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Ori – Transforming Subjective Dentistry Into Objective Results

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Abstract
Intraoral scanners for dental prosthetics have increased in popularity over the last decade due to improvements in software and hardware capabilities. Here we evaluate a new scanner from Ori, Inc. and compare it with an existing state-of-the-art scanner and the traditional method of using polyvinyl siloxane impressions.

Keywords
Dental impressions — Intraoral scanners

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Contents

Introduction

Obtaining polyvinyl siloxane (PVS) records is a daily occurrence in any dental office. Whether these records are taken to provide clear aligner treatment or fabricate a single tooth prosthetic, a majority of dentists still turn to expensive elastomeric materials as a daily procedure when providing basic dental services.

There are various issues surrounding the use of these impression materials, and these issues are routinely encountered in daily office functions. Flaws such as voids and pulls in the impression material plague results and cause distortions in model work at the lab level[1][2]. Furthermore, distortions and expansion issues in gypsum stone complicate the use of impression materials[3]. Many times these flaws go unchecked due to workflow and patient complications leading to emotional pressures to judge and accept adequate outcomes as opposed to superior outcomes. The entire process becomes subjective, which often results in substandard outcomes.

Computer-aided designing and manufacturing processes can eliminate flaws in impression materials and reduce the likelihood of subjective outcomes. Digital scanners allow dentists to record three-dimensional records with accuracies of better than 25 microns of variations[4][5][6]. However, even with superior results utilizing digital scanning in producing common dental prosthetics or providing other modalities of treatment, a majority of dentists continue to utilize the substandard method of impression in treating their patients. Many dentists cite the expensive nature of today's digital scanners on the market as their primary reason for not adopting this technology in their everyday workflow.

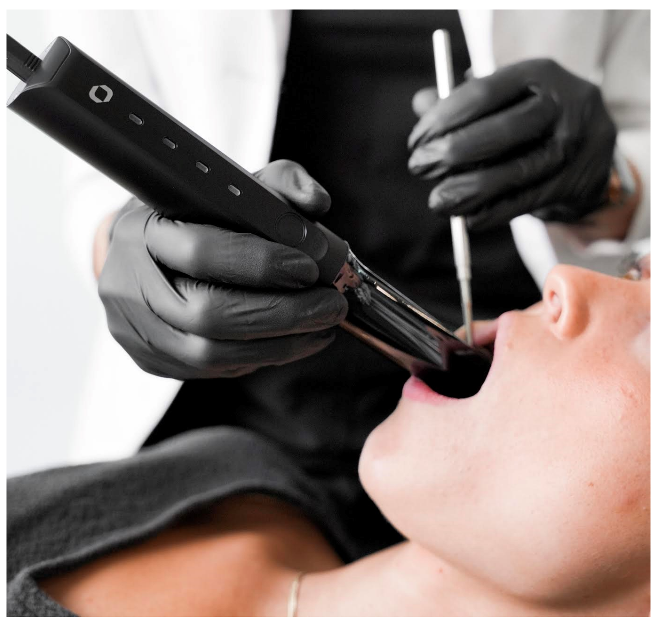

Figure 1. Ori scanner

This article will show how Ori (Pleasant Grove, UT)[7]

Figure 2. Simple Root Tooth Model, Permanent Tooth [A5A-200]

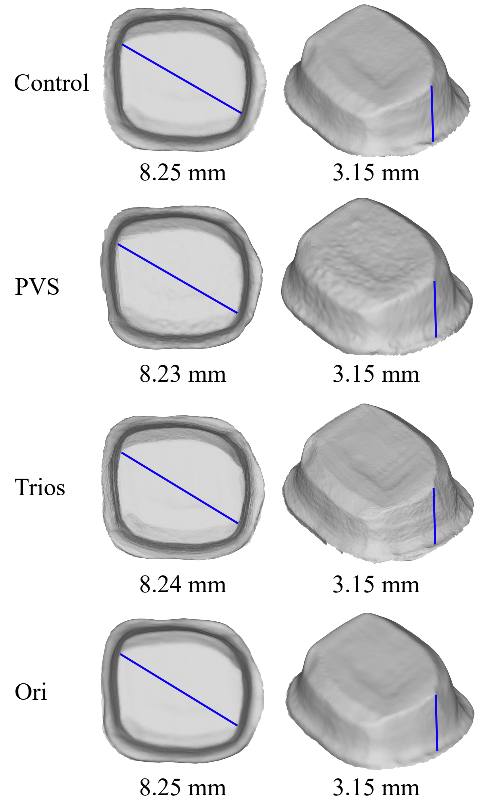

Figure 3. 3D visualizations of crown preparation area from different methods. Cavosurface cross (left column) and marginal (right column) measurements are shown for each image.

