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Intraoral Digital Scans for Fabricating Tooth-Supported Prostheses Using a Custom Intraoral Scan Body

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Abstract

This article describes a technique to assist with intraoral digital scans for fabricating tooth-supported prostheses by using a custom intraoral scan body when the extension of the scan or the clinical characteristics might compromise the reliability of the intraoral digital scan. A preliminary intraoral scan of the tooth preparations is used to design a custom intraoral scan body which is manufactured using polymethylmethacrylate and a 5-axis milling machine. A low-viscosity polyvinyl siloxane impression of the tooth preparations is obtained using the custom intraoral scan body. Subsequently, the custom intraoral scan body is digitized using an intraoral scanner. A design software program is used to align the digitized custom intraoral scan body with the preliminary intraoral scan to obtain the definitive virtual cast. This technique aims to reduce manual conventional laboratory procedures such as pouring dental impression or die trimming which might minimize inaccuracies on the virtual definitive cast.

Intraoral scanners (IOSs) have become popular in dentistry, with a wide range of models and technologies developed and now integrated into dental practice as part of the digital workflow.[1] Information on their characteristics, factors affecting their accuracy, or dentist and patient preferences have been reported.[2,3] Furthermore, different scanning strategies have been evaluated in order to make their use more predictable for fabricating both tooth- and implant-supported restorations.[4,5]

Although IOS systems provide several advantages when compared with conventional impression techniques, IOSs also present disadvantages such as cost, the necessary learning curve, and their limitations in some clinical situations; for example, where it is difficult to reproduce surfaces in a reliable way as for regular and corrugated surfaces.[6] Likewise, as most IOSs emit light and capture its reflection, shiny or translucent surfaces or the presence of saliva or blood[7] can affect this reflection and interfere with the scanning procedure. These factors can make some situations challenging when registering teeth, soft tissues, or implant scan bodies with IOSs.

Scanning accuracy and detail reproduction are parameters needed when fabricating tooth-supported fixed dental prostheses, which require registering the prepared teeth and the surrounding soft tissues. Although tooth preparation should follow the principles described in the literature,[8] additional aspects must be considered for intraoral digital scanning, such as avoiding steep planes, sharp edges,[9,10] or undercut areas.[11] Additionally, the preparation margin might be a challenging surface to reproduce with an IOS,[12] especially in interproximal locations.[13] Dental literature has not detected intraoral scanning accuracy differences between subgingival or supragingival finish line locations.[14] Although limited studies have assessed the influence of this variable on the scanning accuracy of IOSs, it seems reasonable that it would be more difficult to reproduce more subgingival locations,[15] as direct access is essential for IOS. The gingival portion and surrounding soft tissues can be difficult to reproduce reliably, especially surrounding mobile teeth.[16] Furthermore, intraoral digital scanning includes stitching procedures that occurs during the merging of the images captured by the IOS.[17,18] When fabricating long-span tooth-supported prostheses, a great number of overlaps and stitching techniques must be performed to obtain the complete-arch scan by the IOS software which can lead to lower scanning accuracy or higher dimensional discrepancies.[19]

Figure 1 "Intraoral scan" file.

The purpose of the double-step putty-light body conventional impression technique is to capture the tooth preparation details on the light body impression material, provide a uniform light body impression material thickness, and minimize the dimensional change due to the polymerization contraction of the impression material.[20,21] The present manuscript describes a technique that aims to correct some of the current limitations of the IOSs devices including reducing the possible acquisition distortions of subgingival tooth preparation finish line and improving the detail reproduction. For this purpose, a custom intraoral scan body is relined using a light body impression material. The digitized custom scan body aims to aid intraoral digital scans for tooth-supported prostheses fabrication.

Technique

A patient receiving tooth-supported crowns from the maxillary left lateral incisor to the maxillary right canine was selected to demonstrate the technique.

