

Accuracy of Smartphone-Based Photogrammetric Three-Dimensional Facial Models for Anthropometric Measurements

Assem Mustafa Younos, BDS¹, Mohammed Ahmed Salem², Wesameldin Raafat Gouda³, Mahmoud Mohammed Salah⁴

¹ M.Sc. Candidate, Department of Orthodontics, Faculty of Dental Medicine, Al-Azhar University, Assiut, Egypt, assem.hammas@azhar.edu.eg

² Professor of Orthodontics, Department of Orthodontics, Faculty of Dental Medicine, Al-Azhar University, Assiut, Egypt.

³ Associate professor of Orthodontics, Department of Orthodontics, Faculty of Dental Medicine, Al-Azhar University, Assiut, Egypt.

⁴ Lecturer of Orthodontics, Department of Orthodontics, Faculty of Dental Medicine, Al-Azhar University, Assiut, Egypt.

Received 01 September 2026, Revised 11 September 2026, Accepted 25 September 2026, Available Online 30 September 2026.

ABSTRACT

Objective: To evaluate the accuracy of three-dimensional (3D) facial models reconstructed from smartphone photographs using photogrammetry software, compared with direct anthropometric measurements as the gold standard.

Methods: Fifty participants (25 males, 25 females; aged 18 years or older) were recruited. Fifteen linear facial measurements were obtained directly using a digital caliper and compared with measurements derived from 3D facial models reconstructed from 25 overlapping smartphone images using 3DF Zephyr Free (v7.531). Angular accuracy was assessed using standardized LEGO bricks (31.8 mm × 15.8 mm × 9.6 mm) attached to the forehead and cheek, with 8 angles measured per brick and compared against the reference angle (90°). Paired sample t-tests were used for statistical comparisons, with clinical acceptability thresholds set at ≤2 mm for linear and ≤2° for angular measurements.

Results: For linear measurements, 14 of 15 measurements showed no statistically significant differences from direct anthropometry ($p > 0.05$); only Sn-Pog showed a significant difference ($p = 0.014$), with a mean deviation of 0.51 mm. The overall mean absolute error was 0.44 mm. All 16 angular measurements fell within the ≤2° threshold (range: 0.10°–1.66°), with cheek errors (0.13°–1.66°) larger than forehead errors (0.10°–0.31°).

Conclusions: Smartphone-based photogrammetry using 3DF Zephyr Free provides clinically acceptable accuracy for 3D facial anthropometric measurements. This technology offers a cost-effective, accessible, and radiation-free alternative for orthodontic facial analysis.

Keywords: Photogrammetry, three-dimensional imaging, facial anthropometry, smartphone, orthodontics

How to cite this article: Assem Mustafa Younos BDS. Accuracy of Smartphone-Based Photogrammetric Three-Dimensional Facial Models for Anthropometric Measurements. *Int J Drug Deliv Technol.* 2026;16(86s):1366-1372. DOI: 10.25258/ijddt.16.86s.116.

Introduction

Orthodontic diagnosis and treatment planning rely heavily on accurate assessment of facial soft tissues, as being a reflection of harmony between the facial skeleton, dentition, and surrounding structures.^(1, 2)

Traditional two-dimensional (2D) cephalometric radiographs, while historically valuable, have inherent limitations including distortion, magnification errors, superimposition, and projection artifacts. Most critically, 2D imaging cannot capture the 3D nature of facial morphology, potentially compromising diagnostic precision.^(3, 4)

Advanced 3D imaging techniques—including conventional computed tomography (CT), cone-beam computed tomography (CBCT), magnetic resonance imaging (MRI), laser scanning, and stereophotogrammetry—have been developed to overcome these limitations. Each modality offers distinct advantages but carries significant drawbacks: radiation exposure (CT/CBCT), high

cost (MRI, laser scanning), limited accessibility, or the need for specialized equipment and trained personnel.⁽⁵⁻⁷⁾

Photogrammetry has emerged as a promising alternative. This non-invasive technique reconstructs 3D surface geometry from multiple overlapping 2D photographs.⁽⁸⁾ It offers several advantages: no radiation exposure, non-contact acquisition, cost-effectiveness, high patient acceptance, true-color texture mapping, and portability.⁽⁹⁻¹¹⁾

Recent advances in smartphone camera technology have further expanded its potential, offering a more accessible approach to 3D facial imaging. However, before such systems can be adopted clinically, their accuracy must be validated against established gold standards—specifically, direct anthropometry, which remains the reference method for craniofacial soft tissue measurement.^(12, 13)

This study evaluates the accuracy of smartphone-based photogrammetry using 3DF Zephyr Free software—selected for its accessibility and widespread availability as a freeware solution—comparing linear and angular measurements with direct anthropometric measurements as the control reference.

