

Digital fabrication of flanges in removable partial dentures: a step-by-step workflow

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Abstract

The fabrication of flanges in removable partial dentures (RPD) traditionally entails labour-intensive manual manipulation of materials such as wax to sculpt and shape the flanges according to the patient's oral anatomy. This method requires a high level of skill and precision from dental technicians to ensure the final prosthesis fits comfortably and functions effectively. While most RPD framework designs are now executed digitally, the arrangement of artificial teeth and flanges often remains a manual process. This is primarily due to the scarcity of suitable software capable of designing flanges using computer-aided design (CAD) technology. This report addresses this challenge by presenting an alternative approach to flange design using the CAD software of 3Shape Dental System. By utilizing the software's function for custom tray design, we developed the flanges with the aid of abutment teeth, artificial teeth and framework, thereby improving the accuracy of gingival anatomy in flange fabrication.

Keywords: *computer aided design, dental technique, flanges, removable partial denture*

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Introduction

In recent years, there has been a significant transformation in the fabrication of dental prostheses with the widespread adoption of digital technologies. Despite these advancements, the fabrication of removable partial dentures (RPD) using digital techniques is still evolving (Akl & Stendahl, 2022, Piao *et al.*, 2022). The digital design process for RPD utilizes computer-aided design (CAD) software, which integrates patient-specific data obtained from intraoral scans or digital impressions (La Russo *et al.*, 2023). However, due to the diverse shapes

and irregularities of RPD parts (such as major and minor connectors, rests, clasps and base plates), creating a 3D design for the framework is often challenging and time-consuming. Additionally, a notable gap exists in current computer-aided design (CAD) software, which is the lack of dedicated functions and commands for designing flanges within RPD frameworks.

Flanges, which are extensions of the denture base are crucial components of RPD, providing support, stability, and retention for the prosthesis (Mousa *et al.*, 2021). Their proper design is essential for the functionality and comfort of the patient. Yet,

the absence of specialized tools within CAD software means that dental professionals often resort to traditional manual interventions to achieve the desired flange configurations. This reliance on manual methods not only consumes time but also introduces opportunities for human error, potentially compromising the fit and effectiveness of the RPD (Akl & Stendahl, 2022; Bilgin *et al.*, 2016). Furthermore, the lack of these specialized functions within CAD software hinders the full potential of digital technologies in the design and manufacturing processes of RPD.

In the traditional workflow, technicians depend on manual manipulation of materials, such as wax, to sculpt and shape the flanges and abutment teeth according to the dentist's prescription and the patient's oral anatomy, by means of the occlusal rim adjusted during maxillo-mandibular relationship and trial denture procedure. This process is often time-consuming, and heavily relies on the technician's experience to ensure the final prosthesis fits comfortably and functions effectively in the patient's mouth (Ismail & Al-Moghrabi, 2023; Touchstone *et al.*, 2010). While current software includes a custom tray function, it primarily focuses on facilitating the construction of custom trays for impressions rather than directly addressing the design of RPD flanges. Due to a lack of information from current literature on the technical aspects of digital fabrication and the absence of specialized functions for RPD flange design, repurposing and improvisation of existing tools within the software is necessary to meet the needs for designing flanges. The objectives of this technical report were to repurpose existing tools within CAD software to develop a digital workflow that utilizes the artificial teeth, as a guide for designing flanges in RPD.

Technical Notes

This report outlines a digital workflow that uses the abutment teeth as a guide when designing flanges in RPD cases. In order to design the flanges, the artificial teeth and

framework must first be designed. Artificial teeth are the prosthetic components of the RPD that replace missing natural teeth. In contrast, abutment teeth are the patient's existing natural teeth that support and stabilize the RPD framework, often through the use of clasps, rests, or other attachments. The abutment and artificial teeth cohesively inform the design of the flanges within the RPD framework. After the extra- or intra-oral scanning, use CAD software (3Shape Dental System) to process and export the scan in order to design the components of the denture. The step-by-step workflow is explained in the following paragraphs:

Artificial teeth and framework design

Artificial teeth design involves digitally creating replacement teeth to restore the function, aesthetics, and occlusion of missing teeth within the RPD. The design process includes selecting appropriate tooth shapes from a digital library, positioning them to align naturally with the patient's existing dentition, and customizing their appearance to blend with the natural teeth. Once the artificial teeth are properly planned, the framework is designed to incorporate elements like saddle, major connector, rest and clasps.

1. Create an order for the RPD design. Set the order to create the "framework" and "artificial teeth."
2. Initiate the design process by designing the artificial teeth and RPD framework, adhering to established guidelines.
3. Once completed, generate the standard tessellation language (STL) output for both the designed artificial teeth and framework using the standard functions within the CAD software program.