1. Obtain an intraoral digital scan of the interim restorations and tooth preparations during the first appointment using an IOS (TRIOS 3; 3Shape A/S, Copenhagen, Denmark) following the scanning protocol recommended by the manufacturer[22] under optimal ambient lighting conditions.[23] Then export, a standard tessellation language (STL) file named "initial intraoral scan" (Fig 1).
2. Import the intraoral scan file into a dental CAD software program (DentalCad; Exocad GmbH, Darmstadt, Germany). Design a custom intraoral scan body with a similar geometry to that of an interim restoration but increasing the cement space parameter for the margin level and the rest of the intaglio surface to leave space for the impression material used in step 4. Add additional structures on both buccal and lingual surfaces of the custom intraoral scan body design to include reference markers for guiding the posterior alignment. Furthermore, add occlusal holes on the virtual custom intraoral scan body design aiming to facilitate the escape of excess impression material (Fig 2a). Then, export the STL file of the custom intraoral scan body design "custom intraoral scan body original design."
3. Manufacture the custom intraoral scan body design from a polymethylmethacrylate (PMMA) disk (PMMA Block; Huge Dental Materials, Shanghai, China) using

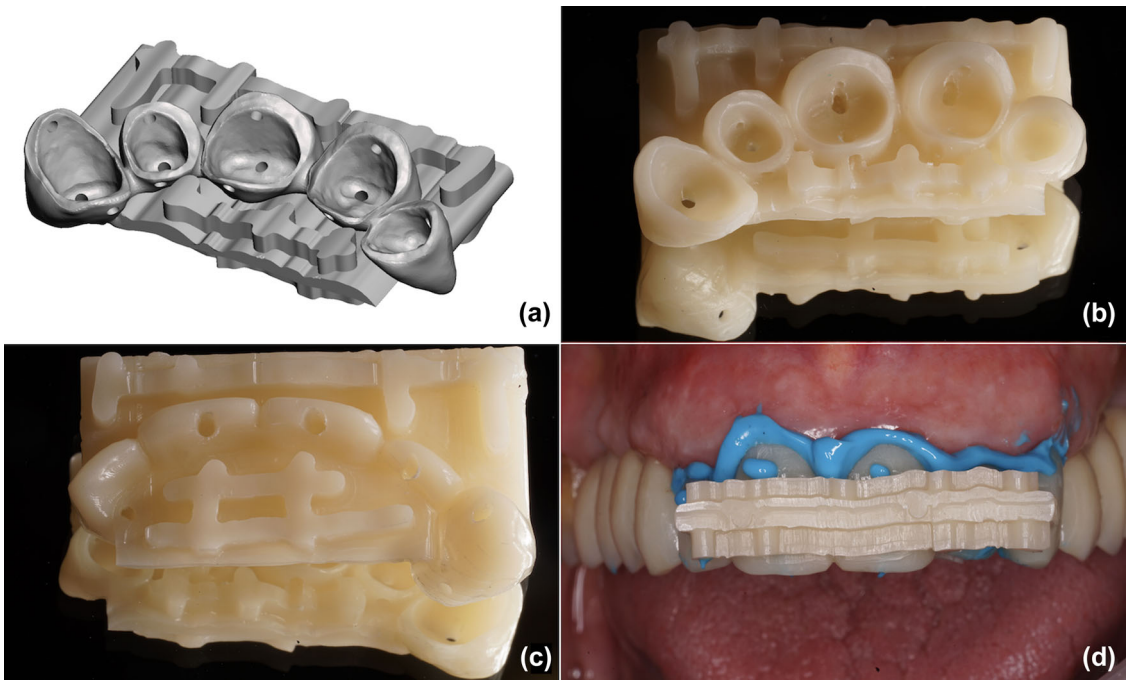

Figure 2 a, Digital file "custom intraoral scan body original design." b, Polymethylmethacrylate milled custom intraoral scan body, occlusal view. c, Polymethylmethacrylate milled custom intraoral scan body, intaglio view. d, Relined custom intraoral scan body device with polyvinyl siloxane material.

