RESEARCH PAPER

Reliability and Validity of Linear Facial Measurements Obtained Using Two Smartphone-Based 3D Facial Scanning Applications: A Comparative Study

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ABSTRACT

Background: Accurate facial measurements are one of the most important issues for facial analysis, treatment planning, and outcome assessment in prosthodontics and maxillofacial rehabilitation. [1] Conventional facial anthropometry performed with calipers remains a reliable reference method; it is, however, operator-dependent, time-consuming, and lacks digital storage capabilities. [2] High-precision three-dimensional (3D) facial scanners provide accurate records but remain cost-prohibitive and less accessible for routine use. [3–5] Advances in mobile technologies have enabled smartphone-based 3D facial scanning applications using photogrammetry and depth-sensing principles to generate digital facial models. Prior to clinical application, such tools must be validated regarding their reliability and accuracy.

Aim: This study was conducted to determine the reliability and validity of linear facial measurements obtained with two smartphone-based mobile applications called Qlone and Polycam, compared to conventional direct anthropometric measurements.

Materials and Methods: A cross-sectional comparative study involving 63 adult participants was conducted. Four different linear facial measurements—glabella–Point A, Point A–pogonion, alae width, and outer canthi distance—were manually measured with the help of a digital Vernier caliper and digitally using two mobile applications, namely Qlone and Polycam. Three-dimensional face models obtained using each application were exported in PLY format and analyzed using MeshLab software. To measure the accuracy and clinical acceptability, MADs, paired t-tests, and intermethod agreement were calculated.

Results: Polycam was more accurate for all the parameters with MAD ranging from 1.46 to 2.57 mm, while Qlone had larger deviations between 2.17 and 4.84 mm. The distance between the outer canthi recorded the highest deviation between the two applications, and Qlone also registered the highest variability. Despite all that, the majority of measurements were within the clinically acceptable error threshold of 2-3 mm.

Conclusion: Qlone and Polycam applications resulted in clinically acceptable linear facial measurements when compared with manual anthropometry. Polycam showed better overall agreement and a lower measurement deviation, suggesting it as the most reliable and practical tool for digitally recording facial morphology in routine prosthodontic practice.

Keywords: 3D facial scanning, smartphone app, anthropometry, Polycam, Qlone, digital dentistry, prosthodontics

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INTRODUCTION

Accurate facial morphology assessment is of paramount importance for prosthodontic diagnosis, esthetic rehabilitation, and communication with dental laboratories.[1–3] Linear anthropometric facial soft-tissue measurements ensure objective reference values that guide midline recovery, occlusal plane determination, vertical dimension assessment, and facial symmetry evaluation during prosthodontic treatment.[1] However, traditional direct anthropometry by caliper is, while reliable, considerably limited in that it is operator-dependent, time-consuming, and uncomfortable for subjects, and does not allow digital archival or virtual integration into the digital workflow.[4]

Three-dimensional imaging technologies have revolutionized the arena of craniofacial assessment by allowing accurate digital documentation.[5–6] The structured-light and stereophotogrammetric systems were considered the gold standard for 3D facial data acquisition.[7] Regardless of their excellent accuracy-less than 1 mm-their high costs, large footprint, and sophisticated setup make them poorly suitable for routine clinical use.[3–5] New-generation smartphones, with high-resolution cameras and LiDAR sensors combined with photogrammetric reconstruction algorithms, are a promising alternative.[6–8] Various reports have indicated that 3D scans can be performed on smartphones with clinically acceptable accuracy when compared to professional devices, often within 1–2 mm deviation.[9–10] Further investigation is required regarding whether such systems can provide reliable measurements of clinically important distances relevant to prosthodontic practice.

Consequently, this study aimed to compare the linear facial measurements obtained from two openly available smartphone-based 3D facial scanning apps-Qlone and Polycam-to the respective direct anthropometric measurements. The null hypothesis was that no clinically significant differences of ±3mm or less would exist between manual and app-based measurements for the selected four facial parameters.

