Open Access Research Journal of
Engineering and Technology
Journals home page: https://oarjpublication/journals/oarjet/
ISSN: 2783-0128 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Check for updates

Comparative analysis of 3D mesh topology generated by mobile photogrammetry

Livia Maria de Tilio *, João Vitor Gazana and Galdenoro Botura Junior

São Paulo State University (UNESP), Faculty of Architecture, Arts, Communication and Design (FAAC), Graduate Program in Design, Bauru, São Paulo, Brazil.

Open Access Research Journal of Engineering and Technology, 2026, 10(01), 024-031

Publication history: Received on 20 December 2025; revised on 28 January 2026; accepted on 30 January 2026

Article DOI: https://doi.org/10.53022/oarjet.2026.10.1.0013

Abstract

This research comparatively evaluated two 3D scanning applications for mobile devices, Kiri Engine and Polycam, in the development of customized external breast prostheses. The applications were used to capture images of a mastectomized volunteer in a controlled environment. The objective was to compare the topological quality of the generated meshes, considering height, vertex and face density, as well as to evaluate the performance of the capture modes (video and photo). The results indicated that both applications failed in the height criterion, compromising the dimensional accuracy of the models. Regarding vertex and face density, Kiri Engine performed better, generating more detailed models. Polycam, although producing lower-density meshes, still generated viable models for rapid prototyping. The video capture mode offered greater consistency in the meshes, especially in the case of Kiri Engine. Despite having lower accuracy compared to specialized equipment, both applications demonstrated significant feasibility. They also showed improvement potential with adjustments to processing algorithms and capture techniques. The ability to perform scans with mobile devices makes the breast prosthesis customization process more accessible, with significant implications for cost reduction and increased practicality for professionals and patients.

Keywords: 3D Scanning; External Breast Prostheses; Kiri Engine; Polycam; Mesh Topology

1. Introduction

Breast cancer is the most frequently diagnosed neoplasm among women worldwide, accounting for approximately 11.6% of all cancer cases diagnosed in 2022, with about 2.3 million new cases and 670,000 deaths reported globally [1]. This pattern of high incidence is also observed in Brazil, where an estimated 73,610 new cases are expected annually during the 2023–2025 triennium, corresponding to an adjusted rate of 41.89 cases per 100,000 women, with the highest rates occurring in the South and Southeast regions of the country [2].

Among the procedures adopted for breast cancer treatment, mastectomy stands out as a surgical intervention involving total or partial removal of the breast and, depending on the patient's clinical condition, may include excision of axillary lymph nodes [3]. Although breast reconstruction is a right guaranteed by the Brazilian Unified Health System (SUS), immediate reconstruction is not always feasible due to clinical limitations or advanced tumor stage [4]. In addition, access to reconstructive surgery remains limited in the public healthcare system: it is estimated that only about 20% of mastectomized women undergo breast reconstruction, either immediately or at a later stage [5].

Given the restricted access to reconstructive surgery following mastectomy, external breast prostheses represent a relevant alternative for women who cannot or choose not to undergo this procedure. In this context, technologies such as 3D modeling and additive manufacturing have emerged as promising strategies for the development of personalized assistive technology resources [6]. The growing use of three-dimensional digitization has been driven both by technological advances and increased accessibility to digital tools. The availability of free software and the integration

* Corresponding author: Livia Maria de Tilio

of high-resolution cameras into mobile devices have contributed to making these processes more widespread and replicable across different applications [7].

Within this framework, the present study proposes a comparative evaluation of two mobile photogrammetry-based 3D scanning applications, Kiri Engine and Polycam, to investigate the use of mobile devices for three-dimensional capture of the torso of a mastectomized patient, a crucial step in the customized fabrication of external breast prostheses. The overall objective is to assess the feasibility of this digitization process, focusing on the topological quality of the meshes generated by each application under two capture modes: video and photographs.

The comparative analysis was based on mesh topology, considering parameters such as height distribution, number of vertices, and number of faces, which directly impact the final quality of the prostheses produced. For this purpose, the *wireframe* tool in Blender software was employed, allowing visualization of the internal mesh structure and comparison of polygon density.

The main hypothesis is that the Kiri Engine application would present superior mesh topology performance when compared to Polycam. Through this investigation, the study aims to contribute to the development of more accessible and effective technological alternatives for the fabrication of customized external prostheses, while also addressing gaps in the literature regarding 3D digitization applied to product design in healthcare contexts.