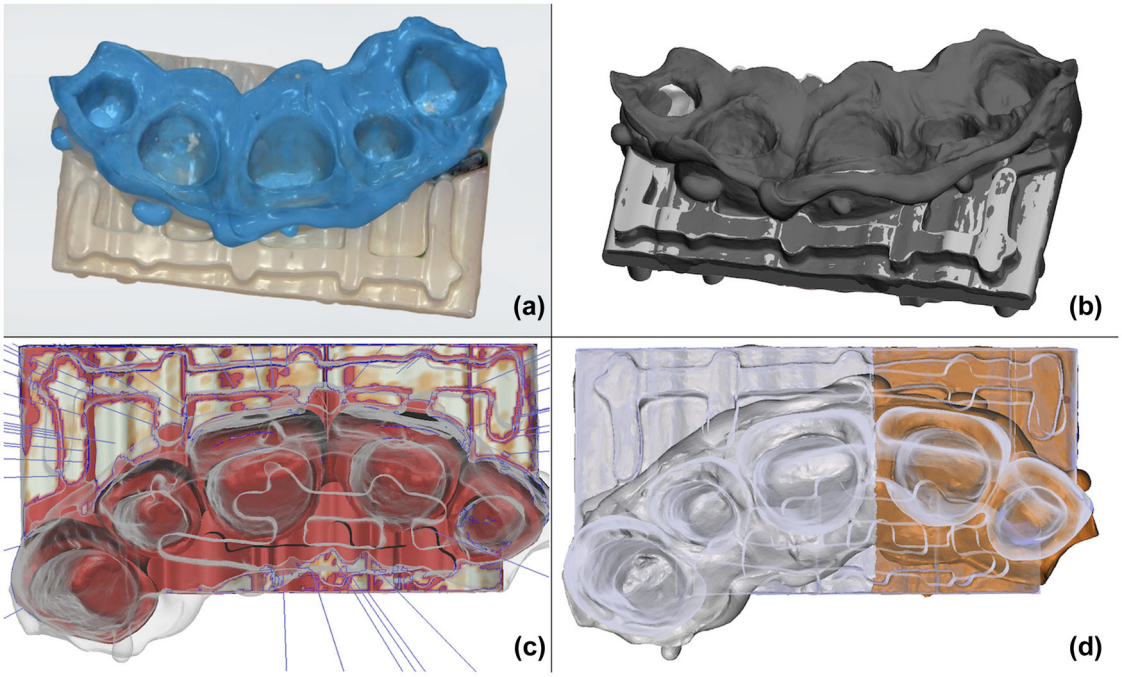

Figure 3 a, "Custom intraoral scan body scan" file. b, Alignment of "custom intraoral scan body scan" (dark gray) with "custom intraoral scan body original design" (light gray). c, Assessment of deviations of "custom intraoral scan body scan" compared with "custom intraoral scan body original design" (deviations greater than 100 μm in red). d, Realignment of "custom intraoral scan body scan" fragments (light gray and orange) on "custom intraoral scan body original design" file (light purple) by using reference markers.

a 5-axis milling machine (Programill PM7; Ivoclar Vivadent AG, Schaan, Liechtenstein) following the manufacturer's recommendations (Figs 2b and c). As an alternative, the custom intraoral scan body design can be additively manufactured using a vat-polymerization printer and an interim polymer material for the selected vat-polymerization technology.

4. Clean and dry the tooth preparations surfaces, during the second clinical appointment, once the interim restoration has been removed. Use the double cord technique impression as in conventional methods. Position a light-bodied polyvinyl siloxane (PVS) material (Elite HD Light body normal set; Zhermack SpA, Badia Polesine, Italy) inside the custom intraoral scan body and on the tooth preparation surfaces, and position the device on the corresponding teeth. Extend the impression material to reproduce the surrounding soft tissues. The excess of impression material will flow through the occlusal escape holes of the custom intraoral scan body, but without covering the reference marks (Fig 2d).
5. Recover the polymerized impression and digitize both the intaglio and external surfaces by using the same IOS device. Then, export the STL file "custom intraoral scan body scan" (Fig 3a).
6. Import the "initial intraoral scan," "custom intraoral scan body original design," and "custom intraoral scan body scan" STL files into a software program for working with 3D meshes (Meshmixer; Autodesk, Inc., San Rafael, CA). Align the "custom intraoral scan body scan" file with the original design of the custom intraoral scan body "custom intraoral scan body original design" file and analyze any deviations (Figs 3b and c). If deviations are observed, divide the "custom intraoral scan body scan" file into sections and realign each fragment over the "custom intraoral scan body original design" (Fig 3d) by using the reference marks to minimize the dimensional alterations. Name the file as "custom intraoral scan body scan corrected."

7. Subsequently, select the intaglio surface of the custom intraoral scan body corresponding with the dental impression in the software program (Meshmixer; Autodesk, Inc.) (Fig 4a). Isolate this selection as an individual file and position in the "initial intraoral scan" file, replacing the prepared teeth and surrounding tissues areas (Figs b, c, and d). Then, align the files using the tooth preparation surfaces as common information trying to avoid sharp edges, undercuts, or irregularities where the intraoral digital scan may present more deviations or inaccuracies. Name the resulting file as "improved intraoral scan file" which represents the definitive virtual cast for designing the definitive restorations.

