



Marginal Accuracy of Zirconia Crowns: A Comparative In Vitro Study of Digital vs. Conventional Impressions

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Introduction

Digital technologies have transformed prosthodontics since the 1980s, moving from basic single-unit CAD/CAM restorations to complex full-arch rehabilitations. The rise of intraoral scanners (IOS) now enables direct digital impressions, improving workflow efficiency and patient comfort over conventional polyvinyl siloxane (PVS) methods. Marginal adaptation remains a crucial factor in restoration longevity, with poor fit linked to cement dissolution and secondary caries. Despite many comparative studies, direct head-to-head evaluation of the latest IOS devices for zirconia crowns under highly controlled conditions is limited. This study investigates the marginal accuracy of five contemporary scanners versus conventional impressions.

Purpose

The aim of this in vitro study is to quantitatively assess the marginal adaptation of monolithic zirconia crowns fabricated using five advanced intraoral scanners (3Shape TRIOS 4, TRIOS 5, Medit i900, Shining 3D Aoralscan Elite, Dexis IS 3800W) and compare them to those produced by the conventional PVS impression workflow. Under tightly regulated laboratory conditions, the study seeks to determine if the latest digital workflows can match or exceed the accuracy of traditional techniques, thereby offering evidence-based recommendations for optimizing restorative outcomes in CAD/CAM zirconia crown fabrication.

Materials & Methods

Sixty identical mandibular molar models, digitally designed and milled from monolithic zirconia, were randomly allocated into six groups (n=10): five digital scanners and one conventional PVS method. Each scanner followed manufacturer-recommended protocols; PVS impressions were poured in Type IV stone and digitized. All crowns were fabricated using the same CAD software and milling machine, then cemented under uniform load using resin cement. Marginal gaps were measured at mesial and distal surfaces after sectioning, utilizing high-resolution stereomicroscopy. Robust statistical analysis, including Kruskal-Wallis and Dunn’s test, assessed group differences.

Results

All impression techniques demonstrated statistically significant differences in marginal adaptation ($p<0.001$). The Trios 4 and Dexis scanners produced the lowest and most consistent marginal gaps (~64 μm), significantly outperforming other scanners and the conventional PVS method (mean gap: 112 μm). Trios 5 and Shining 3D displayed higher variability. Importantly, all digital workflows yielded mean gaps well below the clinically acceptable threshold of 120 μm , while the conventional method approached this limit. The findings highlight the superior precision of selected digital scanners for zirconia crown fabrication.