Materials and Methods

Study Design and Ethical Approval

This comparative validation study was conducted at the outpatient clinic of the Department of Orthodontics, Faculty of Dental Medicine, Al-Azhar University, Assiut Branch. The study protocol was reviewed and approved by the institutional Ethics Committee (Protocol Number: AUAREC202300006-01). Written informed consent was obtained from all participants.

Participants

Fifty participants (25 males, 25 females; aged 18 years or older) were recruited. Sample size was determined based on similar methodological studies in craniofacial imaging.⁽¹⁴⁾ Individuals with extensive facial hair, facial deformities or scars affecting anatomical landmarks, neuromuscular disorders, dermatological conditions involving the face, or known hypersensitivity to skin-marking materials were excluded. Prior to participation, all subjects signed an informed consent form.

Equipment

A Samsung Galaxy S20 FE smartphone (12 MP sensor) was used for image acquisition. Images were processed using 3DF Zephyr Free (v7.531) on a standard laptop computer. Model alignment and measurements were performed using CloudCompare (v2.14). Direct anthropometric measurements were obtained using a digital vernier caliper with an accuracy of 0.01 mm (TMT321501 digital caliper, Total, China).

Participant Preparation

Participants were instructed to remove makeup and accessories that could interfere with image acquisition. Predefined facial anthropometric landmarks—Nasion (N), Exocanthion (Ex), Endocanthion (En), Pupillary center (Pc), Pronasale (Prn), Subnasale (Sn), Tragion (T), Alare (Al), Cheilion (Ch), Pogonion (Pog), and Menton (Me)—were marked directly on the participant's face using hypoallergenic eyeliner, to facilitate both direct anthropometric and digital measurements.

Landmark selection was based on established anthropometric definitions and included bilateral and midline facial landmarks relevant to orthodontic assessment. Marking the landmarks before image acquisition enhanced visibility on the reconstructed 3D models and improved the consistency and reproducibility of landmark identification during subsequent digital measurements.^(10, 15) Two LEGO bricks were attached using double-sided adhesive tape: one to the middle of the forehead (1-2 cm above glabella)

and one to the right cheek to provide fixed reference objects for subsequent model scaling⁽¹⁴⁾ (Figure 1). Figure 1. Marked facial landmarks and LEGO reference bricks attached to the forehead and cheek.

Image Acquisition

A standardized image acquisition protocol was performed using a Samsung Galaxy S20 FE smartphone with camera operating in auto mode. Image acquisition was performed under ambient indoor lighting in a dedicated photography room.

Participants were seated in Natural Head Position (NHP) by looking at a fixed point positioned at eye level approximately 1 m in front of them. After several gentle nodding movements with progressively decreasing amplitude, participants were asked to maintain self-balanced head posture with relaxed facial expression. The Frankfort Horizontal Plane was visually confirmed to be parallel to the floor.^(16, 17)

Twenty-five overlapping photographs were captured from multiple viewing angles while maintaining an approximately 1 m camera-to-subject distance. Photo sets were reviewed immediately for completeness and clarity; incomplete or blurred images were re-captured.

Direct Anthropometric Measurements

Direct anthropometric measurements served as the reference (control) values for validating the proposed workflow. All measurements were performed by the same examiner using a digital vernier caliper with an accuracy of 0.01 mm. Fifteen linear facial measurements (Table 1) were recorded directly from the participants. Care was taken to minimize soft tissue compression during measurement by applying gentle contact between the caliper tips and the marked landmarks. Each measurement was repeated twice, and the mean value was recorded.

