EP-150

영상 기반 3차원 재구성을 이용한 유두 부피 측정의 새로운 접근

(Validation of a Video-Based Three-Dimensional Technique for Nipple Volume Measurement: A Comparative Study With Conventional Methods)

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Purpose : With the increasing demand for nipple reconstruction following mastectomy, accurate and objective nipple volume assessment has become essential for both clinical evaluation and research standardization. Conventional techniques including mold based water displacement, geometric approximation, CT, and Antera 3D® are limited by procedural complexity, cost, radiation exposure, or patient discomfort. This study aimed to propose and validate a novel non-contact, video-based three-dimensional nipple volume measurement method using Gaussian splatting and to compare its accuracy with established techniques.

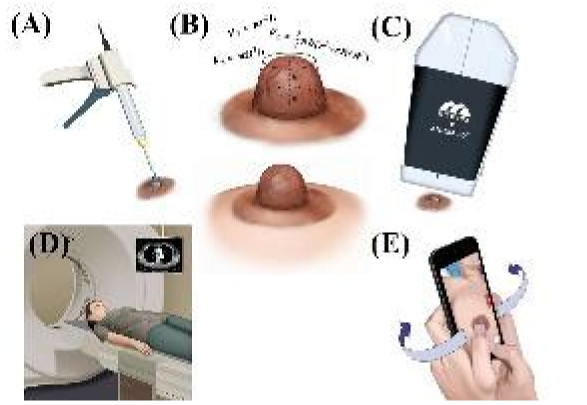

Fig.1 Schematic diagram showing five nipple volume measurement methods. Nipple volume can be measured using silicone molds with water displacement(A), manual geometric estimation(B), or 3D imaging devices(C). It can also be calculated through volumetric reconstruction from CT scans with 3D modeling(D). Recently, smartphone video with Gaussian splatting and surface meshing has emerged as a novel method(E).

Methods : We retrospectively analyzed 37 nipples from 32 women for 2 years. Silicone mold–based water displacement was used as the reference standard. Comparative methods included geometric estimation, CT-based reconstruction, Antera 3D®, and a smartphone-based approach using Gaussian splatting with 3D mesh algorithms. Volumes(cm³) were compared using one-way ANOVA, mean squared error, and Bland–Altman analysis to assess agreement and accuracy.

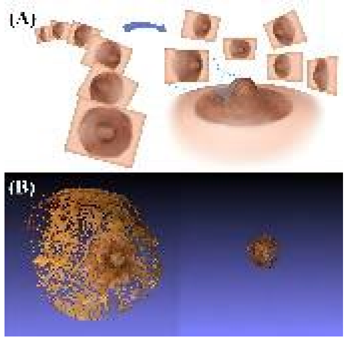

Fig.2 (A) Video-based measurement uses Gaussian splatting of sequential frames, followed by boundary extraction and postprocessing to estimate volume. (B) MeshLab rendering demonstrates boundary delineation before and after processing.

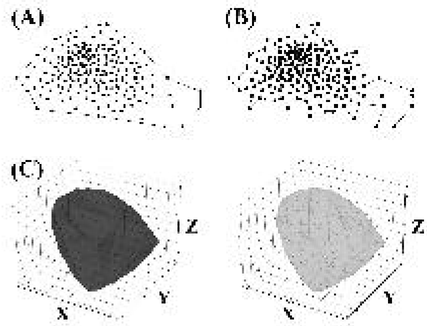

Fig.3 Convex hull creates a smooth outer boundary but ignores concave details. Alpha shape captures surface indentations for more accurate anatomy. Final 3D meshes enable volumetric and morphological analysis.

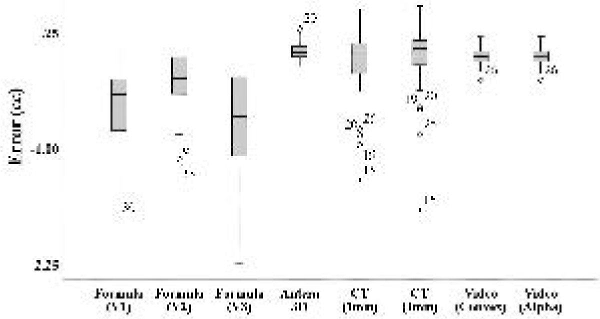

Table1. Box-plot analysis comparing the measurement errors of each of methods against the reference standard.

Results : Significant differences were observed among methods(F=8.788, p<0.001). Antera 3D® demonstrated the lowest MSE(0.011), followed by video-based convex(0.018) and alpha(0.019) reconstructions. CT-based methods showed moderate accuracy (MSE=0.145–0.165), whereas formula-based methods exhibited higher errors (MSE=0.519–0.935). Bland–Altman analysis demonstrated good agreement between the video-based methods and the reference standard without systematic bias.

Conclusions : The proposed video-based Gaussian splatting method provides accuracy comparable to established techniques while offering a low-cost, non-contact, and highly accessible alternative. This approach represents a practical and scalable option for clinical and research applications in nipple reconstruction assessment.