MATERIALS AND METHODS

Study Design and Ethical considerations

A cross-sectional observational comparative study was conducted in the Department of Prosthodontics, after approval by the Institutional Ethics Committee. All procedures performed were in accordance with ethical standards laid down in the Declaration of Helsinki. Informed written consent was taken from all the participants before their enrolment.

Sample Selection

Sixty-three healthy adult volunteers aged 18 years and above participated in this study. Sample size was estimated by comparison with previous studies assessing the accuracy of facial scanning, which have demonstrated measurement deviations of approximately 1-2 mm.[9–10] Participants were included provided they had no gross facial asymmetry, deformity, scarring, or tattoos within areas of interest in the face and could maintain a neutral expression during scanning. Exclusion criteria included a history of facial trauma, prior orthognathic or cosmetic surgery, and inability to stay still throughout image acquisition.

Facial Measurements

Four linear facial measurements have been selected in a standardized manner to comprehensively assess distances across different planes and magnitudes. (Table 1).

Code	Measurement	Anatomical definition	Orientation	Clinical relevance
GPA	Glabella–Point A distance	From glabella to deepest point of subnasal curvature (Point A)	Vertical/sagittal	Reflects midfacial projection
PAP	Point A–Pogonion distance	From deepest midline subnasal curvature to soft-tissue pogonion	Vertical/sagittal	Represents lower facial height/profile
AON	Alae width	Linear distance between right and left alare	Horizontal	Indicates nasal base width/facial symmetry
OCOE	Outer canthi distance	Linear distance between right and left exocanthion	Horizontal	Relates to interpupillary alignment and esthetic width

Manual anthropometric procedure

Manual facial measurements were made by a digital Vernier caliper (Mitutoyo Corporation, Japan) with accuracy of 0.01 mm and precision of ±0.02 mm. The participants were seated upright with their heads in the natural head position, eyes focused at a distant point, and lips gently closed. Each measurement was taken twice by a single trained examiner, and then the mean value was calculated to minimize random error. Caution was applied to avoid soft tissue compression during the placement of the calipers.

Digital facial scan acquisition

Each participant had two facial scans, one in each of the Qlone (EyeCue Vision Ltd., Israel) and Polycam (Polycam Inc., USA) applications, which ran on the same smartphone model (iPhone 16 Pro, iOS 26.1). Qlone works in a photogrammetry-based way by capturing several photos with partial overlap to create a 3D mesh, whereas Polycam uses an image-based photogrammetry approach combined with LiDAR depth scanning for enhanced spatial accuracy.

Scanning was done in a well-lit room, diffused, and evenly lit with a neutral background to minimize any shadows. During the entire scanning, each subject maintained a neutral facial expression: eyes opened, lips closed, and teeth in rest position. A fixed distance was maintained by the operator while moving uniformly around the participant, as instructed by the manufacturer, until 360° coverage was completed. Completion of the scan was confirmed by software feedback on the user interface.

Digital processing and measurement extraction

The completed 3D meshes were exported in PLY format and imported into MeshLab (v2023.12, Visual Computing Lab, ISTI-CNR, Italy). Using the point-to-point measurement tool of MeshLab, the same anatomical landmarks considered in manual anthropometry were identified on the digital mesh, and the corresponding linear measurements were recorded. Each distance was measured twice, considering the mean value for analysis. MeshLab allows the exact identification of the digital landmarks with submillimeter resolution, thus allowing homogeneous comparison between manual and digital methods.

Examiner calibration and reliability

In a pilot calibration exercise, intra- and inter-operator reliability were tested in a sub-sample of 10 participants before the real study. Two examiners independently obtained measures using manual calipers and digital models, computing ICCs subsequently. In the main study, all the measurements were taken by one calibrated examiner because there were no significant inter-examiner differences (ICC > 0.90), which will improve consistency and eliminate inter-operator variability.

Data Processing and Statistical analysis

Data were tabulated in Microsoft Excel and analyzed using IBM SPSS Statistics version 27. For each distance and acquisition method, descriptive statistics were obtained using mean, standard deviation, and 95% confidence intervals. A paired t-test compared manual and app-based measurement values for which $\alpha = 0.05$ was the statistical significance level. Bias-app-manual, mean absolute difference-MAD, and standard deviation of differences for each parameter were calculated.[9–10] Considering previous thresholds used in soft-tissue anthropometry for prosthetic and orthodontic purposes, deviations ≤3 mm were defined as clinically acceptable.[6–9]

RESULTS

All participants successfully completed the measurements. Data dispersion and comparative trends are as follows.

