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Peer Review

Review of: "Methodological Approach to Accuracy Assessment in CAD-CAM Mandibular Reconstruction"

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This study presents a technically robust and innovative approach to evaluating accuracy in CAD-CAM mandibular reconstruction using the Global Positioning Layout (GPL) method. The authors offer a comprehensive explanation of a metrology-based framework that addresses long-standing issues in post-surgical assessment by establishing a unique, reproducible coordinate system (GPL-RS). This systematic and reproducible method is a key strength, setting it apart from other techniques often dependent on manual processes and operator expertise.

A major contribution of this work is its ability to quantify 3D spatial deviations using roto-translational matrices (RTMs). By computing three separate RTMs throughout the workflow—each reflecting different alignment stages—the method provides both rotational and translational metrics of deviation, thereby enabling a multidimensional understanding of surgical accuracy. This quantitative approach addresses a notable gap in the field, where many existing studies rely on 2D measurements or qualitative visualizations like colorimetric maps.

Another strength lies in the rigor with which the reference system (GPL-RS) is constructed. The authors describe in detail the use of anatomical landmarks—such as the center of gravity and symmetry/tangent planes—to define a stable and standardized reference for spatial orientation. This internal anatomical anchoring provides consistency across patients and procedures, reducing reliance on external reference points that may vary or be affected by pathology.

The study's case application provides a tangible demonstration of the method's functionality and reinforces its practicality in clinical contexts. The clear sequence of model alignment—planned mandible, prosthetic device, and postoperative mandible—offers a structured workflow that could be adapted or extended in various clinical scenarios. The use of Geomagic Wrap® and the integration of Python

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scripting enhances reproducibility and shows a thoughtful balance between technical detail and clinical applicability.

However, while the methodological development is well-articulated, the paper could benefit from broader contextualization regarding how deviations in reconstruction affect clinical outcomes. For example, what threshold of deviation (in mm or degrees) is considered clinically significant? Without correlating the accuracy assessment to postoperative function, aesthetics, or patient satisfaction, the practical value of precise measurements remains abstract. This connection would significantly enrich the interpretation and potential impact of the GPL method.

Additionally, the study is limited by its application to a single patient case. Although this effectively illustrates the method, it restricts the generalizability of findings. The authors acknowledge this limitation and propose future testing across broader patient cohorts—a crucial next step to validate the method's reliability, adaptability to various defect types, and reproducibility across institutions and imaging equipment.

The discussion rightly points out the limitations of current accuracy assessment techniques, particularly the reliance on manual landmark identification and STL model comparisons. The critique of condylar alignment methods is especially relevant, highlighting how anatomical variability or postoperative edema can undermine long-term assessments. Still, the paper could explore whether the GPL method can be adapted to accommodate or correct for these dynamic changes over time.

One notable ethical and clinical consideration not fully addressed is the potential psychological impact of accuracy-based assessments on surgical planning and patient expectations. As precision tools become more common, there is a risk that patients may develop unrealistic expectations for perfect outcomes. A discussion of how to communicate these measurements responsibly and integrate them into shared decision-making would be a welcome addition.

Furthermore, while the GPL method is presented as operator-independent, some stages (e.g., model segmentation, data import, ICP parameter selection) may still involve manual steps or subjective choices, especially outside of automated software environments. Future automation efforts, as suggested by the authors, should aim to minimize these variables to fulfill the promise of complete operator-independency.

In conclusion, this study makes a significant technical contribution to the evaluation of CAD-CAM mandibular reconstruction, providing a reproducible and quantitative framework for accuracy

assessment. Its innovative use of coordinate systems and matrix-based analysis offers a strong foundation for future research and clinical application. However, further validation across diverse clinical cases, integration with patient-reported outcomes, and automation of the workflow are necessary to realize its full potential in improving reconstructive surgery outcomes.

Declarations

Potential competing interests: No potential competing interests to declare.