Creation of a *smart template* library for digital transradial prosthetic socket design

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Abstract— The prosthetic socket is an important interface between a residual limb and prosthesis. Its fabrication traditionally relies on manual plaster casting, which is subjective and time-consuming. Digital socket design—utilizing 3D scanning, software-based rectification, and 3D printing—offers a more efficient approach; however, it has been difficult to translate the manual, hands-on skills of clinicians to software on a computer screen. This study addresses this gap by aiming to create a digital shape library of transradial residual limbs and their corresponding sockets, which can be used by prosthetists as an evidence-based, anonymized reference system when designing a new client’s prosthesis. A matching algorithm will be developed to categorize limbs based on certain shape parameters; this algorithm can be used to match a new client’s residual limb with one from the developed library, whose corresponding socket shape can be used as a *smart template*, which acts as a validated basis for digital socket design. Preliminary results indicate that this matching algorithm can be based on i) normalizing the models according to their length; ii) slicing the model along the vertical axis to obtain 2D regions; and iii) comparing these 2D regions using certain parameters, including the Sørenson–Dice coefficient, circularity, and cross-sectional area. Qualitatively, the socket comfort scores and QUEST scores of *smart templates* will be compared with those for traditional sockets during the client’s fitting appointment to evaluate the comfort. To facilitate quantitative validation, traditional sockets will be backfilled with plaster and scanned to obtain a 3D model, which will then be rigidly aligned to the *smart template* model using the iterative closest point algorithm. Subsequently, the shape deviations will be analyzed to assess the closeness of fit. This initial library will be continuously updated with new shapes and data obtained through collaboration and continued patient care. However, this study is not without limitations: the dataset used has been obtained at a single hospital, resulting in a somewhat homogenous population, with prosthetists making similar design adjustments. Data from other hospitals could offer insights into diverse socket types and design considerations. Nevertheless, the templatization of socket design can decrease the frequency of patient visits, improve patient outcomes through increased standardization, and significantly reduce clinicians’ workloads by simplifying software-based rectification. Furthermore, its incorporation into digital socket design workflows can increase accessibility to healthcare, particularly in remote or resource-deprived regions.

Keywords— Prosthetics, Smart templates, Socket design, Socket library, Software-based rectification.