Randomized Controlled Trial Comparing Direct Intraoral Digitization and Extraoral Digitization After Impression Taking

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This study aimed to evaluate the correspondence of intraoral digitization (ID) with extraoral digitization (ED) after impression taking. One-stage putty-and-wash impressions and ID were carried out in a randomized order for 10 subjects. The impressions were used to make casts, which were then subjected to ED. ID datasets were aligned to create computer-aided design reference models. Deviations between ID and ED were calculated. The mean positive and negative deviations were 37.7 and –48.4 µm, respectively, for one quadrant. The results showed that the ID system is well suited for the acquisition of single-tooth restorations and is of limited suitability for the acquisition of small multiple-unit restorations. *Int J Prosthodont 2014;27:30–32. doi: 10.11607/ijp.3455*

The use of computer-aided design/computer-assisted manufacture (CAD/CAM) systems can reduce errors during the production of dental restorations. A prerequisite for the production of CAD/CAM restorations is the accurate transfer of the prepared teeth into a dataset. The advantage of intraoral digitization (ID) is that no impressions, casts, or extraoral digitization (ED) procedures are required. However, whereas extraoral systems can acquire data for restorations of up to 14 units in length, simple intraoral systems are restricted by the size of the camera to the direct digitization of single teeth.[1] If larger areas are required, the individual datasets must be recorded and compiled.[2] This compilation process introduces potential sources of error that may be further amplified by the multiple compilations of the measuring data.[2]

The aim of this clinical trial was to evaluate the correspondence of multi-level ID with the gold standard impression procedure—ie, a conventional one-stage putty-and-wash impression followed by cast fabrication and ED—in relation to a single tooth in an examined quadrant (primary outcome) as well as to the complete quadrant (secondary outcome).

Materials and Methods

The study design was approved by the Ethics Commission of the Medical Faculty Carl Gustav Carus of the Technical University Dresden, Dresden, Germany (EK20811 2003).

Participants

Ten subjects with full dentition in the maxilla (healthy or restored teeth) were included in this study.

Interventions

Following an initial clinical examination, impression taking and ID were carried out for each participant in a randomized order. The randomization list was created via coin toss. All impressions for ED were made with Dimension Penta H and Garant L (3M ESPE), as described by Luthardt et al.[3] The master casts were digitized with a high-resolution optical digitization system for the full arch (digiScan, AmannGirrbach Dental).

ID was accomplished in the maxilla using a CEREC 3D camera (Sirona Dental Systems). After the teeth were dried, CEREC Powder (VITA Zahnfabrik) was evenly applied to the tooth surfaces, keeping an obtuse angle to the object surface and a distance of approximately 2 cm.[4] The optical images were taken with the camera in an overlapping way, as described by the manufacturer. With the experimental software, it was

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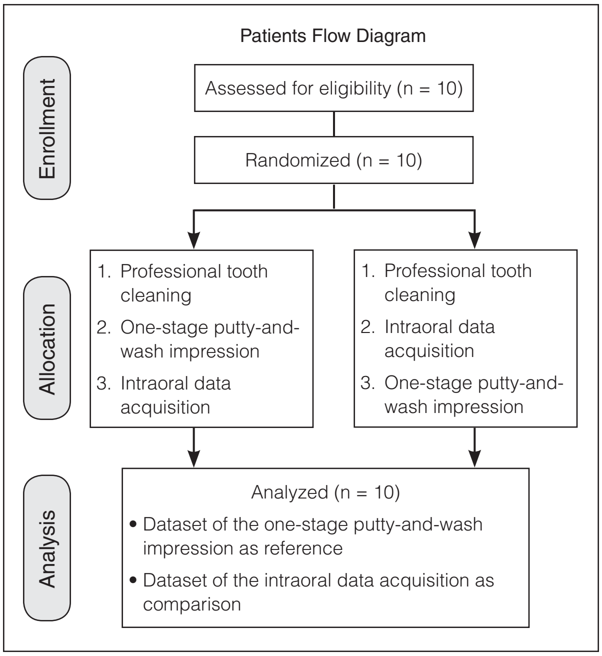

Fig 1 Study flowchart.

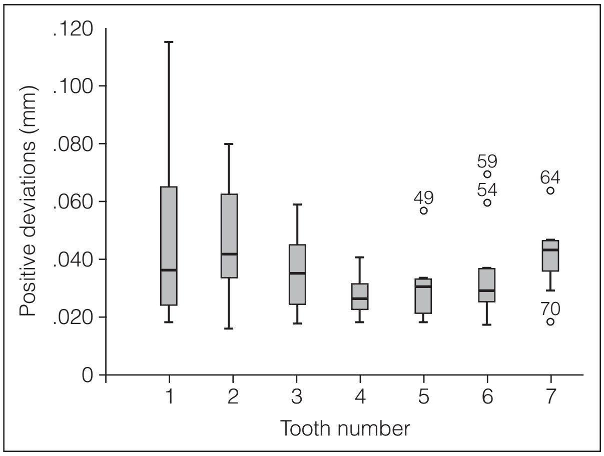

Fig 2 Mean positive deviations between intraoral digitization (ID) and extraoral digitization (ED) related to the single tooth. The circles (°) represent outlier values (more than 1.5 times the box width away). The top and bottom of the boxes represent the outside limits of the second and third quartiles. The bar within the box depicts the median, which is out of center when data are skewed. The whiskers illustrate the maximum and minimum values calculated for each tooth.