(see Figure 1), producers of the newest digital dental scanner on the market, created an intraoral scanner that is a vast improvement in accuracy over polyvinyl siloxane. Additionally, this intraoral scanner has comparable quality to the leading scanners currently available but is much less expensive. The Ori business model provides entry level scanning at a better value proposition than other scanners currently available, allowing dentists to realize the benefits of digital scanning while incurring minimal upfront cost. Furthermore, the Ori "new-scanner-every-three-years" business model removes obsolescence risk caused by purchasing expensive, rapidly changing technology. The model also includes full warranty support for all hardware as well as free software updates. Overall, Ori provides the dentist a solution to all major concerns regarding digital scanning technology.

1. Materials and Methods

To investigate the accuracy of the Ori scanner compared to elastomeric materials and other scanners, we created a control. The control we chose was a typodont with a prepared molar tooth, which is shown in Figure 2 (Simple Root Tooth Model, Permanent Tooth [A5A-200], Nissin Dental Product, Kyoto, Japan). The test consisted of a standard zirconium crown preparation, and records were taken to provide comparisons for recorded accuracy. Polyvinyl siloxane (Aquasil, 3M ESPE, St. Paul, MN) was utilized to represent the common current standard elastomeric material found in nondigital dental offices. The polyvinyl siloxane record was digitally analyzed and compared to three different digital scanners based on multiple points of reference. The scanners utilized in scanning the typodont model to provide a comparative analysis were the ORI One (ORI, Pleasant Grove, UT), the 3Shape Trios (3Shape A/S, Copenhagen, Denmark), and the 3Shape E2 (3Shape A/S, Copenhagen, Denmark) laboratory scanner. The model was scanned with the 3Shape E2 laboratory table top scanner in order to create the digital reference data utilized for comparison. The typodont teeth were scanned with the Ori One and the 3Shape Trios scanner by a single, trained, experienced dentist[1] who also performed the impression of the model utilizing the polyvinyl siloxane material.

To properly measure accuracy, tests should be conducted at both a micro and a macro scale. To this end we created two experiments. First, we measured the accuracy of the crown preparation by scanning the prepared molar tooth in detail. This experiment was done using the polyvinyl siloxane as well as the two scanners for comparison. Second, we measured the cross-arch accuracy of the typodont using the two scanners. A small sphere was used as a fiducial marker by attaching it to the last molar on each side for more accurate measurements.

Each scan was saved in the STL file format and directly compared using MeshLab[8], an open source three-dimensional visualization tool frequently used for geometry comparison in the research community. The scan meshes were trimmed down to only the relevant crown preparation area in the first experiment, and two types of measurements were performed. First, direct measurements were obtained by using a digital ruler on the geometry to determine the distance between various features in the scan. Second, a surface error measurement was computed between each scan and the scan of the control typodont.

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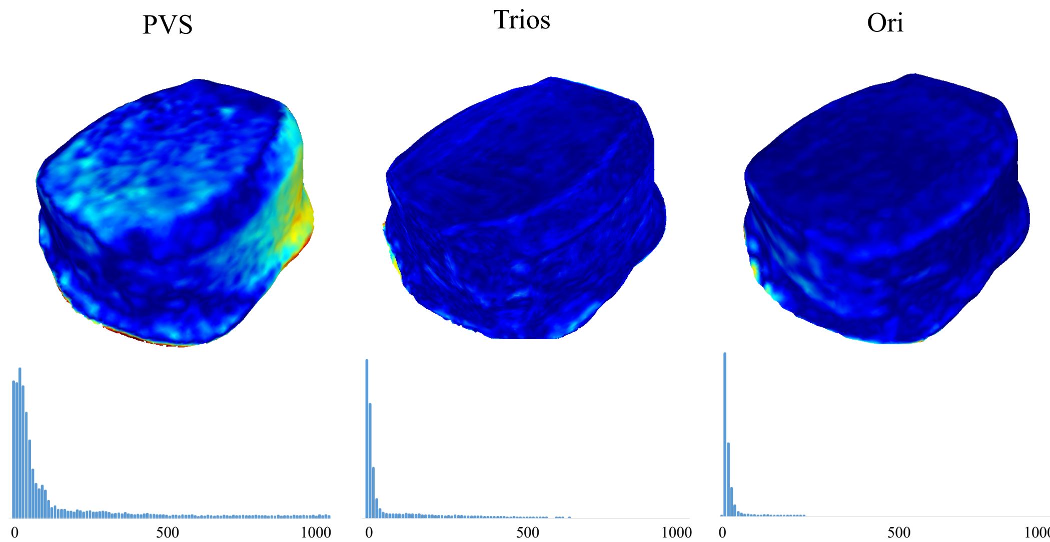

Figure 4. Top: Crown preparation distance errors. Normalized surface distances color mapped from low error (blue) to high error (red) between scans and the control typodont scan. Bottom: Histograms of these surface distances (in µm).