8. Optionally, the original "initial intraoral scan" file can be compared with the virtual definitive cast by looking for discrepancies. The improvements in detail reproduction (Fig 5) and dimensional deviations of prepared teeth can be observed and analyzed (Fig 6).

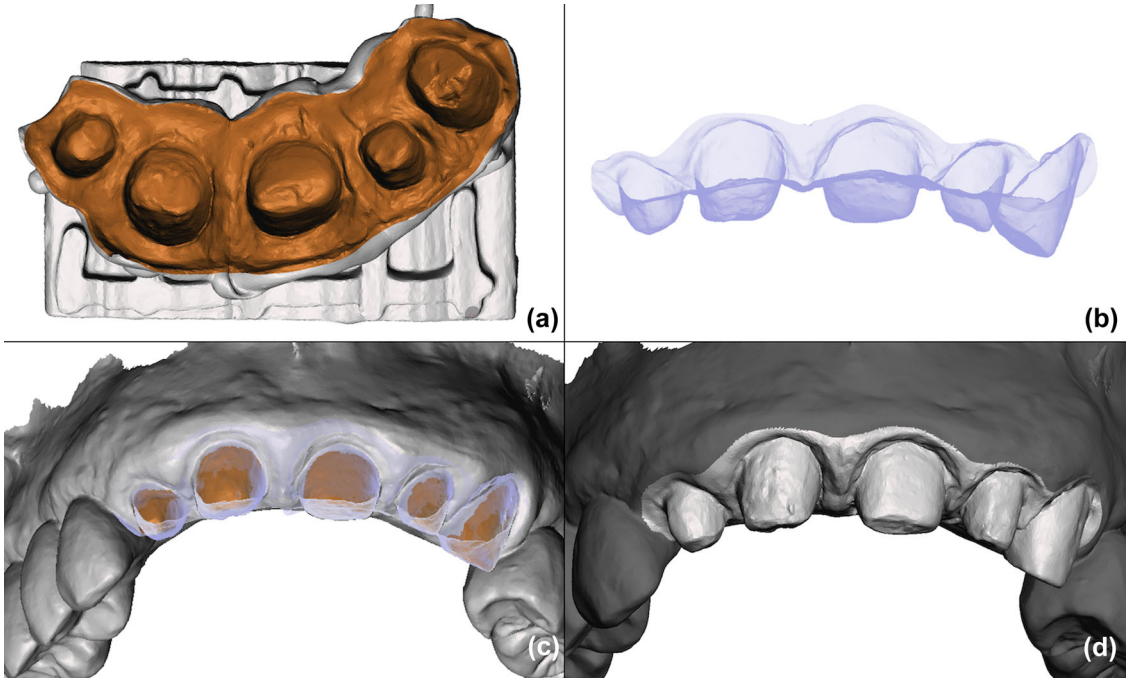

Figure 4 a, Selection of relined surfaces in "custom intraoral scan body scan corrected." b, Selection of relined surfaces in "custom intraoral scan body scan corrected." c, Alignment of relined surfaces on "intraoral scan" file. d, "Improved intraoral scan" file.

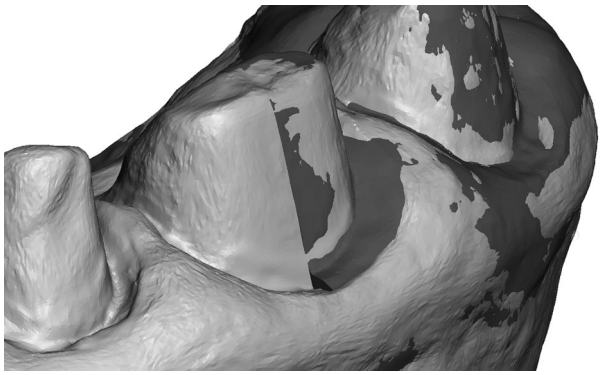

Figure 5 Detail of reproduction of surrounding soft tissue of "intraoral scan" file (dark gray) with "improved intraoral scan" file (light gray) in maxillary left central incisor.

