Curvilinear accuracy of digital models

The use of digital services became a common practice in dental offices worldwide via the advances in computer technology. The most efficient way to obtain digital dental models is through the utilization of intraoral scanners. As digital technology keeps improving, the intraoral scanners should improve as well with regards to their portability, ease of use and accuracy. Accordingly, intraoral scanners are expected to be the standard of care as long as they are capable of providing the clinicians with the most accurate and efficient system in producing digital dental models.

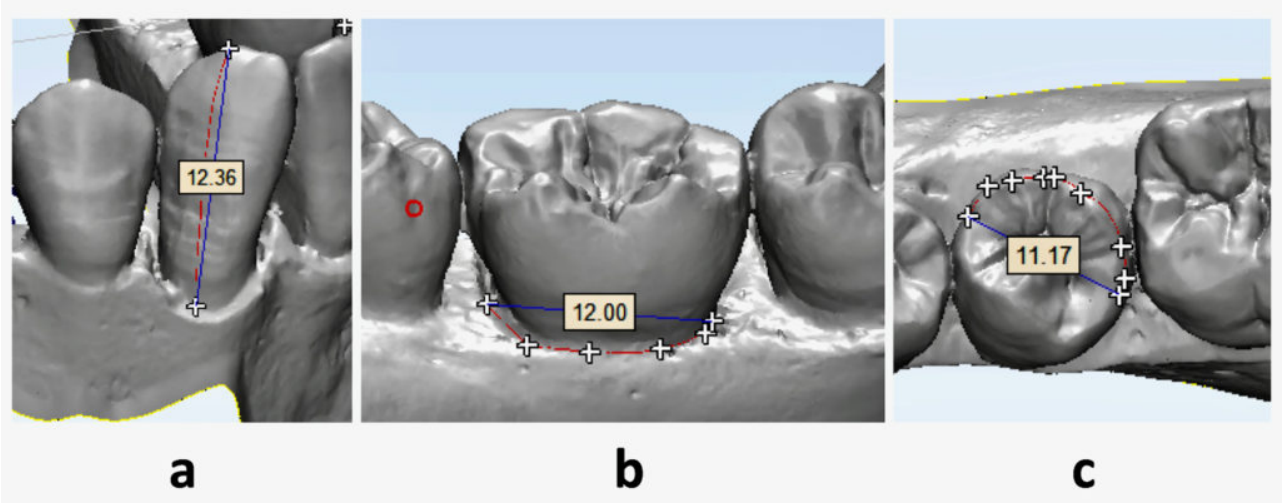

Fig. 1. Curvilinear measurements performed in this study: along the long axis of the mandibular right cuspid (a); along the lingual crestal bone surface of mandibular right first molar (b); along the occlusal surface of the mandibular left second premolar from the mesial to the distal marginal ridge (c).

The aim of this study was to investigate the curvilinear accuracy of two commercial intraoral scanners in comparison to digital caliper measurements. For the purposes of the study, mandibular arches from 61 dry skulls were scanned with Lythos™ Digital Impression system (Ormco Corp., Orange, CA/USA) and Cadent iTero™ scanner (Align Technologies, San Jose, CA/USA). Once the scans were completed, the raw images were converted to stereolithography (STL) files. STL files were used with commercial software (3-matic Research 9.0, x64, Materialise HQ, Leuven, Belgium) for the measurements. Measurements were carried out on unsectioned, shaded digital models of the lower jaws with the software's built-in ruler tool. The ruler tool was set to measure the distance over a surface with a curve creation method set on the true shortest path of a curve using the World Coordinate System. Nylon monofilament and digital calipers were used to perform the curvilinear measurements directly on the tooth surface.

Measurements were performed in different aspects of the lower jaw in various directions. The following curvilinear measurements were performed: buccal surface of the lower right canine along the long axis of the tooth from the cusp tip to the crestal bone (Fig. 1a); the uppermost surface of the crestal bone along the lower right first molar below the most lingual points of the marginal ridges (Fig. 1b); and the uppermost occlusal surface along the lingual cusp of the lower left second premolar, starting from the center of the mesial marginal ridge and ending in the center of the distal marginal ridge (Fig. 1c). There was no fixed bias of one approach vs. the other, and random errors were detected in all comparisons. Mean biases of iTero™ and Lythos™ scanner measurements, when compared to direct measurements were -0.17 mm and -0.13 mm, respectively. The lowest minimum mean bias occurred for the comparison of the two intra-oral scanners (-0.03 mm. with 95% confidence interval (CI), and agreement limits of -0.8 and 0.7). Additionally, there was no proportional bias in any of these comparisons. In other words, no trend was shown for any of the mean differences being above or below the mean bias level.

The importance of measuring lines along the curve and the accuracy of these measurements lie within the ability of intraoral scanners to properly stitch together images and transform the geometric information into 3D models. According to our findings, digital models obtained by intraoral scanners might contain small discrepancies in various spatial distances. However, the mean bias between the scanners is very small. Even though the inter-observer reliability was not assessed, within-observer reliability of the measurements by a calibrated clinician resulted in a relatively small range of operator error with highly consistent repeat measurements. Therefore, it could be concluded that algorithms involved in stitching processes of the two digital platforms did not affect the surface accuracy significantly. Both systems produced comparable accuracy as compared to the actual surface measurements when performing 3-D surface measurements along a curved line.

Sercan Akyalcin
Tufts University School of Dental Medicine Department of Orthodontics

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