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Short Communication

A digital workflow for single complete denture using a multi-functional diagnostic denture

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Abstract Creating a single complete denture against natural dentition can be challenging. To facilitate the clinical procedure and promote balanced occlusion, we developed a digital workflow of a single complete denture using a multi-functional diagnostic denture (DD). The DD was digitally designed and fabricated using a three-dimensional printing process to create a guide for tooth grinding in opposing dentition and a final impression that allows the jaw relationship and dynamic articulation to be recorded by an intraoral scanner. The definitive complete denture was combined with a milled artificial dentition and titanium-plated denture base. Within three clinical visits, this digital workflow provided better efficiency and easy implementation for a single complete denture.

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Single-arch complete denture restoration against natural dentition is always challenging. Due to the fixed position and irregular occlusal planes of the opposing dentition, the dentist's control over the occlusal design and arrangement is always compromised, resulting in frequent fracture and dislodgement of the denture.[1] Hence, the opposing dentition should be modified before denture restoration to form an appropriate occlusal plane as much as possible. The conventional protocol relies on the expertise of the dentist and the technician. Additionally, five to six patient visits, and sometimes more, are necessary to properly fit the denture.

Developments in computer-aided design and computer-aided manufacturing (CAD-CAM) allow full digitalization of the design and the manufacture of complete dentures.[2] This technology facilitates the process of impression taking, designing, and manufacturing using three-dimensional (3D) printing or computerized numerical control milling techniques.[3,4] It offers similar or better results than conventional methods, including a better fit of the intaglio surfaces, improved mechanical properties, and higher patient satisfaction.[5] However, as opposed to fitting both arches, a single-arch complete denture presents an even greater challenge to ensure occlusal balance, requiring conventional lab processes for artificial tooth modification and arrangement.

This article presents a digital workflow of a single complete denture for accurate grinding of the opposing tooth and predictable occlusal balance. The process involves fabricating a multi-functional, digitally designed, 3D-printed diagnostic denture (DD). The DD is then used for guiding tooth grinding, taking the final impression, and recording the jaw relationship and functional movement.

Technique

The proposed digital workflow for a DD was applied to a 68-year-old male patient with a maxillary edentulous arch. At the patient's first visit, a primary impression and virtual bite registration were obtained using a TRIOS 4 intraoral scanner (3Shape, Copenhagen, Denmark) (Fig. 1A), similar to the process reported by Fang.[6] The data were imported into design software (HoteamSoft Co. Ltd., Jinan, China) to design the DD. The border of the denture base was retracted by 2 mm, and the intaglio surface was offset by 1 mm to leave impression space with hemispherical tissue stops. The artificial tooth dentition was located on its original arrangement and normal occlusal plate (Fig. 1B). The data for both jaws and the DD were imported into reverse engineering software (Geomagic Studio 2014; Raindrop Geomagic, Rock Hill, SC, USA). Occlusal interferences were checked on the opposing natural tooth. The shape of the digital cast was modified using a Boolean operation. The modified area was marked in red, as shown in Fig. 1C. The DD was printed with a polylactic acid material (Fig. 1D and E) using a 3D printer (Lingtong I, 0.8 mm diameter nozzle; Beijing SHINO, Beijing, China).

At the patient's second visit, grind interferences on the opposing tooth, according to red marks on the digital cast (Fig. 1C). A final edentulous impression was obtained with the DD (Fig. 1F) using border molding wax (ISO Functional; GC Co., Tokyo, Japan) and a polyether material (3M Impregum ESPE; Seefeld, Germany). The DD intaglio surface (with the final impression) was scanned using 3Shape TRIOS 4. With the DD in place (Fig. 1G), articulating papers were used to check and indicate occlusal interferences with respect to the centric relation and functional movements (Fig. 1H). Both the artificial and opposing natural dentition were modified to achieve the best occlusal balance. The tooth surfaces were polished after grinding (Fig. 1I), and the bite registration and dynamic articulation were recorded. The patient's upper (wearing the DD) and lower dentitions were scanned with centric occlusal registration (Fig. 2A). The dynamic articulation of the lower jaw was then recorded (Fig. 2B), and the 3oxz and dcm files were exported as "model 1". The DD's outer surface was then scanned (Fig. 2C) and aligned with 'model 1' using the n-point method to form the final digital cast (Fig. 2D). To design the definitive denture (Fig. 2E), the characterized dentition was indicated by the DD and its dynamic articulation using 3Shape Dental System software (3Shape, Copenhagen, Denmark). The dentition of the final denture was milled in a 25-mm-thick resin nanoceramic blank (Renci; UPCERA, Shenzhen, China) (Fig. 2F). The final complete denture was fabricated with milled dentition and a titanium-plated denture base, using a process similar to that described in a previous study.[5] The definitive denture was then inserted (Fig. 2G and H). The missing tooth in the lower dentition was then restored with a removable partial denture.