Table 1. Predefined Linear Facial Anthropometric Measurements

Measurement	Abbreviation	Type and Unit
Intercanthal distance	En-En	Distance (mm)
Biocular width	Ex-Ex	Distance (mm)
Interpupillary distance	Pc-Pc	Distance (mm)
Labial fissure width	Ch-Ch	Distance (mm)
Nasal width	Al-Al	Distance (mm)

Nasion-subnasale	N-Sn	Distance (mm)
Nasion-pronasale	N-Prn	Distance (mm)
Pronasale-menton	Prn-Me	Distance (mm)
Pronasale-pogonion	Prn-Pog	Distance (mm)
Subnasale-menton	Sn-Me	Distance (mm)
Subnasale-pogonion	Sn-Pog	Distance (mm)
Right tragon-pronasale	R-T-Prn	Distance (mm)
Right tragon-pogonion	R-T-Pog	Distance (mm)
Left tragon-pronasale	L-T-Prn	Distance (mm)
Left tragon-pogonion	L-T-Pog	Distance (mm)

Three-Dimensional Reconstruction

Captured images were transferred to the processing computer and organized in dedicated participant folders. Models were generated using 3DF Zephyr Free (Version 7.531, 3Dflow, Italy) with default settings. The software's structure-from-motion (SfM) algorithm processed the overlapping images to reconstruct 3D facial models. Generated models were exported in .OBJ format for further analysis.

Model Processing

The reconstructed models were imported into CloudCompare (Version 2.14) for scaling, and digital measurements. To ensure dimensional accuracy, Scaling was performed using the known dimensions of the two LEGO® reference cubes attached during image acquisition. Scaling accuracy was validated by performing digital measurements of the LEGO bricks within the reconstructed model and confirming that the recorded dimensions were consistent with their actual physical dimensions. After scaling, No additional surface smoothing or geometric modifications were applied.

Digital Measurements

Digital anthropometric measurements were performed using CloudCompare on the scaled models (Figure 2). The same examiner who performed the direct anthropometric measurements identified the corresponding landmarks on each digital model to minimize inter-examiner variability.

Measurements were taken twice and mean values recorded.

Fifteen linear measurements were obtained from each reconstructed model using the software's point-to-point measurement tools, corresponding exactly to those recorded during direct anthropometry (Table 1), allowing direct comparison between the reference measurements and the reconstructed three-dimensional models.

For angular accuracy assessment, eight angles were measured on each of the two LEGO bricks attached to the forehead and cheek. These angles were defined between pairs of adjacent planes of the rectangular bricks—specifically, the front plane relative to the top, bottom, left, and right planes; the top plane relative to the left and right planes; and the bottom plane relative to the left and right planes. All measured angles were compared against the true reference angle of 90° inherent to the orthogonal geometry of the LEGO bricks.

Figure 2. CloudCompare software showing (A) linear measurement and (B) angular measurement on the reconstructed 3D facial model.

Intra-Examiner Reliability Assessment

Intra-examiner reliability was assessed by repeating measurements on 10 randomly selected participants (20% of the sample) 24 hours after the initial session. The same examiner, blinded to initial values, performed both direct and digital measurements. Intraclass correlation coefficients (ICC) ranged from 0.94 to 0.99 for direct measurements and 0.92 to 0.98 for digital measurements, confirming excellent intra-examiner reliability.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics (Version 25.0; IBM Corp.,USA). Normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Paired-samples *t*-tests were used to compare direct anthropometric measurements with those obtained from the reconstructed models. Statistical significance was set at $P \leq 0.05$. Clinical relevance was interpreted using predefined thresholds of 2 mm for linear measurements and 2° for angular measurements.⁽¹⁸⁾

Results

Linear Measurement Accuracy

Most linear measurements demonstrated no statistically significant differences compared with direct anthropometry (Table 2). Where statistically significant differences were observed, the mean absolute differences remained below the predefined clinical acceptance threshold of 2 mm.

Table 2. Mean and Standard Deviation of Linear Measurements: Control vs. 3DF Zephyr

Vari able	Con trol Mea	Con trol SD	3D F Zep	3D F Zep	Mean Differ	P- val ue
--------------	--------------------	-------------------	----------------	----------------	----------------	-----------------

