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DENTAL TECHNIQUE

Improving the precision of recordings acquired with digital occlusal analyzers: A dental technique

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ABSTRACT

A technique to improve the precision of recordings acquired with the 2 main digital occlusal analyzers on the market (T-Scan and OccluSense) is presented. This technique consists of using digital occlusal analyzers with a customizable centering tray. The virtual design of the centering tray is available online, together with that of the adapters required for both digital occlusal analyzers. The designs can be downloaded and additively manufactured for clinical use. These parts improve the positioning of the piezoelectric film sensors of the digital occlusal analyzers in the patient's mouth and thus the precision of their records. Improving the precision of the records of the digital occlusal analyzers is especially important for the comparison of records obtained at different stages of rehabilitation treatment. (J Prosthet Dent xxxx;xxx:xxx-xxx)

Digital occlusal analyzers are used to record the location of occlusal contacts and the percentage of force on them at different times,[1–4] information that is valuable for occlusal analysis[5] in prosthodontics[6] or maxillofacial prosthetics.[7] Based on the records, the software program of the digital occlusal analyzers performs a series of calculations, including the forces on each tooth, the center of contact forces, and the right- and left-side balance of these forces.[8–10]

The most widely used and studied[11] device was the first to be marketed (T-Scan; Tekscan Inc), with its accuracy being evaluated for detecting the occlusal contact location[12–15] and magnitude of contact forces.[16–20] These studies confirmed that the most accurate way to analyze the time sequence of occlusal contacts and forces is with digital occlusal analyzers. More recently, a lower-cost digital occlusal analyzer (OccluSense; Dr. Jean Bausch GmbH & Co. KG) has been marketed with the additional advantage of a sensor with built-in articulating paper that marks the occlusal contacts directly on the teeth. However, studies on its use are sparse,[3] and the authors are unaware of any studies on its accuracy.

In some prospective clinical studies of rehabilitation treatments, occlusion has been analyzed at different stages of the treatment by using a digital occlusal analyzer.[21–25] To compare records obtained with digital occlusal analyzers at the different stages of rehabilitation treatment, it is important to minimize the factors that may contribute to the variability of the records, and therefore, improve the precision of the records.[26] A recent study reported that the occlusal forces at the maximum intercuspal position recorded with a digital occlusal analyzer varied throughout the day for the same patient.[27] Such variance could be caused by changes in masticatory forces[28,29] but could also be caused by variations in the positioning of the piezoelectric film sensor of the digital occlusal analyzer in the patient's mouth.

The piezoelectric film sensor of digital occlusal analyzers has the shape of a dental arch. Therefore, different positioning of the piezoelectric film sensor in the mouth of the same patient would lead to different records of the location of the occlusal contact points and consequently to significantly different values of the position of the

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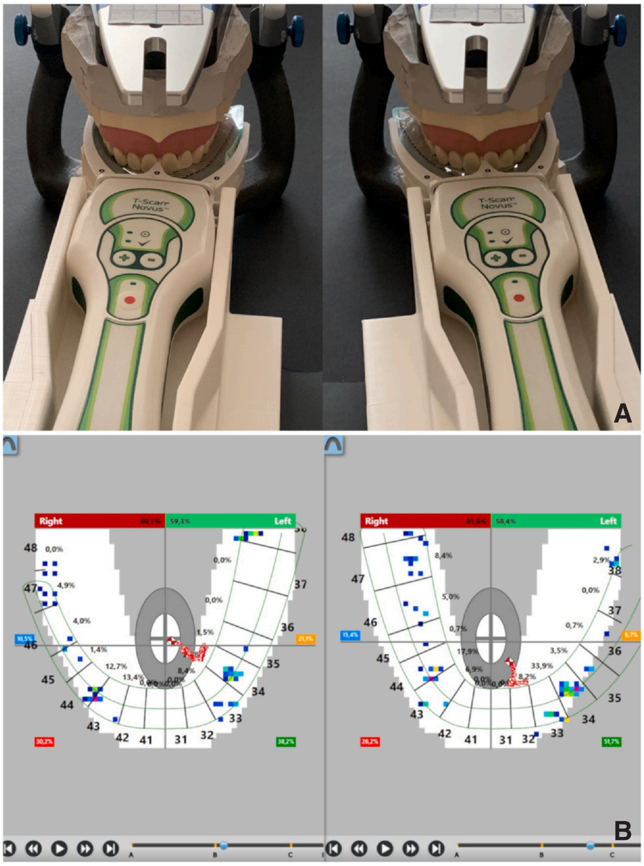