Discussion

To create a single complete denture opposing natural dentition, the conditions that comprise denture restoration should be outlined and corrected before treatment.[1] Conventionally, this involves the extra work of cast measurement, to evaluate and grind the interference of the opposing natural teeth. The accuracy of tooth grinding depends mostly on the dentist's experience and expertise.[7] It also requires a complicated arrangement of artificial tooth, to match the shape and occlusion of the opposing dentition. Using the digital workflow, modification of the opposing dentition was implemented with better accuracy. The grinding surfaces were identified and marked in the digital cast, and then checked by an articulating paper wearing DD. To protect the vital pulp, the modification was located only on the enamel, and the teeth were polished with pumice flour in a rubber cup after grinding.

Digital workflows for a single complete denture have been reported. Lo Russo[8] reported a full process starting from an intraoral scan and fabricating the definitive denture with characterized dentition; however, only the centric occlusion was considered in the design. Functional mandibular movements also affect occlusal balance and denture stability. In this digital workflow, dynamic articulation was recorded efficiently by a TRIOS 4 intraoral scanner, while the patient was wearing the DD. The full process and path of the patient's jaw movement could be used directly to design the artificial dentition, to obtain harmonious occlusion between the maxillary complete denture and the mandibular tooth. The definitive maxillary

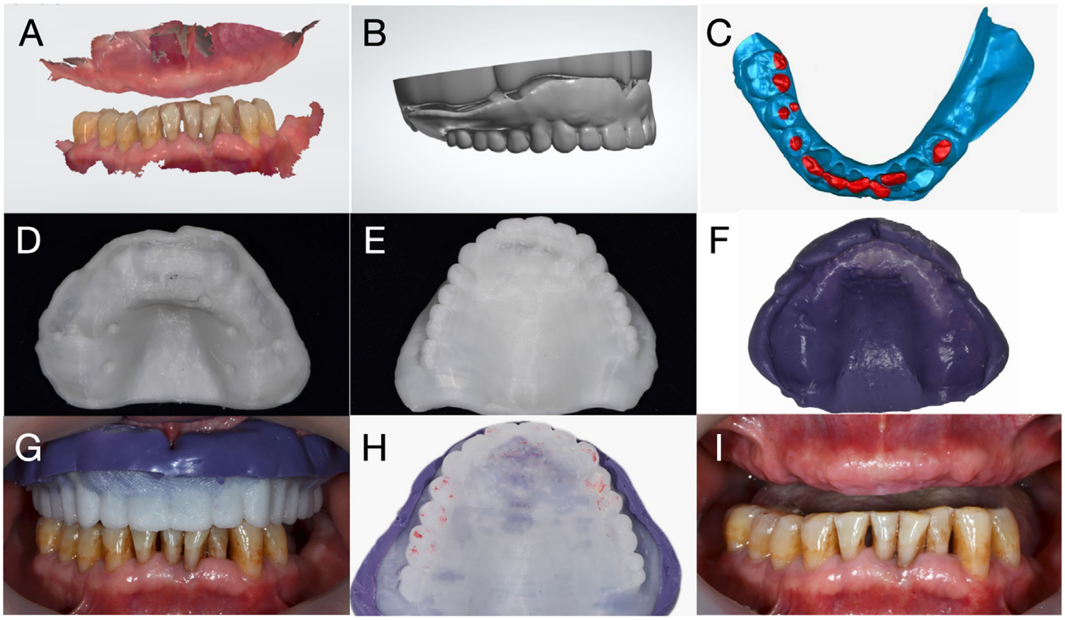

Figure 1 Design and 3D printing of the diagnostic denture (DD). (A) Intraoral scanning of the maxillary edentulous arch and opposing dentition with the primary jaw relationship. (B) Design of the DD. (C) Marking of the grinding surface of opposing teeth. (D) Tissue surface of the DD. (E) Dentition and polishing surface of the DD. (F) Definitive impression of the edentulous arch using the DD. (G) Modification of the opposing natural tooth with the DD in place. (H) Assessment of occlusal contact using articulator papers. (I) Mandibular dentition after tooth grinding and polishing.