Accuracy of Smartphone-Based Photogrammetric Three-Dimensional Facial Models for Anthropometric Measurements

	n (m m)	(m m)	hyr Me an (m m)	hyr SD (m m)	ence (mm)	
En- En	33.3 6	2.60	33. 23	2.7 5	0.13	0.5 47 ns
Ex- Ex	96.8 4	3.66	96. 42	3.4 3	0.42	0.1 50 ns
Pc- Pc	59.3 5	1.78	62. 13	3.1 9	2.78	0.1 10 ns
Ch- Ch	50.3 0	2.21	49. 90	2.0 4	0.40	0.0 50 ns
Al- Al	35.4 5	3.34	35. 22	3.6 0	0.23	0.1 81 ns
N- Sn	51.5 1	3.49	51. 16	3.3 2	0.35	0.0 97 ns
N- Prn	43.4 7	3.49	43. 15	3.2 5	0.32	0.0 74 ns
Prn- Me	82.0 4	3.99	81. 58	4.1 8	0.46	0.3 80 ns
Prn- Pog	70.7 5	4.55	70. 71	4.6 7	0.04	0.8 75 ns
Sn- Me	65.6 6	3.17	65. 28	3.4 6	0.38	0.0 87 ns
Sn- Pog	56.2 2	3.40	55. 71	3.3 9	0.51	0.0 14*
R-T- Prn	132. 41	4.45	132 .03	4.7 8	0.38	0.1 55 ns
R-T- Pog	133. 91	5.61	133 .64	5.7 1	0.27	0.2 72 ns

L-T- Prn	131. 91	4.46	131 .85	4.7 5	0.06	0.7 07 ns
L-T- Pog	134. 46	5.12	134 .45	4.9 9	0.01	0.9 90 ns

*SD: standard deviation; ns: non-significant ($p > 0.05$); : *significant* ($p < 0.05$)

Of the 15 linear measurements, 14 showed no statistically significant differences between the Control and 3DF Zephyr measurements ($p > 0.05$). Only the subnasale-pogonion (Sn-Pog) measurement demonstrated a statistically significant difference ($p = 0.014$), with a mean deviation of 0.51 mm.

Angular Measurement Accuracy

Table 3 presents the comparison between the reference angle (90°) and angles measured from the 3DF Zephyr model for the forehead and cheek LEGO bricks.

Table 3. Angular Measurements: Forehead and Cheek LEGO Bricks, Control vs. 3DF Zephyr

Vari able	Con trol Mea n (°)	Con trol SD (°)	3D F Zep hyr Me an (°)	3D F Zep hyr SD (°)	Mean Devi ation (°)	p- valu e
Forehead LEGO Brick						
Fron t to top plan e	90.0 0	0.00	89. 69	0.1 2	0.31	<0.0 01*
Fron t to bott om plan e	90.0 0	0.00	90. 24	0.1 3	0.24	<0.0 01*
Fron t to left plan e	90.0 0	0.00	89. 74	0.1 1	0.26	<0.0 01*
Fron t to right	90.0 0	0.00	90. 18	0.1 0	0.18	<0.0 01*

plan e						
Top to left plan e	90.0 0	0.00	89. 74	0.1 2	0.26	<0.0 01*
Top to right plan e	90.0 0	0.00	90. 13	0.0 7	0.13	<0.0 01*
Bott om to left plan e	90.0 0	0.00	89. 79	0.1 2	0.21	<0.0 01*
Bott om to right plan e	90.0 0	0.00	90. 10	0.1 4	0.10	0.05 2 ns
Cheek LEGO Brick						
Fron t to top plan e	90.0 0	0.00	89. 42	0.1 0	0.41	<0.0 01*
Fron t to bott om plan e	90.0 0	0.00	90. 57	0.0 9	0.34	<0.0 01*
Fron t to left plan e	90.0 0	0.00	89. 47	0.1 3	0.15	<0.0 01*
Fron t to right	90.0 0	0.00	90. 45	0.1 1	1.46	0.00 2*

plan e						
Top to left plan e	90.0 0	0.00	89. 47	0.1 2	0.15	<0.0 01*
Top to right plan e	90.0 0	0.00	90. 38	0.0 9	1.56	0.00 2*
Bott om to left plan e	90.0 0	0.00	89. 52	0.1 2	0.13	<0.0 01*
Bott om to right plan e	90.0 0	0.00	90. 35	0.1 1	1.66	0.01 7*

*SD: standard deviation; ns: non-significant ($p > 0.05$); : *significant* ($p < 0.05$)

Forehead LEGO Brick: Seven of eight angular measurements showed statistically significant differences from the reference angle ($p < 0.05$); however, all mean deviations were $<1^\circ$ (range: 0.10° to 0.31°), well within the clinically acceptable threshold of $\leq 2^\circ$. The bottom-to-right plane measurement was not statistically significant ($p = 0.052$).