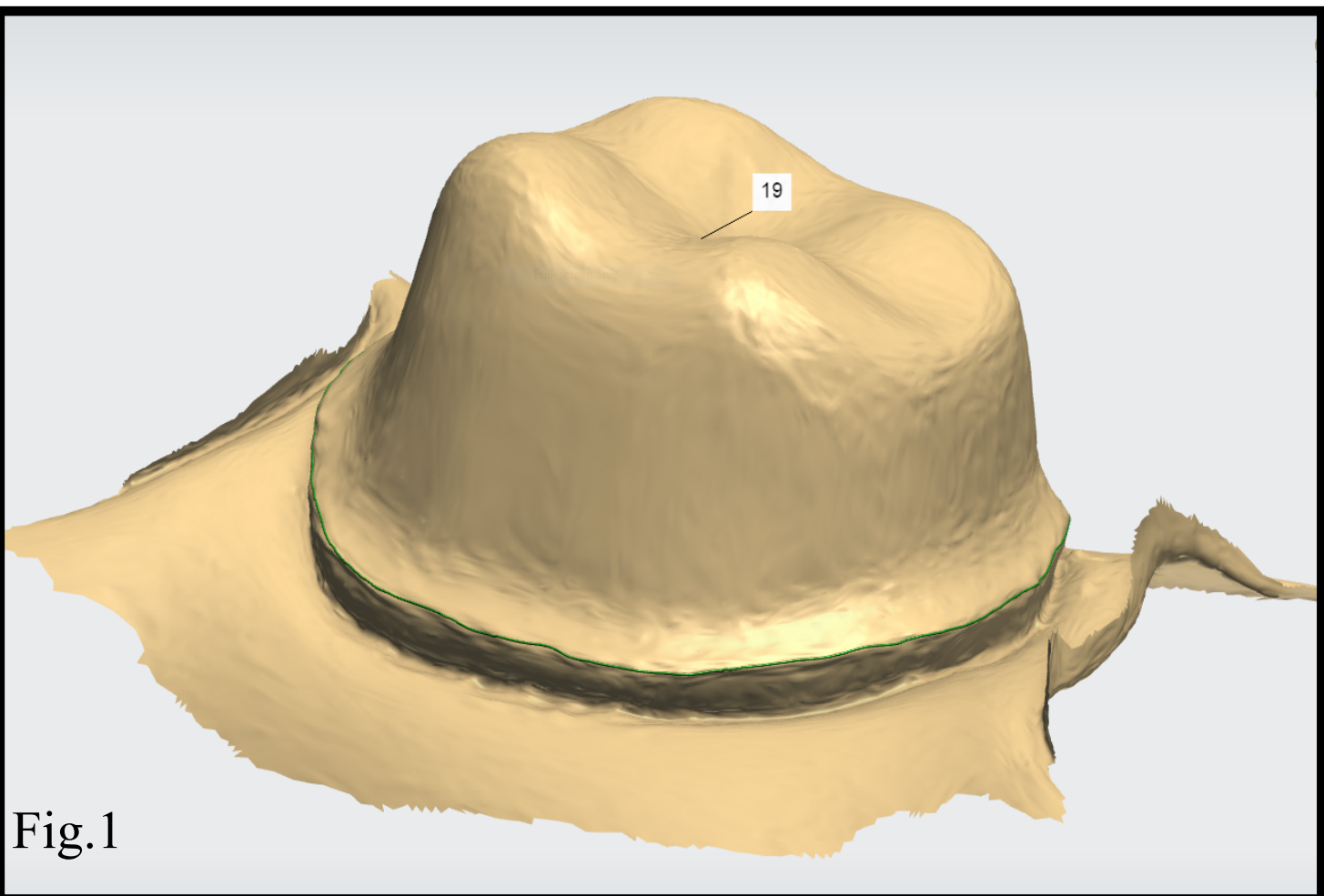


Fig.1 Scanned Conventional die to fabricate