2. Results

2.1 Crown Preparation

Direct measurements were performed to determine the cavo-surface cross distance and the marginal distance of the scans. This was done by selecting corresponding points on each of the scans, as well as the control typodont, and using a digital ruler to determine the distance. The results of this direct measurement are shown in Figure 3.

Table 1. Median surface distance error

Scan	Median error
PVS	48.32 µm
Trios	14.65 µm
Ori	8.56 µm

Surface distance measurements were also performed to measure accuracy of each scan. This measurement was performed by concurrently loading the typodont scan along with each target scan and registering or aligning their orientations as closely as possible manually. To provide a more accurate co-registration, the Iterative Closest Point (ICP) operation was used repeatedly until it converged. The typodont scan was then sampled in approximately 20,000 random positions across the surface. A Hausdorff distance was computed between the typodont scan and the target scan at each sampled position to determine error in the scan. Figure 4 shows the distances along the surface as a colormap for qualitative comparison and distances in a histogram for quantitative comparison. Table 1 shows the median distance across all samples as a single metric for comparison. Figure 5 shows the distribution of these errors in quartiles as a box plot.

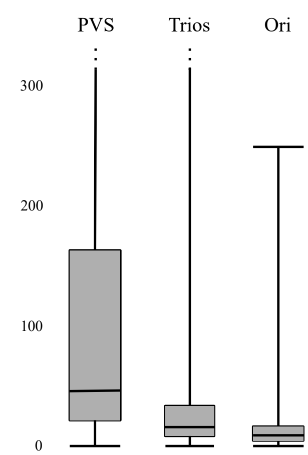

Figure 5. Crown preparation box plots of surface error (in µm) between scans and typodont (control)

2.2 Full Arch

Similar to the crown preparation experiment, direct measurements were performed to determine the cross-arch distance of the scans. This was done by selecting the inner edge of the fiducial sphere on each scan, as well as the control typodont, using a digital ruler to determine the distance. The results of this direct measurement are shown in Figure 6.

2.3 Discussion

The results of the crown preparation experiment definitively represent Ori as a vast improvement in accuracy and predictability of results when compared to polyvinyl siloxane. The median error is about half that of the PVS impression. Furthermore, Ori is comparably representative to other leading scanners in accuracy and quality of outcome[9], and achieves the results at a lower price. One observation during scanner

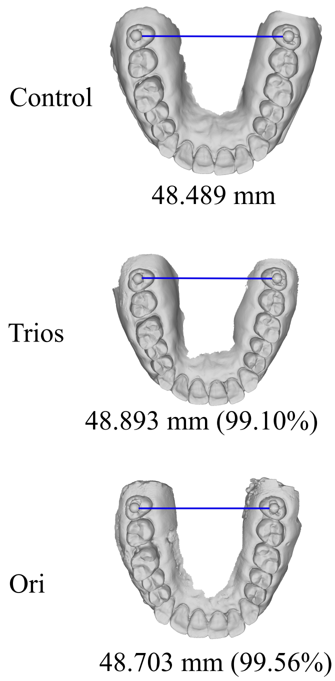

Figure 6. 3D visualizations of full arch from different methods. Cross-arch distances are shown for each image.

comparison testing was the total overall scan time taken to scan a quadrant. The Ori scanner routinely took 15 seconds longer per scan quadrant than the Trios scanner. This was consistent in scanning the prepared quadrant, opposing quadrant, or the bite registration. Furthermore, the Ori software took 10 seconds longer to register an accurate occlusal orientation when compared to the Trios scanner. However, the overall data gathering workflow is comparable and intuitive between the two scanners.

Currently we have completed over 75 dental prosthetics utilizing Ori scan technology. 100% of these units were deemed clinically functional and then subsequently delivered to patients as permanent restorations by two trained, experienced dentists[2] who are monitoring and evaluating the function of these restorations long term. Clinical quality and function were evaluated utilizing radiography and clinical evaluation of marginal fit as well as standard occlusal and contact evaluation procedures.

The results of the full arch accuracy show that the Ori One scanner compares favorably to a leading scanner for cross-arch accuracy[9]. Distance measurements between arches are within 99% of direct length deviation for both scanners which is well within expected tolerances[10].

3. Conclusion

A majority of dentists continue to utilize substandard materials in providing expensive dental prosthetics and treatment to patients. Polyvinyl siloxane consistently underperforms in accuracy when compared to digital dental scanners. Digital scanning is a statistically significant improvement in the quality and accuracy of dental prosthetics leading to long-term success in patient treatment[11]. The Ori One provides consistent results comparable to other scanners currently on the market today and is more accurate than standard elastomeric impression material in producing dental prosthetics. Ori is comparable in its data gathering capability to other leading scanners, and its workflow is simple to understand. Ori will continue to make ongoing improvements to software and hardware designs to improve the speed of scanning.

[2] Jared Theurer and David Blackhurst

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