Figure 1. Recordings acquired with a digital occlusal analyzer at different positioning of its piezoelectric film sensor. A, Digital occlusal analyzer at 2 different positions of its piezoelectric film sensor (rotated around midline). B, Recordings acquired with a digital occlusal analyzer in each position of its piezoelectric film sensor (observe variations in the location of occlusal contact points, location of the center of contact forces, and percentage of contact forces in each quadrant).

center of contact forces or of the sum of percentage of forces in each quadrant (Fig. 1). The T-Scan, unlike the OccluSense, has a centering pin that is inserted between the maxillary incisors to facilitate the reproducible positioning of the piezoelectric film sensor in the patient's mouth, thus minimizing the variability of its records and improving precision. However, this centering pin does not ensure a perfectly reproducible position of the piezoelectric film sensor, because even when the centering pin is properly fixed to the maxillary dental arch, the sensor may rotate around the midline, contributing to variability in the records (Fig. 1A).

The present technique established a procedure to ensure reproducible positioning of the piezoelectric film sensor of digital occlusal analyzers in the patient's mouth and thus improve the precision of their records. This technique requires by using digital occlusal analyzers with a centering tray. Its virtual design is available online (Supplementary File 1, available online), together with that of the adapters required for both the T-Scan

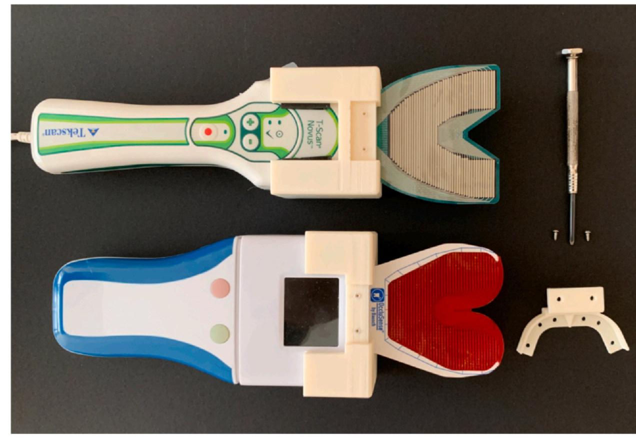

Figure 2. Components used for both digital occlusal analyzers.

(Supplementary File 2, available online), and OccluSense (Supplementary File 3, available online), and can be downloaded and used by the dental community. As the same technique is used for both digital occlusal analyzers (Fig. 2), only that for the T-Scan is described.

TECHNIQUE

1. 1. Manufacture the centering tray (Supplementary File 1, available online) and required adapter for the digital occlusal analyzer (Supplementary File 2, available online) in a material that meets biocompatibility requirements[30,31] (VisiJet M2R-WT; 3D Systems, Inc) with an additive manufacturing machine (ProJet MJP 2500 Plus; 3D Systems, Inc) (Fig. 3).
2. Test the centering tray and customize it if necessary (Fig. 4). To do that, insert the pin of the centering tray between the maxillary incisors of the patient and ensure that there is no contact between the tray and the teeth before the pin is completely inserted. Also, ensure that the centering tray does not obstruct the

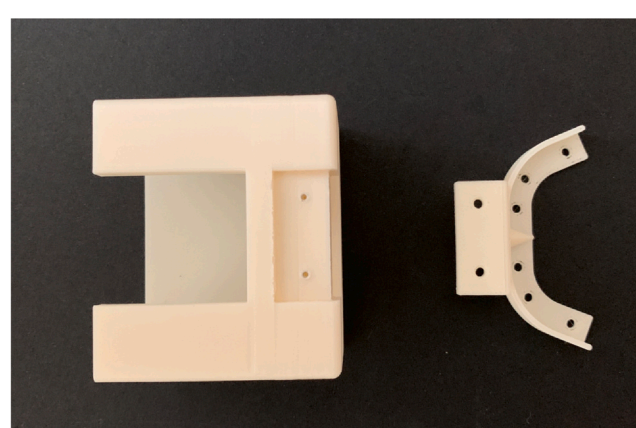

Figure 3. Additively manufactured centering tray (right) and its adapter for digital occlusal analyzer (left).

