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A simplified digital workflow using a modified 3D printed anatomical tray with LEGO plates as occlusal rims for digital complete denture fabrication

Running title: Digital workflow for complete denture fabrication

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ABSTRACT:

This technique describes a simplified, time efficient, low cost digital workflow to fabricate anatomic trays (MAT) designed in various sizes and shapes to fit edentulous arches, modified with LEGO building plates that enable the clinician to make impressions and record jaw relationships for completely edentulous patients accurately and consistently in the first clinical visit allowing denture delivery at the third visit.

KEYWORDS: Digital denture, impression, intraoral scan, jaw relationship, 3D printing.

INTRODUCTION:

Conventional method for complete dentures (CD) fabrication involves series of clinical and laboratory procedures which are time consuming and labor intensive.¹⁻³ However, Computer-aided design and computer-aided manufacturing CAD/CAM technology enables not only the usage of intraoral scanning (IOS) without the need for conventional impression materials, but also provides the flexibility to integrate both digital and conventional impressions.⁴ This integration permits accurate alignment and superimposition of datasets, enhancing precision while reducing clinical and laboratory time, without completely replacing the gold-standard conventional techniques.⁵

This advent of fabrication of complete dentures using CAD/CAM technology introduces innovative ideas in removable prosthodontics, it produces reliable, accurate and efficient dentures while minimizing time, physical laboratory work and clinical visits.⁶⁻⁸

Despite these advancements, recording maxillomandibular relations digitally in completely edentulous patients remains a significant clinical challenge due to the absence of stable vertical stops and reliable anatomical landmarks. This often compromises the accuracy of jaw relation records and increases technique sensitivity. To address this limitation, several systems and digital

solutions have been introduced, including specialized occlusal rims, gothic arch tracing devices, and digitally assisted jaw registration tools.⁹⁻¹¹

Achieving a method that is simple, cost-effective, reproducible, and reusable remains an ongoing area of research. Although often perceived as toys, commercially available LEGO building plates have been previously utilized in various dental applications, including bimaxillary osteotomies, mandibular advancement procedures, and laboratory applications.¹² With the integration of CAD/CAM technologies, these plates can now be precisely designed and fabricated with high precision and tailored dimensions, enabling their adaptation for versatile applications within the field of dentistry, specifically as auxiliary tools to provide a stable vertical stopper during bite registration.

Although numerous commercial CAD/CAM systems use anatomic measuring device (AMD) for impression making and bite registration in the first clinical visit.¹²⁻¹⁸ However, these systems are expensive or unavailable in some regions, so, obtaining them could be challenging.

Although literature has introduced several techniques for digital complete denture fabrication,^{11,19,20} making an impression of an edentulous jaw with an accurate registration of jaw relationship in the first visit remains challenging.

This technique describes a simplified, time efficient, low cost method to digitally fabricate modified anatomic trays (MAT) that make impressions and record jaw relationships for completely edentulous patients in the first clinical appointment allowing denture delivery at the third visit.

TECHNIQUE:

All experimental protocols and methods were approved by in accordance with the relevant guidelines and regulations of the ethical committee of the faculty of dentistry, Tanta University, Egypt under the number of # R-RP-1-25-3178. An informed consent from all subjects and/or their

legal guardian(s) for publication of identifying information/images in an online open-access publication were taken from the enrolled subjects in this report.