Zirconia Crown

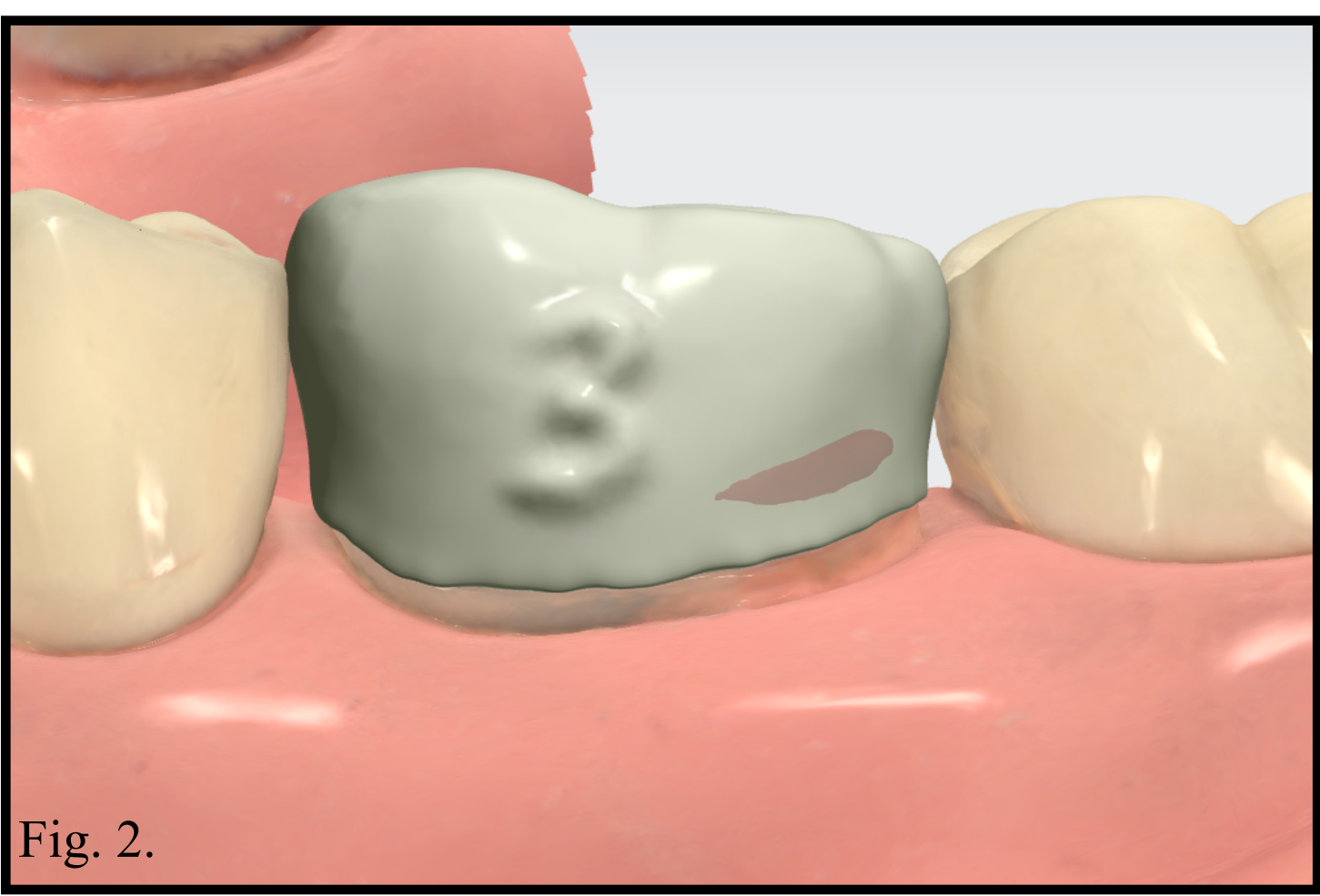


Fig. 2. Digitally designed Zirconia Crown

