Analysis of intra-arch and interarch measurements from digital models with 2 impression materials and a modeling process based on cone-beam computed tomography

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Introduction: Study models are an essential part of an orthodontic record. Digital models are now available. One option for generating a digital model is cone-beam computed tomography (CBCT) scanning of orthodontic impressions and bite registrations. However, the accuracy of digital measurements from models generated by this method has yet to be thoroughly evaluated.

Methods: A plastic typodont was modified with reference points for standardized intra-arch and interarch measurements, and 16 sets of maxillary and mandibular vinylpolysiloxane and alginate impressions were made. A copper wax-bite registration was made with the typodont in maximum intercuspal position to accompany each set of impressions. The impressions were shipped to OrthoProofUSA (Albuquerque, NM), where digital orthodontic models were generated via CBCT. Intra-arch and interarch measurements were made directly on the typodont with electronic digital calipers and on the digital models by using OrthoProofUSA’s proprietary DigiModel software.

Results: Percentage differences from the typodont of all intra-arch measurements in the alginate and vinylpolysiloxane groups were low, from 0.1% to 0.7%. Statistical analysis of the intra-arch percentage differences from the typodont of the alginate and vinylpolysiloxane groups had a statistically significant difference between the groups only for maxillary intermolar width. However, because of the small percentage differences, this was not considered clinically significant for orthodontic measurements. Percentage differences from the typodont of all interarch measurements in the alginate and vinylpolysiloxane groups were much higher, from 3.3% to 10.7%. Statistical analysis of the interarch percentage differences from the typodont of the alginate and vinylpolysiloxane groups showed statistically significant differences between the groups in both the maxillary right canine to mandibular right canine (alginate with a lower percentage difference than vinylpolysiloxane) and the maxillary left second molar to mandibular left second molar (alginate with a greater percentage difference than vinylpolysiloxane) segments. This difference, ranging from 0.24 to 0.72 mm, is clinically significant.

Conclusions: In this study, digital orthodontic models from CBCT scans of alginate and vinylpolysiloxane impressions provided a dimensionally accurate representation of intra-arch relationships for orthodontic evaluation. However, the use of copper wax-bite registrations in this CBCT-based process did not result in an accurate digital representation of interarch relationships.

Read the full text online at: www.ajodo.org, pages 456.e1-456.e9.

EDITOR’S COMMENT

Our dependence on stone models for the storage of 3-dimensional information has come under attack on several fronts involving many new technologies. As orthodontists adjust office procedures to be more efficient, answers to the question of what technology to rely on in the long term require high-level evidence. This article has answers to some of these concerns. Although laser surface scanning of plaster models generated from alginate and vinylpolysiloxane impressions has been studied extensively and has demonstrated a comparable level of accuracy to plaster models, the more recent method of CBCT scanning of alginate impressions has not received an extensive examination. Whereas this method is comparable with the scanning process used by Invisalign for vinylpolysiloxane impressions, because of the costs, most practitioners prefer to use a material with less dimensional stability over time. Therefore, although this process is promising, requiring no intermediate plaster models, the accuracy of the entire process from alginate impression to final digital model set has not been thoroughly tested.
With this in mind, this study was undertaken to answer 2 questions. (1) How do intra-arch measurements of digital models derived from CBCT scanning of 100-hour stable alginate impressions compare with those from vinylpolysiloxane impressions when shipped to OrthoProofUSA under the same conditions? (2) Does the use of a copper wax-bite registration result in an accurate reproduction of interarch dimensions, when used to generate digital model sets in this CBCT-based system?

This lengthy and complex study makes for an interesting read. The conclusions will help clinicians plan ahead. For the generation of digital models, a 100-hour dimensionally stable alginate used as the manufacturer directs and shipped within 48 hours as directed by OrthoProofUSA has comparable accuracy for intra-arch linear measurements as vinylpolysiloxane in a CBCT-based digital modeling system. The use of a copper wax-bite registration in the CBCT-based modeling system of OrthoProofUSA does not provide a consistently accurate digital representation of interarch relationships. Therefore, use of a Collision Mapping Tool, available in the DigiModel software, is often required to correct inaccuracies in occlusal relationships.

### Q & A

**Turpin:** Do you believe that outsourcing all impressions for CBCT scanning will become economically viable for a typical practitioner?

**White:** Yes. The costs associated with the digital modeling system in this study (OrthoProofUSA) are comparable with those of companies using laser surface scanning. The costs per model set for both digital scanning methods compare favorably with those associated with pouring and trimming plaster models. Therefore, all current digital model systems are a cost-effective alternative for a typical practitioner. Additionally, the costs for storage and maintenance of plaster models (cabinet or floor space, model boxes, and so on) would be eliminated and should also be considered when evaluating the expense of a digital model system.

**Turpin:** What other studies of related impression materials do you plan to conduct?

**White:** Even though both alginate and vinylpolysiloxane impression materials provided clinically accurate digital arch dimensions in this study, the wax-bite registration method we used was not sufficiently accurate in representing the occlusal relationships of the test model set. Therefore, we have designed future studies to evaluate the accuracy of a new material (BluVue HD, Lancer Orthodontics, Vista, Calif) for use in this CBCT-based modeling system and the bite registration methods in other digital modeling systems.

**Turpin:** Is there still a need to study laser-scanning procedures for accuracy or are the published data now sufficient?

**White:** As stated in the introduction to our article, many scientific studies have validated the accuracy of digital models. We believe that their results, supplemented by our current findings, provide sufficient evidence of intra-arch dimensional accuracy of digital models generated by both laser and CBCT scanning. However, future research is needed to evaluate the accuracy of bite registration methods in both laser and CBCT-based scanning systems.

**Turpin:** Are there other digital modeling systems that should be the focus of future studies?

**White:** Yes. Direct intraoral scanning systems would eliminate the need to use both impression and bite registration materials to generate digital models, thereby eliminating the errors associated with them. However, only future research will determine whether there is measurable improvement in accuracy over laser or CBCT scanning of plaster models, impressions, and their associated bite registrations.

### Table IV. Expense of alginate compared with vinylpolysiloxane impressions

<table>
<thead>
<tr>
<th>Impression material</th>
<th>Cost per impression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alginate</td>
<td>$1.10*</td>
</tr>
<tr>
<td>Vinylpolysiloxane</td>
<td>$9.13†</td>
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*Disposable impression tray, impression material, and tray adhesive; †Disposable impression tray, customization putty, impression material, and tray adhesive.