Fabrication of the modified anatomic tray:

- 1- Scan the readymade tray set (Xanlgin Tray Set 1, Bayer Dental) using intraoral scanner (Alliedstar AS 100) after being sprayed with scan spray (SHERA, Werkstoff-Technologie GmbH). Export the standard tessellation language (STL) files for each tray, name and save them according to its size and shape for easy organization.
- 2- Import each STL file in B4D design software (Blender for Dental Software, version 1.1.32) to create model from each file using model creator module and a record base of 2mm thickness using the denture module.
- 3- Download free STL files for a Lego unit brick (3001-2*4) and a Lego plate (3020-2*4) (The LEGO Group). Import the unit plate file into your design software, duplicate it for each side, and position them on the crest of the ridge posteriorly, with height of 16-18 mm from the buccal vestibule/ border without covering the maxillary tuberosity and retromolar pad. Orient the studs of the Lego plate to face the occlusal plane for the maxillary arch and set the hollow side up for the mandibular arch at half the height of the retromolar pad. Connect the mandibular base with the unit plate and export as a single STL file.
- 4- For the maxillary base, import the Lego plate STL and attach it to the anterior labial flange with a slight labial inclination, at a height of 20-22 mm from the labial vestibule. Unite the maxillary base with the plates, then export as one STL file. (Fig 1 a,b)

- 5- Print the complete set of MATs and several Lego plates (Fig. 2 a, b) using 3D printing resin (SAVOY Digital systems C&B Resin) using 3D printer (Anycubic Photon S - High-precision SLA).

First clinical appointment:

- 1- Select the appropriate size and shape of the MAT for both the maxillary and mandibular arches. Modify the tray's borders by adding or reducing the added green compound (Kerr Corp., Kerr) where needed. Make the impression using polyvinyl siloxane impression material (Elite HD+, Zermach)
- 2- For digital impression do scan of both arches using an intraoral scanner. To facilitate future alignment and superimposition, add an impression material to the anterior part of the upper and lower trays (Fig. 3 a, b).
- 3- Modify labial support by adding a Lego plate if necessary. Mark the midline and occlusal plane on the Lego plate with a pencil clearly and refine these markings with a grinding bur in a low-speed handpiece. Adjust the upper occlusal plane by adding Lego plates to the maxillary unit plates until the correct level is achieved.
- 4- Insert the mandibular tray asking the patient to close in centric relation several times ensuring the Lego plates stay connected. Adjust the vertical dimension by adding or removing Lego plates as needed. Once confirmed, apply bite registration material (Occlufast+, Zermack) to the unit plates to register the centric relation between the upper and lower plates, ensuring precise results. (Fig. 4 a).
- 5- Remove the maxillary and mandibular trays from the patient's mouth as one unit. Spray them using scan spray, then scan using an intraoral scanner. Export the STL file and save it with the patient's name. (Fig. 4 b).

- 6- Import the STL file of the scanned MAT to B4D design software (Blender for Dental Software, version 1.1.32) to start complete denture designing. Create maxillary and mandibular models from the maxillary and mandibular impressions using model creator modules.
- 7- In case of making scanning instead of conventional impression of both arches, import their STL files and align them with that of MAT using the added impression material as a stitching point in the alignment module then create maxillary and mandibular models from the intraoral scans. (Fig. 5).
- 8- Design the denture base and set the teeth using the denture module. Arrange the teeth using the guidelines marked on the MAT (midline and occlusal plane). Remove any occlusal interferences using the articulator module. (Fig. 6)
- 9- Do the wax-up, export the trial dentures and print them using 3D printing resin (SAVOY Digital systems C&B Resin) (Fig. 7).

Second clinical appointment:

- 1- Do the try-in step with the trial dentures in the patient's mouth verifying the following points: labial support, midline alignment, occlusal plane, centric relation, vertical dimension and centric occluding relation.
- 2- If any correction is needed, modify it and rescan the trial dentures in the same manner as with MAT. For minor modifications, adjust the design and proceed to fabricate the final denture. However, if the changes are significant, create a new design based on the new scan and schedule a third clinical appointment to try the new trial dentures.
- 3- Once the try-in step is completed, export the maxillary and mandibular dentures with the teeth as a separate unit from the denture base using design phase.

- 4- Print the denture bases and teeth using permanent resin (Asiga DentaBASE) for bases and (Asiga DentaTOOTH) for teeth.
- 5- Follow the manufacturer's instructions regarding washing and post-curing times.
- 6- Finally, bond the teeth to the denture base using the same resin used for the denture base, then make final curing.