2. Theoretical background

Advances in digital technology have enabled new possibilities in the healthcare field, particularly in the development of customized external prostheses. The combination of 3D scanning and additive manufacturing allows the production of devices with high geometric precision, anatomical fidelity, and individualized customization, representing a promising alternative for users who do not have immediate access to surgical breast reconstruction [8,9]. Recent studies indicate that the integration of these technologies enables the creation of breast prostheses that not only replicate breast anatomy but also provide improved comfort and aesthetics, contributing positively to the quality of life of mastectomized women [10,11].

Three-dimensional digitization of anatomical structures can be performed using different technologies, including laser scanners, structured light scanning, and photogrammetry [12]. Photogrammetry relies on multiple two-dimensional images captured from different angles, which are processed by specific algorithms to generate an accurate three-dimensional surface [13,14]. Improvements in triangulation algorithms, surface modeling, and the evolution of open-source software have significantly enhanced photogrammetry quality, making it a viable and accessible technique for various contexts, including applications using mobile device cameras [7].

The use of mobile devices for 3D scanning has become increasingly consolidated as a practical and low-cost solution. Applications such as Kiri Engine and Polycam allow the creation of three-dimensional models from photos or videos captured directly by smartphones, processing data in the cloud and offering tools for editing, refinement, and texture adjustment. Kiri Engine combines advanced photogrammetry techniques with neural radiance fields (NeRF), enabling detailed reconstructions and flexible visualization of scanned objects [15]. Polycam offers similar functionalities, with the added advantage of integrating LiDAR sensors in compatible devices, enhancing depth capture and geometric detail [16].

The growing development of accessible 3D digitization technologies, such as Kiri Engine and Polycam, democratizes access to personalized solutions, enabling external prosthesis fabrication to become faster and more economically viable, particularly in resource-limited contexts. The combination of mobile devices, photogrammetry, and additive manufacturing represents a significant advancement in prosthesis planning and fabrication, opening new perspectives for personalization and innovation in healthcare [17].

3. Methodology

3.1. Study Characteristics and Ethical Aspects

This study was adapted from the protocol proposed by Tannús et al. [18], who compared 3D digitization techniques such as photogrammetry and structured light scanning using medium-sized objects as references. The principles of these protocols were applied to the digitization of the torso of a mastectomized volunteer, ensuring methodological consistency and reproducibility.

All procedures were conducted in accordance with Resolution No. 466/2012 of the Brazilian National Health Council [19] and were approved by the Research Ethics Committee of Dr. Amaral Carvalho Foundation (CAAE 82525724.4.0000.5434; approval No. 7,066,938).

3.2. Participants

The study included one participant who had undergone mastectomy, selected through convenience sampling. The participant was informed about the objectives of the study and provided written informed consent prior to participation.

3.3. Capture Environment

- Location: closed room with controlled lighting;
- Patient position: seated on a chair, relaxed posture, with a 90° angle relative to the camera;
- Distance between mobile device and participant: approximately 40 cm.

The capture environment and participant positioning adopted during data acquisition are illustrated in Figure 1.