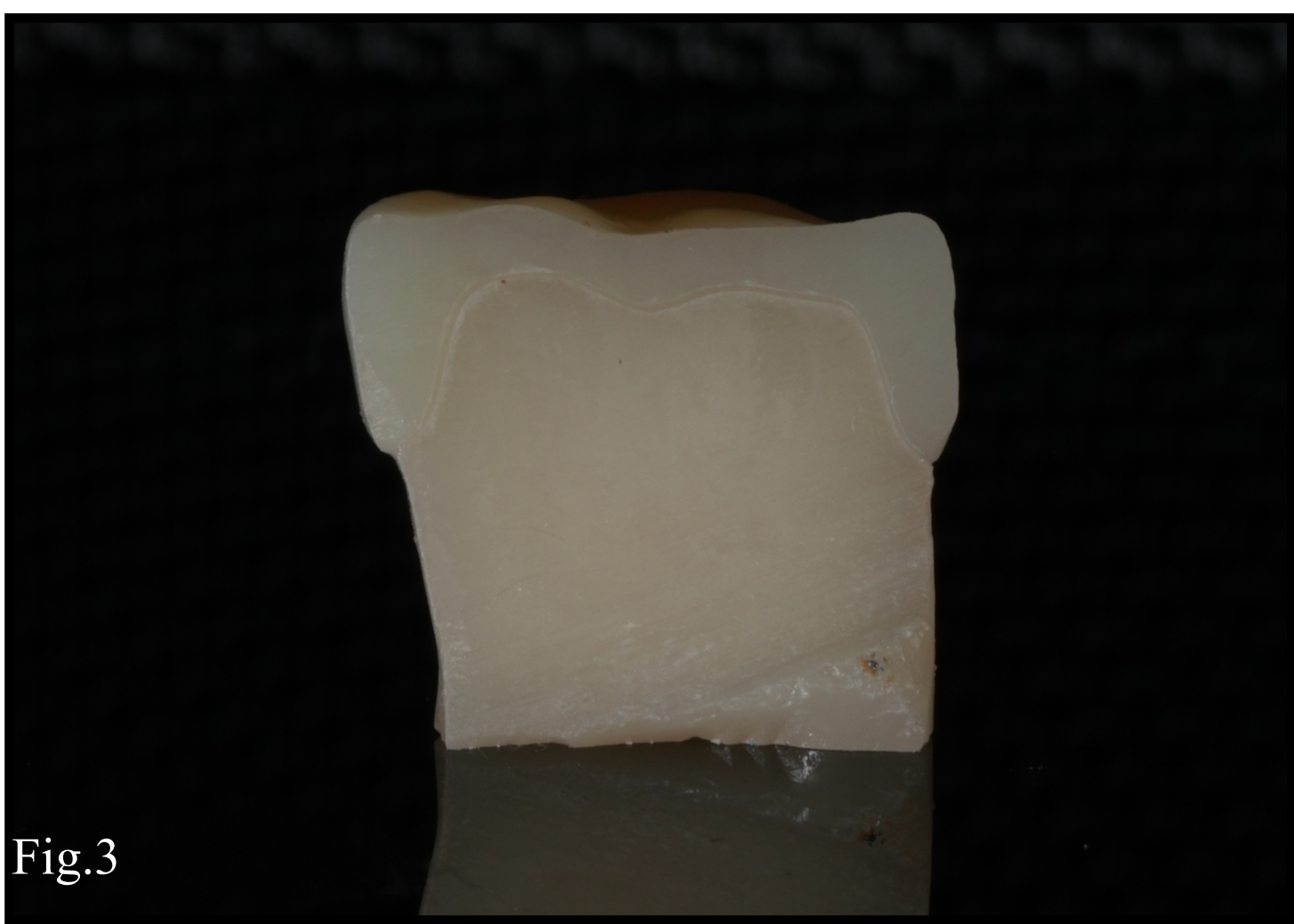


Fig.3 Specimen sectioned mesio-distally