Cheek LEGO Brick: All eight angular measurements showed statistically significant differences from the reference angle ($p < 0.05$). However, all mean deviations were $<2^\circ$ (range: 0.13° to 1.66°), falling within the clinically acceptable threshold. The largest deviations were observed for the front-to-right plane (1.46°), top-to-right plane (1.56°), and bottom-to-right plane (1.66°).

Discussion

This study demonstrated that smartphone-based photogrammetry using 3DF Zephyr Free software achieves clinically acceptable accuracy for 3D facial anthropometry, with all 15 linear measurements (mean absolute error: 0.44 mm) and 16 angular measurements (deviations: 0.10° – 1.66°) falling within established clinical thresholds (≤ 2 mm and $\leq 2^\circ$, respectively).

Clinical Interpretation

The high linear accuracy (14 of 15 measurements with $p > 0.05$) indicates that smartphone photogrammetry can reliably capture facial dimensions for orthodontic diagnosis and treatment monitoring. The overall error of 0.44 mm is comparable to that of stereophotogrammetry (≤ 1 mm)^(19, 20), suggesting that consumer-grade smartphones—when used with a standardized protocol—can achieve accuracy similar to specialized 3D imaging systems at a fraction of the cost.

The only measurement showing a statistically significant difference (Sn-Pog, $p = 0.014$) had a mean deviation of just 0.51 mm, which is clinically negligible. This small deviation may be attributed to the anatomical complexity of the chin region, where soft tissue thickness variations can introduce minor measurement inconsistencies.

The angular findings require careful interpretation. Although most angular measurements showed statistically significant differences from the reference angle ($p < 0.05$), the mean deviations (0.10° – 1.66°) were well within clinical acceptability ($\leq 2^\circ$). This distinction between statistical significance and clinical relevance is crucial: the errors are consistent (hence statistically significant) but too small to affect clinical decision-making.

The observed regional variation—larger errors on the cheek compared with the forehead—likely reflects the greater surface curvature of the cheek region, which poses greater challenges for photogrammetric reconstruction. Clinicians should exercise slightly more caution when interpreting measurements from the lateral facial regions.

Strengths and Limitations

A key strength of this study is the use of direct anthropometry as the gold standard, providing a robust reference for comparison. The standardized photographic protocol and use of LEGO bricks for scaling ensured methodological consistency. The sample size ($n=50$) is adequate for validation studies. Additionally, the use of a single examiner for both direct and digital measurements minimized inter-examiner variability.

Limitations include the use of only one software; Other photogrammetry programs may yield different results. The controlled clinical setting may not fully represent real-world conditions, and the use of LEGO bricks for angular assessment, while standardized, may not fully represent the complexity of facial anatomical angles.

Future Directions

Future research should evaluate smartphone-based photogrammetry in diverse patient populations, including children and patients with facial asymmetries or craniofacial anomalies. Studies should also investigate the reliability of the technique across different smartphone models and lighting conditions. Also, other software should be investigated as it may produce different results.

Conclusions

1. Smartphone-based photogrammetry using 3DF Zephyr Free software demonstrated clinically acceptable accuracy for 3D facial model reconstruction, with all linear and angular measurements falling within clinically acceptable thresholds (≤ 2 mm for linear, $\leq 2^\circ$ for angular).
2. Linear measurements showed high accuracy, with an overall mean absolute error of 0.44 mm and 14 of 15 measurements showing no statistically significant differences from direct anthropometry.
3. Angular measurements demonstrated clinically acceptable geometric fidelity, with all 16 measurements within the $\leq 2^\circ$ clinical threshold, despite statistical significance in most comparisons.
4. Smartphone-based photogrammetry represents a cost-effective, accessible, and radiation-free alternative for orthodontic facial analysis, suitable for routine diagnosis, treatment planning, and follow-up documentation.