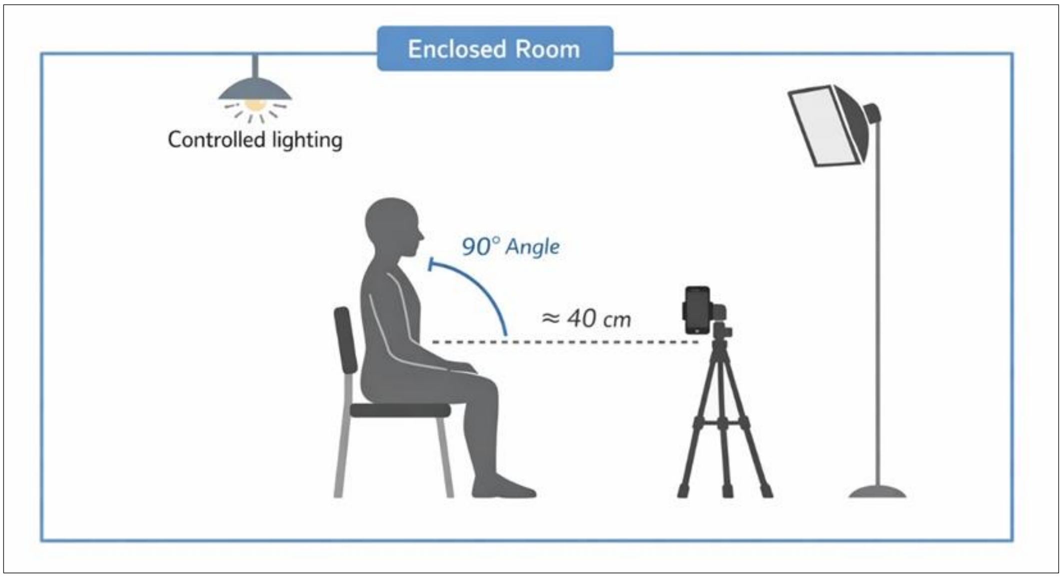

Figure 1 Capture environment and participant position adopted during 3D data acquisition

3.4. Instruments and Software

- Mobile device used for 3D scanning:
- iPhone XR (Apple Inc, iOS version 18.6.2).
- 3D scanning applications:
- Kiri Engine (proprietary software, freemium model);
- Polycam (proprietary software, freemium model).
- 3D processing and visualization software:
- Blender (free and open-source software);
- Meshmixer (freeware).

3.5. Capture Modes

Data acquisition was performed using two capture modes:

- Photographs: 45 images captured circumferentially around the patient’s torso;
- Video: a continuous full rotation video captured around the patient.

3.6. Analysis Criteria

The comparative evaluation focused on mesh topology. The following parameters were quantified:

- Number of vertices;

- Number of faces;
- Mesh height.

The wireframe visualization tool in Blender was used to enable detailed geometric analysis of each model.

3.7. Methodological Procedures

The methodological procedures comprised the following steps, as illustrated in Figure 2.

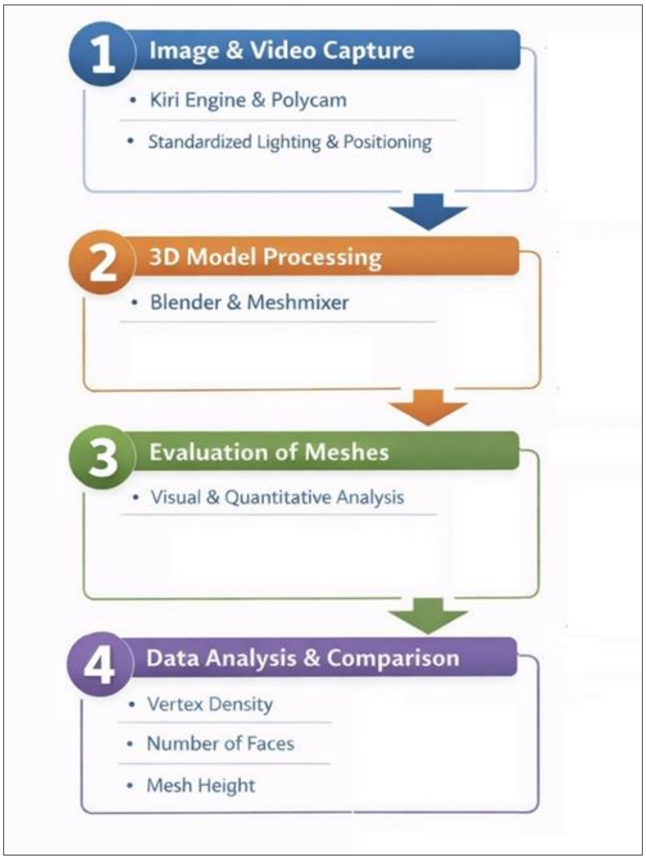

Figure 2 Methodological Procedures

- Image and video capture using Kiri Engine and Polycam under standardized lighting and patient positioning conditions;
- Processing of the generated 3D models using Blender and Meshmixer;
- Visual and quantitative evaluation of the meshes based on predefined parameters;
- Data recording and comparative analysis between the applications in terms of vertex density, number of faces, and mesh height, aiming to assess geometric fidelity and suitability for customized prosthesis fabrication.

3.8. Data Analysis

The collected data were organized into images and tables, enabling both visual and quantitative comparisons between applications and capture modes. The analysis considered dimensional variations, vertex and face density, and additional metrics relevant to the final quality of the prostheses.

