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Assessing and benchmarking low cost 3D scanners for transtibial prosthetic socket design

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Objective

Plaster casting and manual rectification are the clinical benchmark prosthetic socket design methods[1] against which new technologies should be appraised, beside high accuracy digital scanning and CAD/CAM tools[2]. Low cost CAD/CAM technologies are being proposed, including 3D printers, scanners and rectification software. We undertook a review of 3D technology innovations, and present a case study repeatability assessment of two low cost 3D scanners *in vivo* for clinically-relevant residuum shape capture, using digitised shape analysis, in comparison to a high accuracy scanner and plaster casting.

Materials and Methods

Eleven individuals with established transtibial amputation were recruited. Within a single session, their residua were scanned twice each with an Omega scanner (Creaform), and two low cost laser scanners (Sense and iSense; 3DS). Two positive plaster casts for each participant were produced by an expert prosthetist, and digitised using the Omega scanner. Deviations between scan volumes, cross-sections and shapes were calculated by Bland-Altman analysis and pairwise surface comparison.

Results

Method	Volume Repeatability Coefficient (ml)	Perimeter Repeatability Coefficient (mm)	95% Surface Area Height Deviation Mean (S.D.)
Casting	46.1 (3.47%)	9.6 (3.53%)	2.6 (0.5)
Omega Scanner	24.3 (1.83%)	4.9 (1.80%)	1.26 (0.18)
Sense Scanner	78.8 (5.93%)	15.3 (5.63%)	2.67 (0.39)
iSense Scanner	122.4 (9.21%)	20.1 (7.39%)	4.06 (0.79)

Table 1: Repeatability Results Summary

In the present study, the Sense scanner's repeatability was similar to manual plaster casting for landmarking, and slightly lower for gross measurements (Table 1). The more expensive Omega scanner outperformed all other methods.

Discussion and Conclusion

The data from this small cohort are relevant to transtibial residual limb casting but may not be applicable to other amputation levels, or orthoses. We considered variability for residuum shape capture and landmarking for subsequent rectification, where other studies have measured variability in rectification itself[3], and from residuum fluctuations[4].

This study provides a platform to appraise new clinical shape capture technologies in the context of best practice in manual plaster casting, which showed good consistency. The methods and benchmark results will support prosthetists in acquiring and applying their clinical experience, and identifying appropriate technologies in future.

References

1: ICRC 2006, *Manufacturing guidelines: trans-tibial prosthesis*
2: Dickinson et al 2016, JRRD
3: Convery et al 2003, POI
4: Sanders et al 2013, JRRD

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