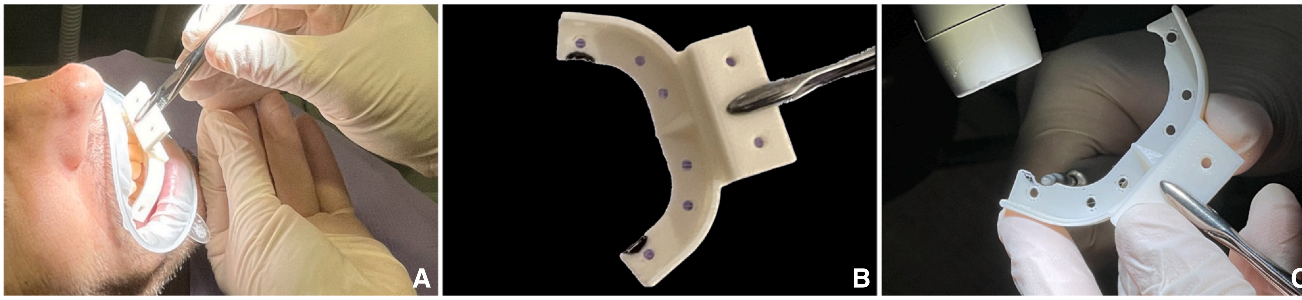

Figure 4. Testing and customization of centering tray. A, Testing of centering tray. B, Marking of centering tray collision areas with indelible marker. C, Removing of centering tray collision areas with an acrylic resin bur.

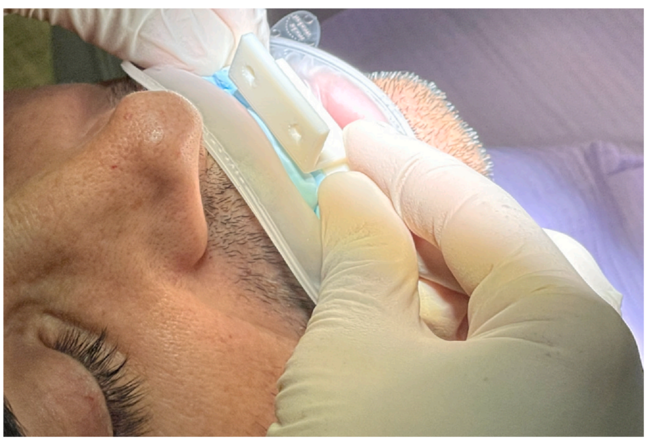

Figure 5. Impression making.

occlusion once the pin is completely inserted between the maxillary incisors (Fig. 4A). If necessary, the centering tray can be customized to eliminate contact between the tray and teeth by marking the areas of the centering tray that collide with the teeth with an indelible marker (Fig. 4B) and grinding with an acrylic resin bur (Tungsten Carbide Cutter with ISO reference 500104194145045; Edenta AG) (Fig. 4C).

3. Make an impression of the labial surfaces of the maxillary anterior teeth with a medium-viscosity polyvinyl siloxane (PVS) impression material (3M Imprint Bite; 3M) loaded onto the centering tray (Fig. 5). Keep the tray centered until the PVS polymerizes. Use the tip of the patient's nose as a visual reference and keep it centered between the 2 existing screw-holes in the tray.
4. Trim the impression material extending beyond the rim of the centering tray with a scalpel blade, including excess posterior impression material (Fig. 6). After trimming, the centering tray can be positioned against the labial surfaces of the teeth in a reproducible way, and will allow visualization to ensure it is positioned correctly.
5. Attach the customized centering tray to its adapter for the digital occlusal analyzer with 2 screws (Tapping screw ISO 7050—ST 2.2×6.5) (Fig. 7).[32]

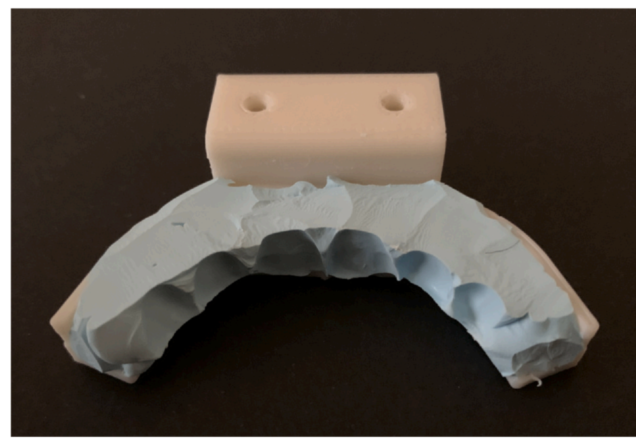

Figure 6. Impression of labial surfaces of anterior teeth after trimming excess impression material.