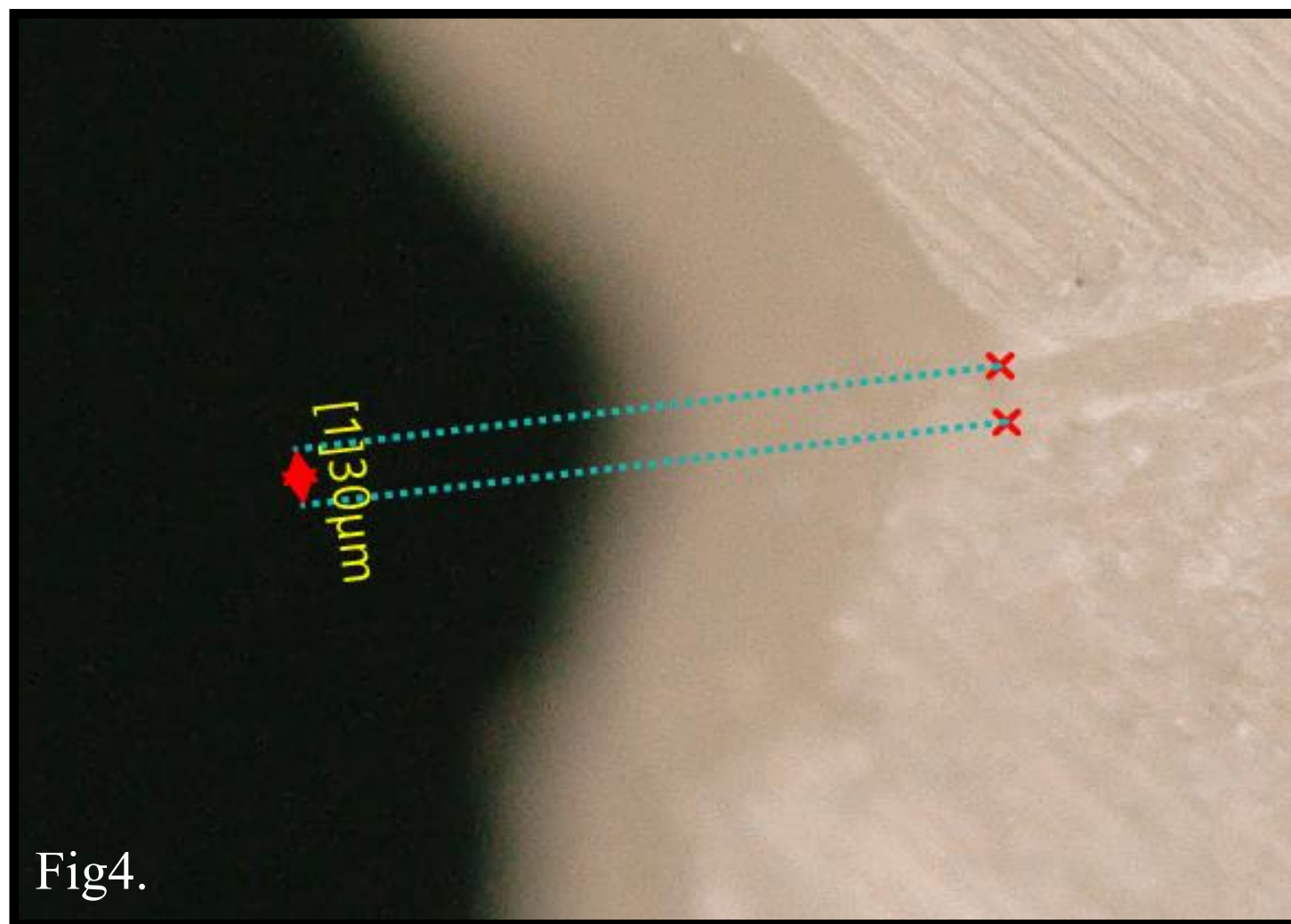
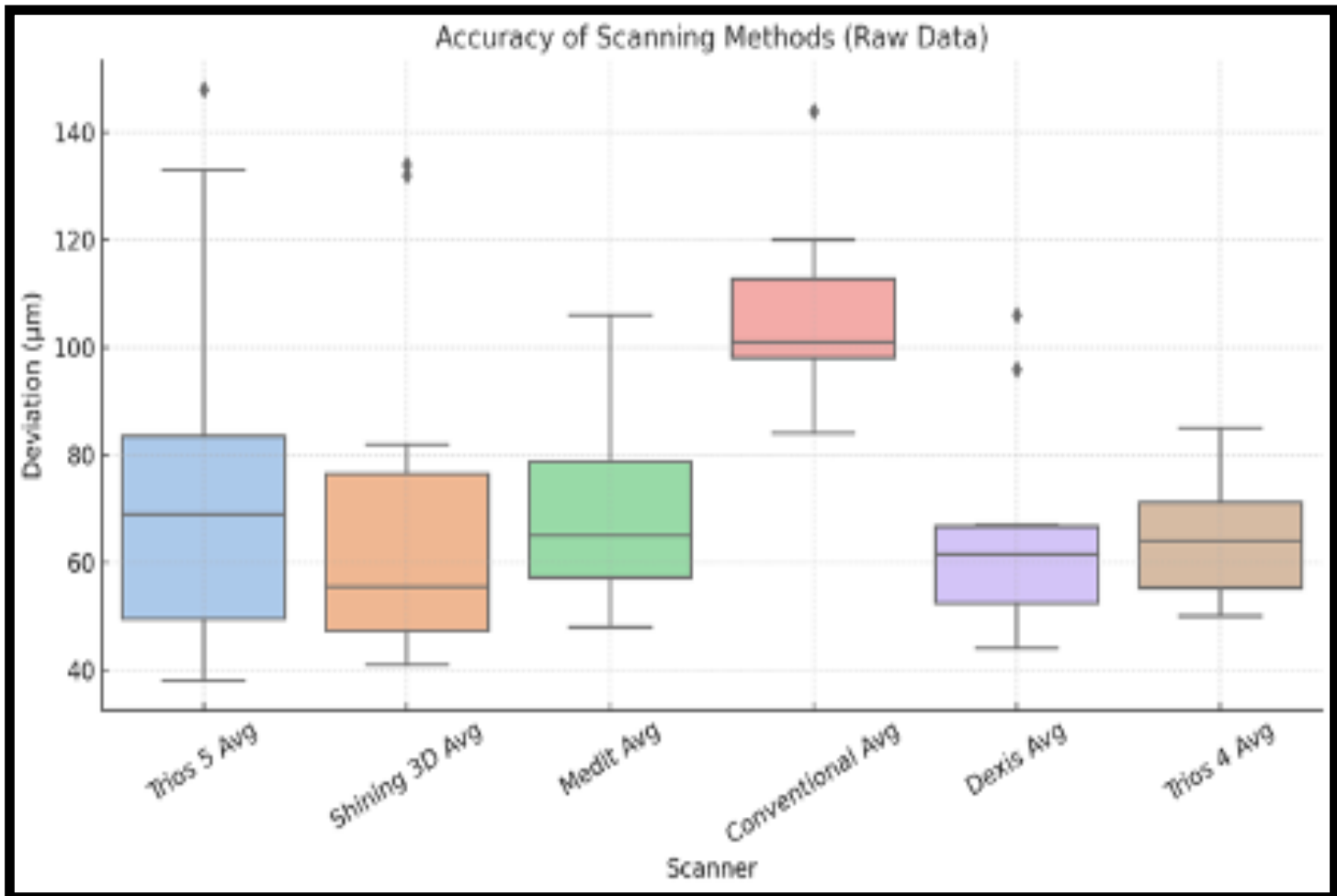