4. Results

The analysis revealed that both evaluated applications, Kiri Engine and Polycam, were capable of generating consistent three-dimensional representations with potential applicability in the customization of external breast prostheses. However, the dimensional accuracy of models generated using mobile devices was lower than that achieved with more advanced scanning equipment. Although the 3D models provided a satisfactory representation of the affected breast, limitations were identified, particularly regarding dimensional precision. Observed variations suggest that improvements in software processing and capture techniques could enhance the technology, making it more accurate and efficient for producing higher-quality prostheses.

Figures 3 and 4 present the models generated by both applications and processed in Blender software. Figure 3 illustrates the generated meshes, enabling a visual comparison of reconstruction quality between photo and video capture modes.

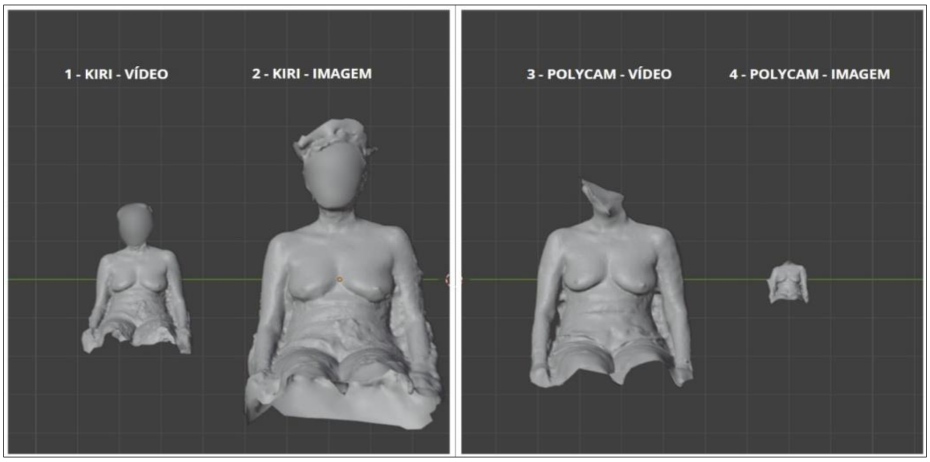

Figure 3 Comparison of 3D models

Figure 4 presents the digital measurements performed on the 3D models, highlighting dimensional variations between the capture modes.

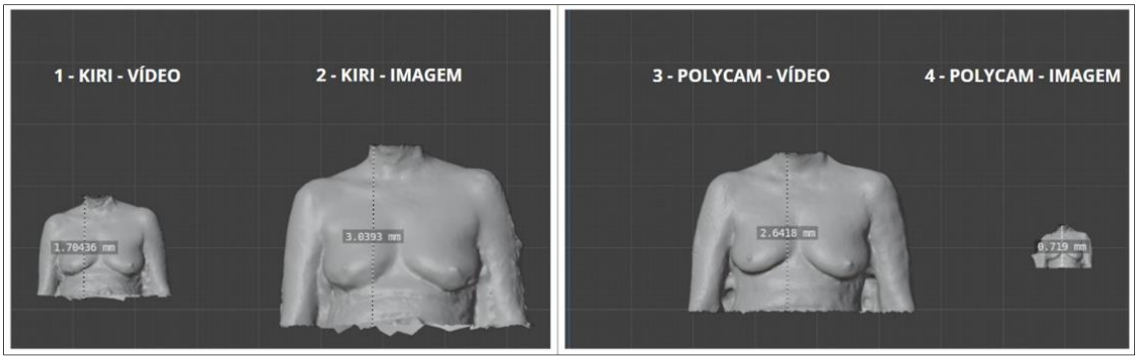

Figure 4 Comparison of digital measurements of 3D models

Table 1 summarizes the comparative analysis between Kiri Engine and Polycam based on height (mm), number of vertices, and number of faces, parameters that directly affect prosthesis quality. The *wireframe* tool in Blender enabled visualization of internal mesh structure and polygon density differences.

Table 1 Digital measurements of 3D models generated in Blender

Software – Capture	Height (mm)	Vertices (number)	Faces (number)
Kiri Engine - Photos	3.039	26,056	51,704
Kiri Engine - Video	1.704	42,120	83,793
Polycam - Photos	0.719	17,544	34,718
Polycam - Video	2.641	11,866	23,356

Regarding model height, Kiri Engine using photo capture generated the highest value (3.039 mm), whereas Polycam with photo capture produced the lowest value (0.719 mm). Significant discrepancies between capture modes were observed in both applications, indicating limitations in dimensional standardization, particularly for height, a critical parameter for morphological fidelity.