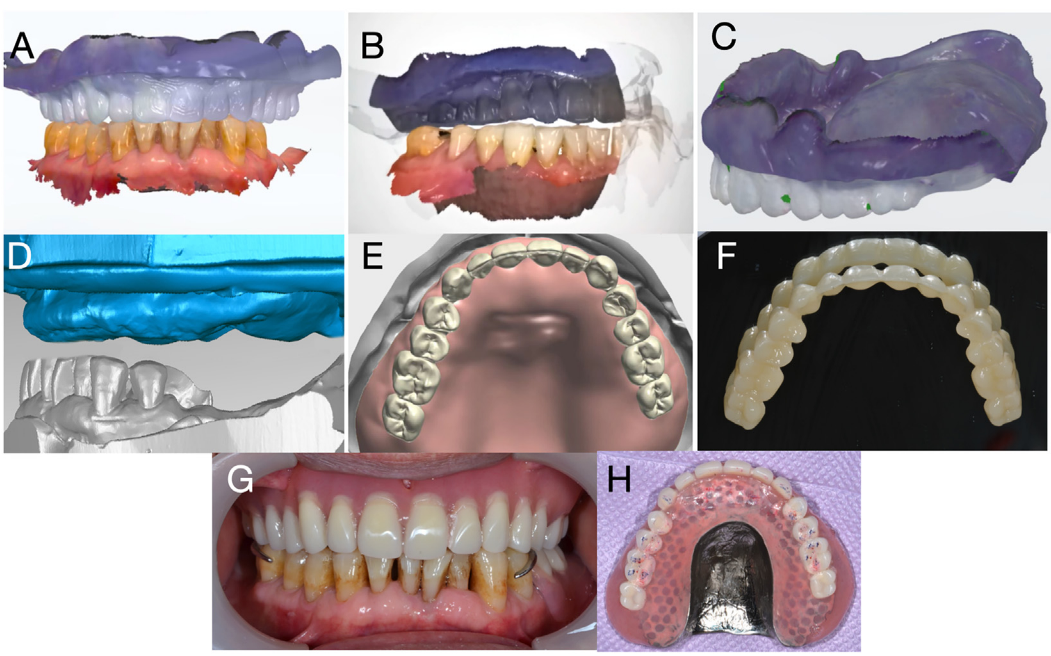

Figure 2 Digital workflow of the final complete denture. (A) Oral scanning wearing the DD, including the centric occlusion record and dynamic articulation. (B) Scanning of the DD. (C) The final working digital cast. (D) Design of the artificial dentition and denture base. (E) The milled artificial dentition. (F) The final titanium-plated complete denture. (G) Intraoral view of denture insertion. (H) Occlusal balance of the final denture.

denture was rated by the patient as good for both function and retention. No complication had been observed as of 6 months of denture usage.

Although direct digital impression using intraoral digital scanning has been reported as promising and highly efficient, the mucosa, especially in the vestibular area, exhibits high displacement, making the border difficult to determine.[9] For accurate molding of the edentulous arch, we used intraoral scanning as the sole, primary impression. The DD was also used as a custom-tray for the definitive impression. After the final impression, the intaglio surface of the DD should be scanned immediately. Although the polyether material could ensure and maintain the accuracy of the impression, there may be some deformation during functional movements. With the modified multi-functional DD, only one visit is required to obtain accurate opposing dentition grinding, a final impression, and the proper occlusal relationship with mandibular movement.

The denture base fabricated using CAD-CAM technology was very promising.[10] Considering the frequent fracture of single complete dentures, in this workflow, we still chose a metal baseplate with semi-digital denture fabrication. The lab process has been reported before, and the process has demonstrated good retention and suitability.[5]

In conclusion, here we introduce a digital workflow for single complete denture restoration, to facilitate the clinical procedure and promote balanced occlusion. The workflow comprises digital design and 3D-printing of a multi-functional DD to guide opposing natural teeth grinding, taking the final impression, and recording the jaw relation and functional movement. Accurate modification of the opposing dentition and characterized artificial dentition both promote final balanced occlusion. Overall, this proposed digital workflow is promising and highly efficient; however, long-term clinical validation is necessary.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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References

1. Stansbury CB. Single denture construction against a non-modified natural dentition. *J Prosthet Dent* 1951;1:692—9.
2. Bilgin MS, Erdem A, Aglarci OS, Dilber E. Fabricating complete dentures with CAD/CAM and RP technologies. *J Prosthodont* 2015;24:576—9.
3. Baba NZ, Goodacre BJ, Goodacre CJ, Müller F, Wagner S. CAD/CAM complete denture systems and physical properties: a review of the literature. *J Prosthodont* 2021;30:113—24.
4. Deng K, Chen H, Wang Y, Zhou Y, Sun Y. Evaluation of functional suitable digital complete denture system based on 3D printing technology. *J Adv Prosthodont* 2021;13:361—72.
5. McLaughlin JB, Ramos Jr V, Dickinson DP. Comparison of fit of dentures fabricated by traditional techniques versus CAD/CAM technology. *J Prosthodont* 2019;28:428—35.
6. Fang Y, Fang JH, Jeong SM, Choi BH. A technique for digital impression and bite registration for a single edentulous arch. *J Prosthodont* 2019;28:e519—23.
7. Tan HK. A preparation guide for modifying the mandibular teeth before making a maxillary single complete denture. *J Prosthet Dent* 1997;77:321—2.
8. Lo Russo L, Salamini A. Single-arch digital removable complete denture: a workflow that starts from the intraoral scan. *J Prosthet Dent* 2018;120:20—4.
9. Zarone F, Ruggiero G, Ferrari M, Mangano F, Joda T, Sorrentino R. Accuracy of a chairside intraoral scanner compared with a laboratory scanner for the completely edentulous maxilla: an in vitro 3-dimensional comparative analysis. *J Prosthet Dent* 2020;124:761.
10. Prpić V, Schauperl Z, Ćatić A, DulčićN ČimićS. Comparison of mechanical properties of 3D-print CAD/CAM and conventional denture base materials. *J Prosthodont* 2020;29:524—8.