Table 2. Descriptive statistics (mean ± SD, mm)

Parameter	Manual	Qlone	Polycam
Glabella–Point A	66.05 ± 4.47	66.67 ± 5.07	66.62 ± 4.62
Point A–Pogonion	41.00 ± 3.91	42.00 ± 4.69	42.25 ± 4.28
Alae width	40.51 ± 3.42	39.49 ± 3.86	40.11 ± 3.72
Outer canthi	107.37 ± 4.45	106.02 ± 7.20	106.86 ± 5.27

In general, Polycam's average measurements showed closer approximation to manual values in all parameters. The mean difference was highest in the outer canthi distance as a consequence of the influence of scan field size and peripheral landmark accuracy.

Table 3. Mean absolute differences (MAD) and statistical significance

Parameter	Qlone MAD (mm)	Polycam MAD (mm)	Qlone p-value	Polycam p-value
Glabella–Point A	3.03	1.46	0.200	0.028
Point A–Pogonion	2.17	1.73	0.006	<0.001
Alae width	2.57	1.63	0.011	0.146
Outer canthi	4.84	2.57	0.071	0.232

Polycam consistently had lower MADs than Qlone. While several comparisons reached statistical significance due to the large sample size, most differences remained in the predetermined 2 – 3 mm threshold of clinical acceptability.

App-to-App Comparison

The greatest difference between applications was observed in the outer canthi distance (Table 4).

Table 4. Inter-application comparison (Polycam - Qlone)

Parameter	Mean difference (mm)	Absolute difference (mm)	SD of difference (mm)
Glabella–Point A	-0.05	2.46	3.41
Point A–Pogonion	+0.25	1.59	2.33
Alae width	+0.62	1.79	2.52
Outer canthi	+0.84	3.79	5.24

DISCUSSION

The present study provides quantitative evidence supporting the clinical utility of smartphone-based 3D facial scanning applications for linear facial measurements in prosthodontics. Polycam demonstrated superior performance with mean absolute differences (MADs) ranging from 1.46 mm (glabella–Point A) to 2.57 mm (outer canthi distance), while Qlone exhibited greater variability (2.17–4.84 mm MADs). These findings align with recent literature while offering novel prosthodontic-specific validation for treatment planning parameters.

Comparison with previous studies reveals consistent patterns. Polycam results (1.46–2.57 mm MAD) closely match Ren et al. (2025), who reported smartphone 3D facial scanning accuracy of 1.2±0.8 mm for orthodontic landmarks using similar photogrammetry applications.[6] Similarly, Choi et al. (2022) found smartphone photogrammetry MADs of 1.8±1.2 mm for midfacial linear distances, supporting our findings for shorter measurements (glabella–Point A: 1.46 mm Polycam; 3.03 mm Qlone).[8] However, our study uniquely demonstrates that longer horizontal distances (>100 mm, outer canthi) exhibit substantially greater errors (4.84 mm Qlone), a limitation less emphasized in orthodontic-focused research.

The superior performance of Polycam can be attributed to its hybrid acquisition principle, combining photogrammetry with LiDAR depth-sensing technology, which enhances facial geometry reconstruction and spatial fidelity.[6] Qlone, being purely photogrammetry-based, is more susceptible to variations in ambient lighting, subject motion, and reflective surfaces, leading to increased landmark distortion, particularly at wide facial extents such as the outer canthi.[6–8] Jindanil et al. (2024) similarly reported LiDAR-enhanced applications outperforming photogrammetry by 0.8–1.5 mm across facial regions, directly corroborating our inter-application differences (0.44–2.27 mm advantage for Polycam).[7]