Third clinical appointment:

Deliver the maxillary and mandibular dentures and review the previous steps. Provide the patient with essential instructions for maintaining oral and denture health. (Fig. 8).

DISCUSSION:

Incorporating digital technology in complete denture fabrication workflow requires making functional impression during the first clinical visit which overcomes the limitations of intraoral scanning in capturing the viscoelasticity of the soft tissue resulting in short sulcus depth of edentulous ridges in nearly most of cases.^{4,16} Trimming the peripheral borders of conventional impressions to a similar extent to the intraoral scan causes mobile tissue stretching and compression leads to improving the accuracy value.¹⁷ Kalberer et al;¹⁵ found that the polyvinyl siloxane was significantly more accurate than the digital scan at the inner seal and about 2 mm from the border molded impression. Additionally, taking an impression facilitates the creation of a record base to establish a reliable bite plate for accurate jaw relation registration.

The significant reduction in number of clinical visits and physical laboratory steps are advantages of the digital workflow. Despite advancements in systems that facilitate impression making and bite registration in the same clinical appointment with AMD reduces the number of visits.¹³⁻¹⁴ it still faces challenges such as deficiencies and high costs. Even recent studies have thought to refine

the used technique or overcome these limitations had its own limitations in using existing denture or depending on opposing already restored arch.^{4,19}

To address these issues, this modified technique has been developed to simplify the use of digital workflows in daily dental practice.

This approach offers a promising, simplified alternative for improving the accuracy and consistency of maxillomandibular relationship records. The clinician will be able to make a functional impression with anatomical trays suitable for any size or shape of the arch and register jaw relations in the first clinical visit, reducing the number of clinical visits required to fabricate a complete denture into three visits with the ability to make modifications during the try-in visit. Also, if the clinician goes for scanning instead of using impression material, it presents easy incorporating of intraoral scans into the design, ease of design. Moreover, it reduces the cost of the whole process through reusing of 3D printed trays and designed LEGO plates multiple times. However, further scientific evidence and further evaluative studies to validate the reproducibility and accuracy validation are still required.

Conclusion:

This modified technique aids in optimizing the digital workflow of complete denture fabrication by elevating the level of patient care, minimizing visits and allowing for personalized adjustments.

Data availability statement:

All authors declared full control of data.

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

We confirm that all experimental protocols were approved by the ethical committee, faculty of dentistry, Tanta University, EGYPT under the number of # R-RP-1-25-3178.

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PATIENT CONSENT:

Informed consent was obtained from the patient included in this technique that his images will be used in a scientific manuscript.

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FIGURE LEGEND:

Figure 1a, b: The exact position of the unit plate on the maxillary and mandibular modified trays

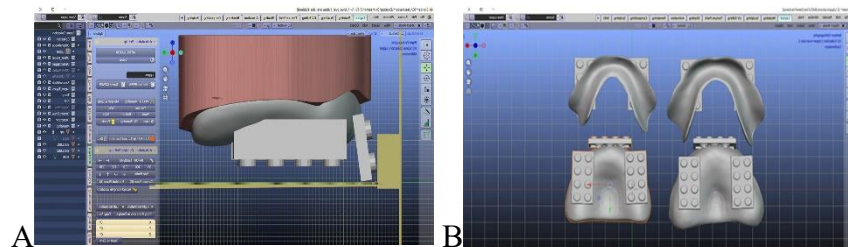


Figure 2 a,b: The printed modified trays and LEGO plates

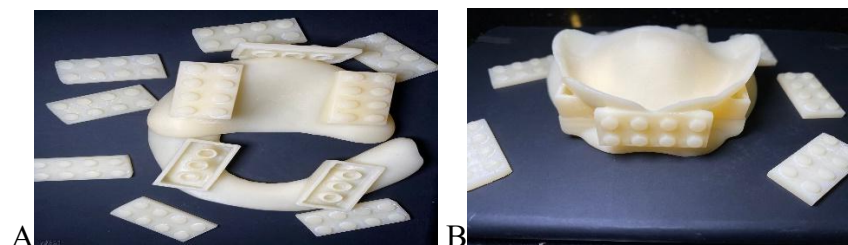


Figure 3 a,b: The scanned maxillary and mandibular jaws.

