Day
To what extent have you used, or how do you intend to use, AAOF funding to further your career?	This project represented the initiation of an extensive undertaking by the UCLA Section of Orthodontics in an attempt to create a full and comprehensive three-dimensional analysis of the skull. With our initial results, made possible by the generosity of this AAOF Biomedical Research Award, we have successfully created an initial skull surface average. We are now in the process of expanding this protocol to include internal craniofacial structures and will soon begin developing a comprehensive database of three-dimensional images for use in the averaging process. In addition, we are collaborating with basic science laboratories at UCLA to evaluate the utility of this protocol in evaluating genetic differences and their effect on craniofacial morphology in a mouse mandible.