Smartphone-based Measurements of Deformational Plagiocephaly and Brachycephaly: A Prospective Study

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Background: Deformational plagiocephaly and brachycephaly (DPB) is manifested in ~20% of newborns in the US. DPB can be effectively corrected by repositioning and/or physical therapy if detected and monitored before 4 months of age. The cranial index (CI) and cranial vault asymmetry index (CVAI) are used for DPB diagnosis and monitoring. As there is no current tool available for pediatricians or parents to quantitatively measure these indices at the point-of-care, we developed a smartphone app, called SoftSpot, that measures CI and CVAI from photographs of a child's head to increase the chances of early detection and treatment.

Objective: To prospectively evaluate the accuracy of the smartphone measurements of CI and CVAI in a clinical setting.

Methods: Bird's eye-view head photos of 117 infants aged 2-11 months (42 female, 75 male) were captured at a large multidisciplinary craniofacial center with the SoftSpot app (PediaMetrix Inc. Rockville, MD) using an iPhone X (Apple Inc., Cupertino, CA). The study was IRB approved and parent consent was obtained. Measurements included width, length, and diagonals of the patients' head were obtained by a single CRNP and were used to calculate CI and CVAI as the ground truth. At least five images for each patient were chosen by an analyst, CI and CVAI were automatically measured by the proprietary algorithms of the app, and results were averaged for each patient. Automated and ground truth CI and CVAI measurements were compared using the Bland-Altman method and Spearman Correlation Coefficient after excluding outliers with mean absolute error (MAE) greater than two standard deviations.

Results: MAE was 2.47 ± 1.68 for CI, 1.55 ± 1.03 for CVAI. Spearman correlation coefficients were 0.93 and 0.91 (p-values < 0.001) for CI and CVAI, respectively (see Fig. 2). Bland-Altman analysis (see Fig. 2 resulted in limits of agreement of [-4.41, 6.53] for CI and [-3.64, 3.68] for CVAI, with respective biases of 1.06 and 0.02.

Conclusion: Our app measures CI and CVAI from head 2D photos with very high correlation to caliper-based measurements obtained in the craniofacial clinic. This prospective study demonstrates the clinical feasibility of using a smartphone app for cranial measurements at the point-of-care with the potential to early detect and monitor DPB. The app can potentially be used in telemedicine encounters when in-person visits are difficult due to circumstances like COVID-19 or for remote and underserved areas.

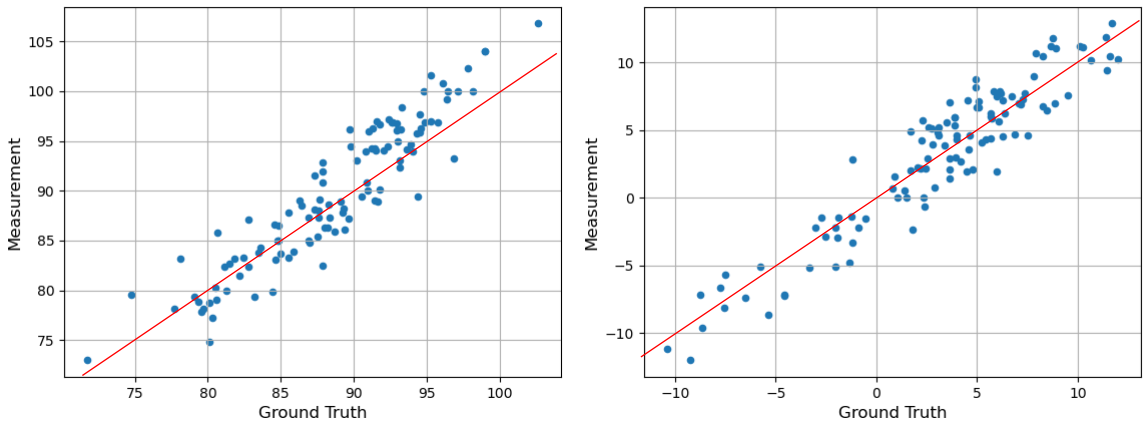

Figure 1: Correlation between ground truth (caliper) and image-based measurements for: CI (left) and CVAI (right). Red line indicates x = y.

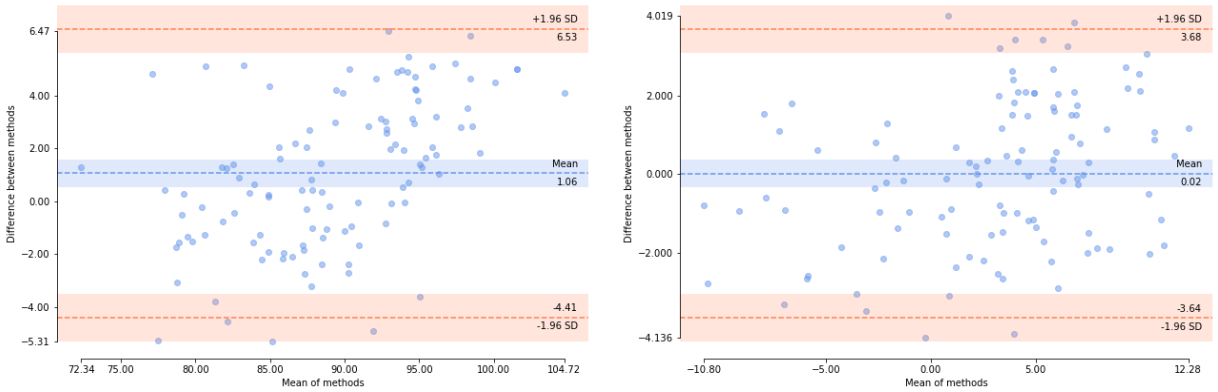

Figure 2: Bland-Altman comparison of ground truth (caliper) and smartphone-based measurements for: CI (left) and CVAI (right)