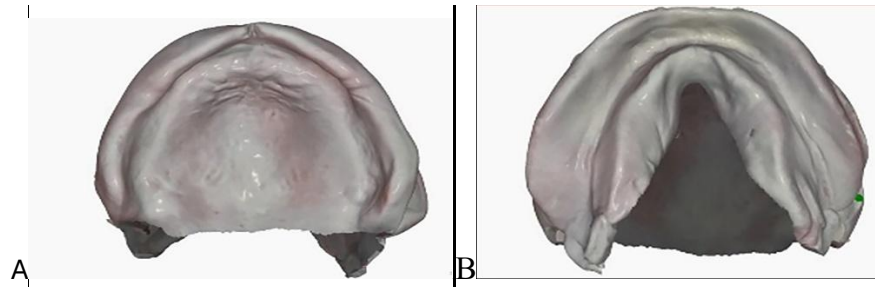


Figure 4 a, b: The scanned maxillary and mandibular modified anatomical trays with the polyvinylsiloxane bite registration material in-between.

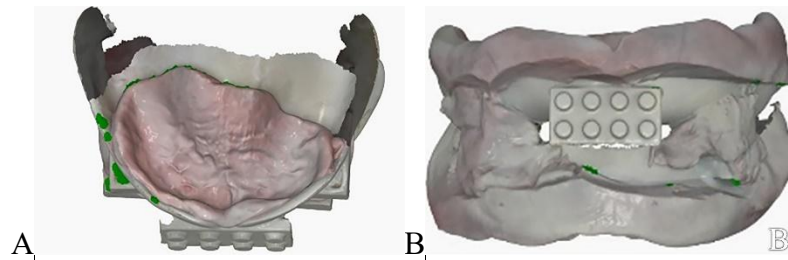


Figure 5. The scanned MAT with the polyvinylpolysiloxane material in the palatal region as an index.



Figure 6. The designed upper and lower dentures with teeth set.

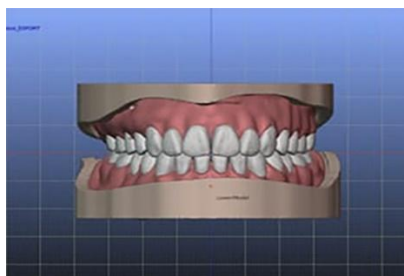


Figure 7. the printed maxillary denture try in.



Figure 8. Insertion



CRedit authorship contribution statement

Maha M. Abo Shady: Conceptualization, Investigation, Methodology, Software, Data curation.

Mohamed M. Elsheikh: Writing- original draft, supervision. **Tamer Mostafa:** Writing- reviewing and editing. **Marwa M. Amer:** Visualization, Software, Validation, Writing- reviewing and editing

Declaration of Interest Statement

We confirm that all authors have seen and approved the final version of the manuscript being submitted and that this work is original and has not been published elsewhere, nor is currently under consideration for publication elsewhere.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Figure legend:

Figure 1.a: The exact position of the unit plate on the maxillary and mandibular modified trays

Figure 1.b: Attaching the unit plate on the maxillary modified tray

Figure 2 a,b: The printed modified trays and LEGO plates

Figure 3 a,b: The scanned maxillary and mandibular jaws.

Figure 4 a, b: The scanned maxillary and mandibular modified anatomical trays with the polyvinylsiloxane bite registration material in-between.

Figure 5. The scanned MAT with the polyvinylpolysiloxane material in the palatal region as an index

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Figure 8. Insertion