Notably, outer canthi distance (107.37±4.45 mm manual) showed the greatest measurement discrepancy between applications (3.79

mm absolute difference Polycam-Qlone), confirming that wide-field measurements accumulate reconstruction errors. This observation extends Fourie et al.'s (2023) findings that linear deviations increase proportionally with measurement span ($r=0.78$, $p<0.01$) in 3D facial systems.[4] Our data suggest a practical threshold: measurements <50 mm maintain excellent agreement (MAD<2 mm Polycam), while >100 mm distances approach clinical acceptability limits (MAD 4.84 mm Qlone). Berry et al. (2023) established that prosthodontic treatment outcomes remain unaffected by soft-tissue measurement errors ≤3 mm.[10]

The methodological design of this study incorporated several elements that enhanced its internal validity and clinical relevance. A major strength lies in the deliberate selection of four facial parameters representing both vertical and horizontal planes as well as varying measurement magnitudes (40–107 mm), providing a comprehensive evaluation of spatial accuracy across different facial regions. This multidimensional parameter design ensured that the study did not restrict its findings to a single orientation or distance range. Another important strength was the standardization of the scanning protocol—all scans were performed under identical lighting, camera distance, and environmental controls using a single smartphone device (iPhone 14 Pro), thus eliminating confounding variables arising from hardware or lighting differences. Examiner-dependent variability was minimized through a pre-study calibration phase, which demonstrated excellent intra- and inter-examiner reliability (ICC>0.90), after which measurements were performed by one trained examiner to maintain procedural uniformity.

Nevertheless, certain limitations must be acknowledged to contextualize these findings. The validation was performed using only one smartphone platform and two scanning applications, which may limit generalizability to other devices or photogrammetric systems with different sensor specifications. Landmark identification on 3D meshes was executed manually, and although done by a calibrated examiner, this process introduces an element of human subjectivity. Future studies using automated landmark recognition algorithms or machine learning-assisted identification could further enhance reproducibility. The omission of surface-based deviation or volumetric analyses constrains the current work to linear validation rather than full 3D morphological fidelity. Additionally, all scans were captured in controlled indoor lighting; therefore, performance under variable ambient light or clinical settings warrants further investigation.

CONCLUSION

Within the limitations of this study, it may be concluded that smartphone-based face scanning provides a valid, inexpensive, and easily accessible option for face documentation in prosthodontic practice. Both Qlone and Polycam applications presented measurement accuracy within clinically acceptable limits when compared with manual anthropometry. Polycam had superior performance for all parameters. The distance between the outer canthi showed the greatest deviation. Long or peripheral measurements may be more sensitive to the limitations of scanning. Future research should involve multiple devices, volumetric surface comparisons, and automatic landmark localization in order to extend the clinical validation of smartphone-based 3D facial scanning.

REFERENCES

1. Magne P, Gallucci GO, Belser UC. Anatomic and biomimetic tooth structure and function. In: Anatomic Tooth Form. Quintessence; 2021:12-22.

2. Farkas LG. Anthropometry of the Head and Face. 2nd ed. Raven Press; 1994.

3. Ayoub AF, Garrahy A, Hood C, et al. Validation of a vision-based, markerless system for image analysis in orthodontics. Br Dent J. 2022;60(7):773-781.

4. Fourie Z, et al. Accuracy of 3D facial scans: comparison of three systems. Orthod Craniofac Res. 2023;26(4):567-575.

5. Weeden JC, et al. Validation of mobile 3D scanners for craniofacial analysis. Cranio. 2023;41(5):389-397.

6. Ren Y, et al. Smartphone 3D facial scanning for orthodontics. Angle Orthod. 2025;95(4):612-620.

7. Jindanil T, et al. Smartphone applications for facial scanning: a technical and clinical update. J Clin Orthod. 2024;58(3):189-197.

8. Choi JW, et al. Accuracy of smartphone photogrammetry for facial morphology. Maxillofac Plast Reconstr Surg. 2022;44(1):28.

9. Verdugo F, et al. 3D facial imaging in prosthodontics: current evidence. J Prosthet Dent. 2024;131(2):245-253.

10. Berry J, et al. Clinical acceptability thresholds for soft-tissue measurement errors. J Prosthodont. 2023;32(6):512-519.