In terms of vertex count, Kiri Engine demonstrated a substantial advantage in video capture, with 42,120 vertices, an increase of 61.65% compared to photo capture. Polycam showed smaller differences between capture modes, suggesting that video capture did not significantly enhance mesh complexity for this application.

Similarly, Kiri Engine exhibited superior performance in face count during video capture (83,793 faces), whereas Polycam showed higher face counts in photo capture mode. These findings indicate that while Kiri Engine benefited from increased detail in video capture, Polycam presented an inverse performance trend.

5. Discussion

The comparative analysis between the Kiri Engine and Polycam applications revealed relevant findings regarding the applicability of mobile 3D scanning technologies in the fabrication of customized external breast prostheses. Although both applications demonstrated potential, the dimensional accuracy of the generated models still presents limitations, particularly in terms of height, which did not faithfully represent the real dimensions of the scanned object. This finding highlights the need for improvements in processing algorithms and calibration techniques [21, 3].

Regarding mesh quality, the results indicated that Kiri Engine tends to generate models with a higher number of vertices and faces, resulting in greater surface detail and smoothness, whereas Polycam showed greater variability, although it was also capable of producing detailed models, especially when configured for higher quality levels. These findings are consistent with studies that assess mobile 3D scanning in clinical and aesthetic contexts, which emphasize the importance of vertex and face density to ensure accuracy and clinical usability [22, 23].

Comparison with previous studies confirms that accuracy remains a challenge: models generated using mobile devices still do not reach the same level of precision as those produced by specialized equipment. However, they stand out due to their accessibility and ease of use, enabling scanning procedures to be performed in resource-limited settings [3]. The implementation of more sophisticated algorithms and the incorporation of depth sensors are promising strategies for increasing the fidelity of three-dimensional models and improving their clinical applicability.

Therefore, both applications demonstrate potential for the fabrication of customized prostheses, provided that good scanning practices are followed and the limitations of each tool are considered. Future studies should focus on the clinical validation of the generated models, including testing with real patients, volumetric overlap assessments, and the exploration of artificial intelligence–based methods to enhance the robustness of 3D reconstruction.

6. Conclusion

This study aimed to evaluate the Kiri Engine and Polycam applications for generating 3D models intended for the fabrication of customized external breast prostheses. The results demonstrated that both applications offer intuitive interfaces, facilitating agile capture and export of models in accordance with application guidelines.

Both applications proved feasible for scanning the volunteer's breast region and generating 3D models suitable for additive manufacturing. Based on the proposed evaluation criteria, particularly mesh topology, both applications exhibited acceptable performance in photo and video-based models, although improvements in capture techniques remain necessary.

Height measurements revealed limitations in accurately representing real object dimensions. Nevertheless, Kiri Engine showed quantitative advantages in vertex and face counts, indicating greater potential for producing geometrically detailed and faithful prostheses.

Improvements in object scaling and dimensional calibration are recommended, including the use of reference objects with known dimensions during scanning. While mobile devices offer accessible and practical alternatives to professional scanners, inherent precision limitations highlight the importance of skilled post-processing. Future studies should extend beyond digital model generation to include physical prosthesis fabrication and comprehensive functional and aesthetic evaluation.

Compliance with ethical standards

Acknowledgments

This work was supported by the National Council for Scientific and Technological Development (CNPq) – Processes 307215/2022-9 and 473235/2011-0; and the Coordination for the Improvement of Higher Education Personnel – Brasil (CAPES) – Funding Code 001.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of Ethical Approval

This study was conducted in accordance with Resolution No. 466/2012 of the Brazilian National Health Council and was approved by the Research Ethics Committee of the Dr. Amaral Carvalho Foundation (CAAE 82525724.4.0000.5434; approval No. 7,066,938).

Statement of Informed Consent

Informed consent was obtained from all participants involved in the study.

References

[1] Almeida CSC, et al. Comparative analysis of mastectomies and breast reconstructions performed in the Brazilian Unified Health System over the last five years. Brazilian Journal of Plastic Surgery. 2021;36(3):263–269. doi:10.5935/2177-1235.2021RBCP0039.

[2] Baleotti LR, Medola FO, Rodrigues OV. 3D digitization and printing in assistive technology: development of an upper-limb orthosis. In: Medola FO, Paschoarelli LC, editors. Assistive Technology: Development and Application. Bauru: Channel Publishing House; 2018. p. 199–206.