Fig4. Marginal Gap Measurement (200x Images)
Scanner Technique-Meanm-SDm-Rank Best to Worst



Scanner	Mean (μm)	SD (μm)	Rank (Best to Worst)
Trios 4	64.0	11.4	1
Dexis	65.7	20.3	2
Medit	69.2	17.6	3
Shining 3D	70.2	35.1	4
Trios 5	76.9	37.4	5
Conventional PVS	112.4	23.1	6

Clinical Implications

Adopting digital intraoral scanners, especially Trios 4 and Dexis, can greatly improve the marginal fit of zirconia crowns, reducing the risk of microleakage and cement dissolution. The study supports a transition towards digital workflows, which not only optimize clinical outcomes but also reduce chairside adjustments, enhance patient comfort, and streamline lab communication. However, conventional PVS impressions remain relevant for complex or full-arch cases where digital accuracy may decline. Overall, modern digital workflows present a compelling case for routine use in single-unit and short-span prosthodontics.

Conclusions

Digital intraoral scanners, particularly Trios 4 and Dexis, offer superior and more consistent marginal adaptation compared to the conventional PVS workflow in vitro. All tested digital systems produced results well within clinically acceptable limits for zirconia crowns. These findings strongly support the adoption of contemporary digital impression techniques for precision-dependent restorative procedures, contributing valuable evidence to the evolving field of digital dentistry. Further clinical studies are recommended to validate these results under actual patient conditions and expand to other material types and restoration scenarios.

Reference

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