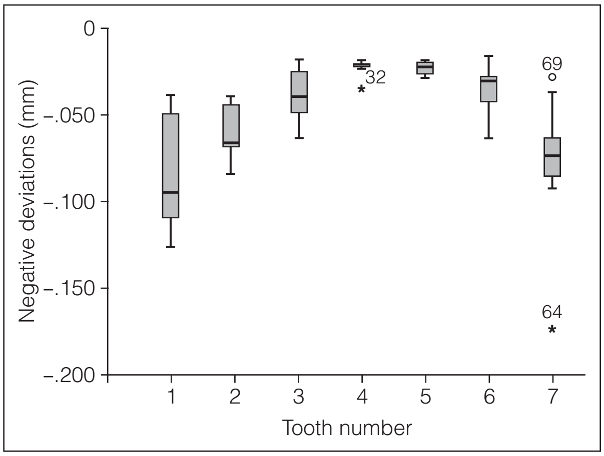

Fig 3 Mean negative deviations between ID and ED related to the single tooth. The circle (°) represents outlier values (more than 1.5 times the box width away) and the asterisks (*) represent extreme values (more than 3 times the box width away). The identifiers accompanying outliers and extremes represent the consecutive numbering of the 10 participants and their respective 7 teeth (1 to 70). Please refer to Fig 2 for further information.

possible to compile the single datasets and to save them as single or complete datasets. The data-processing method was described in a previous study.[3] To analyze the three-dimensional (3D) shape deviations, each dataset acquired using ID was compared with the respective quadrant of the dataset acquired using ED. The datasets were aligned via the two right premolars. The 3D differences between each point of the datasets were calculated for each tooth as well as for the complete dataset and presented as color-coded difference images.

Statistical Analysis

The mean deviations of the ID from the ED in relation to a single tooth were examined as the primary outcome, with the mean deviations for a complete quadrant serving as the secondary outcome.

For the mean values, Pearson correlation coefficient was calculated for the respective pairs of teeth between ID and ED to prove a linear correlation between the individual teeth of both datasets.

Results

Figure 1 shows the flowchart of the study. Five subjects were randomized to the order ID-ED, and the other five subjects to the order ED-ID.

For the assessment of the deviations for each single tooth and the complete quadrant, the shortest distance (surface normal) between any point of the ID data sets and the respective ED surface was calculated.[3] A distinction was made between the mean positive and negative deviations of ID in relation to ED, thus taking in to account the differing spacial orientation of the deviations. The information on the latter would be lost if positive and negative values were combined. The values related to each single tooth are shown in Figs 2 (mean positive) and 3 (mean negative). The mean positive and negative deviations between ID and ED related to the single tooth are shown in Figs 2 and 3.

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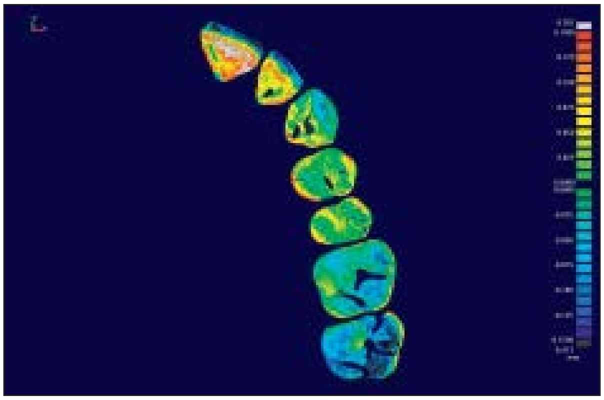

Fig 4 Color-coded image showing the differences within one subject. All deviations between 150 and –150 µm were colored. Red = positive deviations (the comparative dataset [intraoral digitization; ID] is larger than the reference dataset [extraoral digitization; ED]); blue = negative deviations (the comparative dataset [ID] is smaller than the reference dataset [ED]). Green = strong correspondence. All differences greater than or less than these values are shown in light gray and dark gray, respectively.

The mean positive deviations of ID from ED reached 37.7 µm (SD: 18.6) for one quadrant; the mean negative deviations reached –48.4 µm (SD: 31.7). Maximum positive and negative values of 203 µm (SD: 117) and –257 µm (SD: 132), respectively, were found. Color-coded difference images were used to illustrate the location of the calculated deviations (Fig 4).

When evaluating the mean deviations between the respective teeth according to Pearson correlations, a few significant correlation coefficients ($\alpha \leq 0.05$) occurred far from the alignment center at both premolars. Regarding the mean positive deviations, a significant correlation coefficient was found at the mesial and lateral incisor (r = 0.706, P = .023), second premolar and first molar (r = 0.770, P = .009), and first molar and lateral incisor (r = 0.693, P = .026). The mean negative deviations showed a significant correlation coefficient between the mesial and lateral incisor (r = 0.664, P = .036) as well as between the first and second molar (r = 0.894, P = .000).

Discussion

Limitations

The tooth surfaces were powdered to allow for digitization of the translucent tooth surfaces. This creates an additional error of 27 to 85 µm.[5]

Generalizability

When comparing the correspondence of ID with the underlying one-stage putty-and-wash impression, cast fabrication, and ED, a good correspondence was found related to the single tooth (primary outcome), especially at the alignment center (premolars). Therefore, the ID system examined in this study is well suited for the 3D acquisition of single-tooth restorations.

Within the combination of optical effects and matching errors, negative deviations were more common in areas far apart from the alignment center. Therefore, the mean positive and negative deviations are not balanced. However, when considering the quadrant as a whole (secondary outcome), high positive and negative deviations occurred in areas far from the alignment center (incisors, molars). These deviations in areas far from the alignment center showed a partially linear correlation, which means that a random error can be ruled out and that a systematic error—the compilation process—can be assumed.

Conclusions

The ID system examined in this study is well suited for the acquisition of single-tooth restorations and is of limited suitability for the acquisition of small multiple-unit restorations (eg, three-unit fixed partial dentures).

Acknowledgments

The authors reported no conflicts of interest related to this study.

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