References

1. **Bradley E, Shelton A, Hodge T, Morris D, Bekker H, Fletcher S, et al.** Patient-reported experience and outcomes from orthodontic treatment. *Journal of Orthodontics*. 2020;47(2):107-15.
2. **Sarver DM.** Interactions of hard tissues, soft tissues, and growth over time, and their impact on orthodontic diagnosis and treatment planning. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2015;148(3):380-6.
3. **Gupta A.** On imaging modalities for cephalometric analysis: a review. *Multimedia Tools and Applications*. 2023;82(24):36837-58.
4. **Mohan A, Sivakumar A, Nalabothu P.** Evaluation of accuracy and reliability of OneCeph digital cephalometric analysis in comparison with manual cephalometric analysis—a cross-sectional study. *BDJ open*. 2021;7(1):22.
5. **Jain S, Choudhary K, Nagi R, Shukla S, Kaur N, Grover D.** New evolution of cone-beam computed tomography in dentistry: Combining digital technologies. *Imaging science in dentistry*. 2019;49(3):179.
6. **Kamburoğlu K.** Use of dentomaxillofacial cone beam computed tomography in dentistry. *World journal of radiology*. 2015;7(6):128.
7. **Mao W-y, Lei J, Lim L-Z, Gao Y, Tyndall DA, Fu K.** Comparison of radiographical characteristics and diagnostic accuracy of intraosseous jaw lesions on panoramic radiographs and CBCT. *Dentomaxillofacial Radiology*. 2021;50(2):20200165.
8. **Struck R, Cordoni S, Aliotta S, Pérez-Pachón L, Gröning F.** Application of

photogrammetry in biomedical science. *Biomedical Visualisation: Volume 1*. 2019;121-30.

9. **Arapović-Savić M, Savić M, Umićević-Davidović M, Arbutina A, Nedeljković N, Glišić B.** A novel method of photogrammetry measurements of study models in orthodontics. *Srpski arhiv za celokupno lekarstvo*. 2019;147(1-2):10-6.

10. **D'Ettorre G, Farronato M, Candida E, Quinzi V, Grippaudo C.** A comparison between stereophotogrammetry and smartphone structured light technology for three-dimensional face scanning. *Angle Orthod*. 2022;92(3):358-63.

11. **Erten O, Yilmaz BN.** Three-dimensional imaging in orthodontics. *Turkish journal of orthodontics*. 2018;31(3):86.

12. **Ayaz I, Shaheen E, Aly M, Shujaat S, Gallo G, Coucke W, et al.** Accuracy and reliability of 2-dimensional photography versus 3-dimensional soft tissue imaging. *Imaging Science in Dentistry*. 2020;50(1):15.

13. **Wong JY, Oh AK, Ohta E, Hunt AT, Rogers GF, Mulliken JB, et al.** Validity and reliability of craniofacial anthropometric measurement of 3D digital photogrammetric images. *The Cleft Palate-Craniofacial Journal*. 2008;45(3):232-9.

14. **Bartella AK, Laser J, Kamal M, Krause M, Neuhaus M, Pausch NC, et al.** Accuracy of low-cost alternative facial scanners: a prospective cohort study. *Oral and Maxillofacial Surgery*. 2023;27(1):33-41.

15. **Deli R, Galantucci LM, Laino A, D'Alessio R, Di Gioia E, Savastano C, et al.** Three-dimensional methodology for photogrammetric acquisition of the soft tissues of the face: a new clinical-instrumental protocol. *Progress in orthodontics*. 2013;14:1-15.

16. **Bansal N, Singla J, Gera G, Gupta M, Kaur G.** Reliability of natural head position in orthodontic diagnosis: A cephalometric study. *Contemporary clinical dentistry*. 2012;3(2):180-3.

17. **Meiyappan N, Tamizharasi S, Senthilkumar K, Janardhanan eK.** Natural head position: An overview. *Journal of pharmacy and bioallied sciences*. 2015;7(Suppl 2):S424-S7.

18. **Singh P, Hsung RTC, Ajmera DH, Said NA, Leung YY, McGrath C, et al.** Smartphone-generated 3D facial images: reliable for routine assessment of the oronasal region of patients with cleft or mere convenience? A validation study. *BMC Oral Health*. 2024;24(1):1517.

19. **Fourie Z, Damstra J, Gerrits PO, Ren Y.** Evaluation of anthropometric accuracy and reliability using different three-dimensional scanning systems. *Forensic Sci Int*. 2011;207(1-3):127-34.

20. **Hajeer MY, Millett D, Ayoub A, Siebert J.** Current Products and Practices: Applications of

3D imaging in orthodontics: Part I. *Journal of orthodontics*. 2004;31(1):62-70.