[3] Baronio G, Harran S, Signoroni A. A critical analysis of a hand orthosis reverse engineering and 3D printing process. Applied Bionics and Biomechanics. 2016;2016:1–7. Available from: ResearchGate.

[4] Brazil. Law No. 12,802, of April 24, 2013. Provides for the mandatory breast reconstruction in cases of mutilation resulting from cancer treatment. Official Gazette of the Federative Republic of Brazil. April 24, 2013. Available from: Planalto website.

[5] Carrivick JL, Smith MW, Quincey DJ. Structure from motion in the geosciences. Hoboken: John Wiley & Sons; 2016.

[6] Lyons E, et al. 3D printed lightweight breast prostheses for a patient of breast size 38F who was unhappy with the heavy weight of their silicone prosthesis. Curr Probl Cancer Case Rep. 2025;18:100366. doi:10.1016/j.cpccr.2025.100366.

[7] Haleem A, Javaid M. 3D scanning applications in medical field: a literature-based review. Clin Epidemiol Glob Health. 2019;7(2). Available from: Elsevier ScienceDirect.

[8] National Cancer Institute (INCA). Breast cancer data and statistics: 2023 annual report [Internet]. Rio de Janeiro: National Cancer Institute; 2023 [cited 2024 Mar 31]. Available from: INCA website.

[9] National Cancer Institute (INCA). Cancer incidence in Brazil: 2023 estimates. Rio de Janeiro: National Cancer Institute; 2023.

[10] National Cancer Institute (INCA). Breast cancer treatment [Internet]. Rio de Janeiro: National Cancer Institute; 2024 [cited 2024 Apr 10]. Available from: INCA website.

[11] Kiri Engine. Kiri Engine: 3D Scanner App [Internet]. 2025 [cited 2025 Sep 16]. Available from: https://www.kiriengine.app/.

[12] Leme JC, et al. Development of low-cost and personalized external silicone breast prosthesis produced by additive manufacturing for women who have undergone mastectomy: a pilot study. Clin Biomech. 2023;110:106123. doi:10.1016/j.clinbiomech.2023.106123.

[13] Luhmann T, et al. Close-range photogrammetry and 3D imaging. 2nd ed. Berlin: De Gruyter; 2023.

[14] Maia BA. Dimensional parameterization, by regression model, of hand prostheses for children manufactured by additive manufacturing [dissertation]. Catalão: Federal University of Goiás; 2016. Available from: Federal University of Goiás repository.

[15] Moraes CAC, Dornelles R, da Rosa E. Facial photogrammetry protocol. v.1. 2020. ISBN 978-65-00-05349-4. doi:10.6084/m9.figshare.12923801.v1.

[16] Oncoguia. Breast reconstruction: only 30% of women with breast cancer have access through the Brazilian Unified Health System [Internet]. 2021 [cited 2025 Apr 10]. Available from: Oncoguia website.

[17] Polycam. Polycam: 3D Scanner App [Internet]. 2025 [cited 2025 Sep 16]. Available from: https://poly.cam/.

[18] Sung H, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2023;73(1):17–48. doi:10.3322/caac.21660.

[19] Tannús J, et al. Comparison between photogrammetry techniques and structured light scanning for 3D object reconstruction. In: Scientific Initiation Workshop – Symposium on Virtual and Augmented Reality (SVR); 2019. Proceedings. p. 21–22.

[20] Titmus M, et al. A workflow for the creation of photorealistic 3D cadaveric models using photogrammetry. J Anat. 2023;243(2):319–333. doi:10.1111/joa.13872.

[21] Botti E, Jansen B, Ballen-Moreno F, Kapila A, Brahimetaj R. Evaluating the accuracy and repeatability of mobile 3D imaging applications for breast phantom reconstruction: insights for clinical scanning. Sensors (Basel). 2025;25(15):4596. doi:10.3390/s25154596.

[22] Mai H-N, Lee D-H. Accuracy of mobile device–compatible 3D scanners for facial digitization: systematic review and meta-analysis. J Med Internet Res. 2020;22(10):e22228. doi:10.2196/22228.

[23] Hartmann R, Nieberle F, Palm C, et al. Utility of smartphone-based three-dimensional surface imaging for digital facial anthropometry. JPRAS Open. 2024;39:330–343. doi:10.1016/j.jpra.2024.01.014.