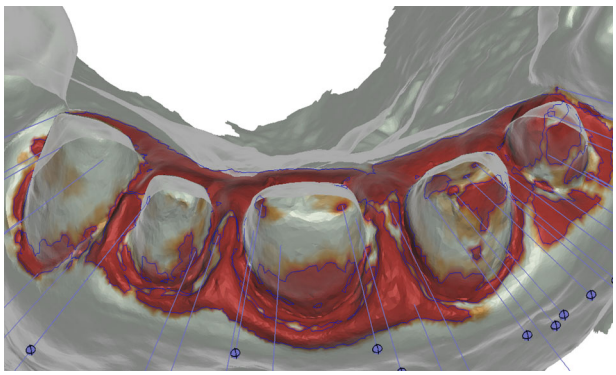

Figure 6 Deviations comparing "intraoral scan" file with "improved intraoral scan" file (deviations greater than 100 μm in red).

Discussion

The described technique aims to assist intraoral digital scans for tooth-supported prostheses fabrication by using a custom intraoral scan body. The custom intraoral scan body presented a design similar to that of an interim restoration but with additional design features on the buccal and lingual surfaces to facilitate the posterior alignment procedures. The custom intraoral scan body has two main functions. Firstly, the custom intraoral scan body is relined with PVS material to register the tooth preparations and surrounding soft tissues assisting the acquisition procedures of the definitive virtual cast; therefore, the custom intraoral scan body was used as a custom impression tray aiming to provide a higher detail reproduction. Secondly, the custom intraoral scan body design provides reference marks that allow the alignment of digital scans aiming to correct possible deviations. However, additional studies evaluating the accuracy of the virtual definitive cast obtained using the outlined technique are required.

The described technique might be conceptually similar to the double-step conventional impression technique.[20,21] But, in the digital workflow, the aim of the technique is to aid intraoral scanning techniques capturing subgingival tooth preparation finish line. Additionally, the technique reduces manual conventional laboratory procedures such as pouring dental impression

or die trimming, which might minimize inaccuracies on the definitive cast.

The procedure described is a simple technique with low cost, although increased laboratory time and cost and the additional appointment for relining with impression material are disadvantages of the technique. Additionally, once the custom intraoral scan body and the elastomeric impression material is registered, its digitization and file management require additional work. Advantages of the technique include that the reference markers might provide assistance when comparing the discrepancy between the digitized custom intraoral scan body and the preliminary intraoral digital scan to look for dimensional discrepancies. If these deviations are found, the files can be segmented and each fragment relocated on the original in order to get a more reliable scan. Furthermore, the relining of the custom intraoral scan body with impression material provides higher detail reproduction in some challenging areas like the marginal and gingival areas, which might increase the reliability of the definitive digital file that will be used for the design and manufacturing of the definitive restorations. The technique contained in this manuscript may assist with complete-arch digital scans for fabricating tooth-supported prostheses solving some of these problems;[20] however, further studies are recommended to assess the accuracy of the digital definitive cast obtained with the described technique.

Previous dental literature has evaluated the influence of cutting-out and rescanning procedures on the accuracy of IOSs devices.[17,18] Both in vitro and in vivo studies have shown how the cutting out of areas of an existing intraoral digital scan with its posterior rescanning technique decreased intraoral scanning accuracy of the IOS system tested.[17,18] The results showed that cutting-out and rescanning methods decreased trueness from 5 to 26 μm and precision from 2 to 150 μm.[17,18] The technique described in the present study did not included cutting-out and intraoral rescanning methods; however, the virtual definitive cast was obtained by correcting the initial intraoral digital scan.

Among the limitations of the described technique, a CAD software program, a milling machine, and a laboratory dental scanner is needed. The narrow space for the elastomeric material might be considered a disadvantage, as it can lead to inaccuracies in the intaglio surface. Further studies are needed to evaluate the accuracy of the described technique using alternative elastomeric materials such as polyether impression material. However, an additional clinical appointment is required for developing the proposed technique. The combination of the conventional and digital impression procedures aims to facilitate the clinical intervention. Nevertheless, further clinical and in vitro investigations must be developed to assess the accuracy and efficacy of this technique.

Summary

This article describes a technique to improve the accuracy of intraoral digital scans for tooth-supported prostheses by using a custom intraoral scan body. The technique allows the evaluation and correction of the inaccuracies or deviations of the intraoral digital scans for tooth-supported prostheses and aims to improve detail reproduction, especially in tooth preparation margins and surrounding soft tissues.

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