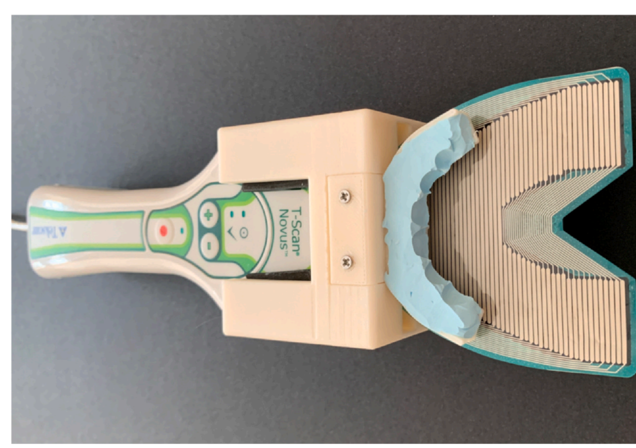

Figure 7. Customized tray attached to T-Scan.

6. Make a record with the digital occlusal analyzer as per the manufacturer's protocol (Fig. 8).

DISCUSSION

The aim of this technique was to increase the precision of the records acquired with digital occlusal analyzers and thus improve their performance for comparing

Figure 8. Record-making with T-Scan.

information recorded at different treatment stages. The technique requires by using the digital occlusal analyzers with a centering tray, the virtual design of which is available online (Supplementary File 1, available online), together with that of the adapters required for both the T-Scan (Supplementary File 2, available online), and OccluSense (Supplementary File 3, available online). The technique is identical for both T-Scan and OccluSense, and the same centering tray could be used with both digital occlusal analyzers.

This technique ensures reproducible positioning of the piezoelectric film sensor of digital occlusal analyzers. The technique maintains the insertion of a pin between the maxillary incisors but prevents rotation around the midline thanks to the centering tray and the impression of the labial surfaces of the maxillary anterior teeth. The need for an impression of the labial surfaces of the maxillary anterior teeth could be avoided by manufacturing the centering tray with the geometry of the labial surfaces of the maxillary anterior teeth obtained from a digital scan of the maxillary arch. This alternative is feasible but would need to be manufactured in an elastic material to avoid problems of insertion into interproximal undercuts.

The centering tray and its adapters for the digital occlusal analyzers must be additively manufactured from a material that meets or exceeds the biocompatibility requirements established for medical devices in contact with intact mucosal membrane surfaces.[30,31] Studies are needed to analyze the influence of the positioning of the piezoelectric film sensor on the precision of the records acquired with the digital occlusal analyzers. Studies are also needed to analyze the precision of records acquired with digital occlusal analyzers by using this technique. The protocol of previous in vitro studies could be adapted by using this technique to determine whether the precision of the recordings acquired with digital occlusal analyzers improves.[12–15,19]

SUMMARY

A technique to improve the precision of recordings acquired with T-Scan and OccluSense digital occlusal analyzers is presented. The technique uses digital occlusal analyzers with a customizable centering tray to ensure the reproducible positioning of the piezoelectric film sensor in the patient's mouth and thus to improve the precision of their records. Improving the precision of the records of the digital occlusal analyzers is essential for the comparison of records obtained at different stages of rehabilitation treatment. The virtual design of the centering tray is available online, together with that of the adapters required for both the T-Scan and OccluSense digital occlusal analyzers. These virtual designs can be downloaded and additively manufactured for clinical use.

PATIENT CONSENT

The patient illustrated signed an informed consent form. The procedure was approved by the university ethics committee (M10_2019_254) according to local and international ethical rules.

APPENDIX A. SUPPORTING INFORMATION

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.prosdent.2023.08.001.

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CRediT authorship contribution statement
Mikel Jauregi: Conceptualization, Methodology, Software, Investigation, Writing – original draft **Xabier Amezua:** Investigation, Writing – original draft, Visualization **Mikel Iturrate:** Formal analysis, Data curation, Visualization **Eneko Solaberrieta:** Validation, Writing – review & editing, Supervision, Project administration, Funding acquisition.

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