Denture flange design

1. Due to the absence of a specific command within the 3Shape Dental System software for flange design, a modification approach was employed utilizing a "custom tray" function. Utilizing the same scanning model,

- proceed by generating an order for a "custom tray" (Figure 1).
2. The artificial teeth, abutment teeth and framework are used as guides for the next step, which is to design the flanges. Use the "additional scans" loading function to add the STL files of these parts to the workflow. Use the "move" function to realign the framework and artificial teeth as necessary (Figure 2). These artificial teeth will serve as guides to optimize the design of the denture flanges, particularly in proximity to the natural abutment teeth.
 3. Initiate the design (as seen in blue dotted line) of the denture flanges utilizing the

custom tray mode. If the design involves both quadrants, ensure that the flanges extend across the midline as necessary (Figure 3).

4. Use the sculp toolkit and wax knife setting to fill the space between the abutment teeth and framework to aid in accurately sculpting the gingival anatomy. Adjust the filling as necessary to achieve the desired results (Figure 4. a-b).
5. The final design is depicted in Figure 5. Upon completion, generate the STL output for the denture flanges (Figure 6).

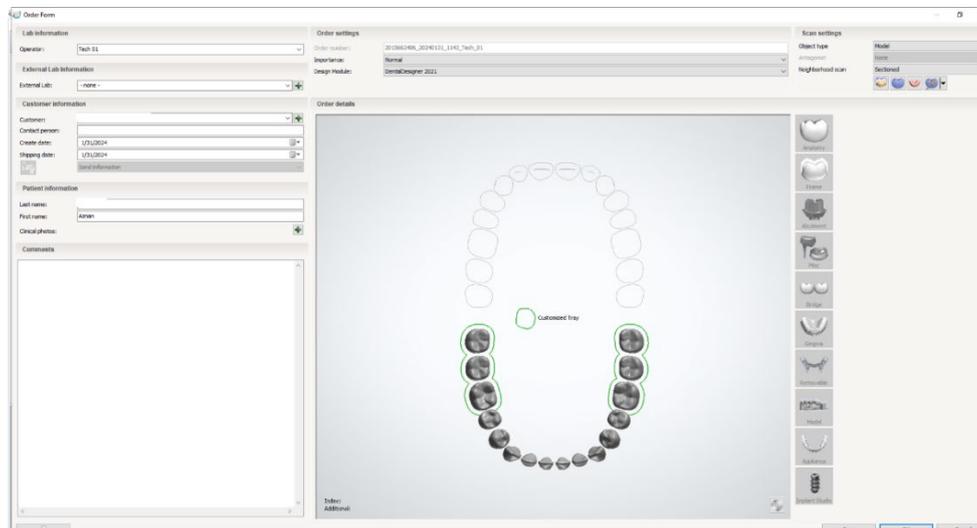


Figure 1. Creating order using "custom tray" function.



Figure 2. Alignment of framework, artificial teeth with abutment teeth using the 'move' function for integration into the workflow.

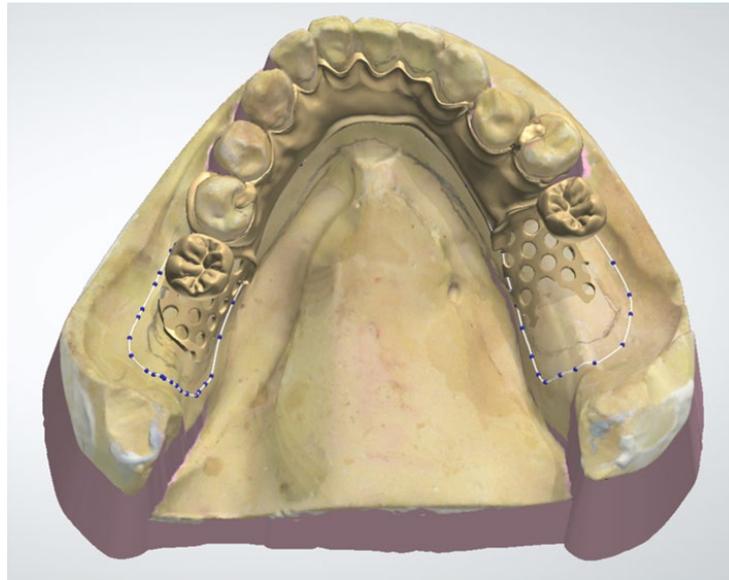


Figure 3. Initiation of denture flange design depicted by blue dotted lines, employing custom tray mode. Flanges extend across the midline for cases involving both quadrants.

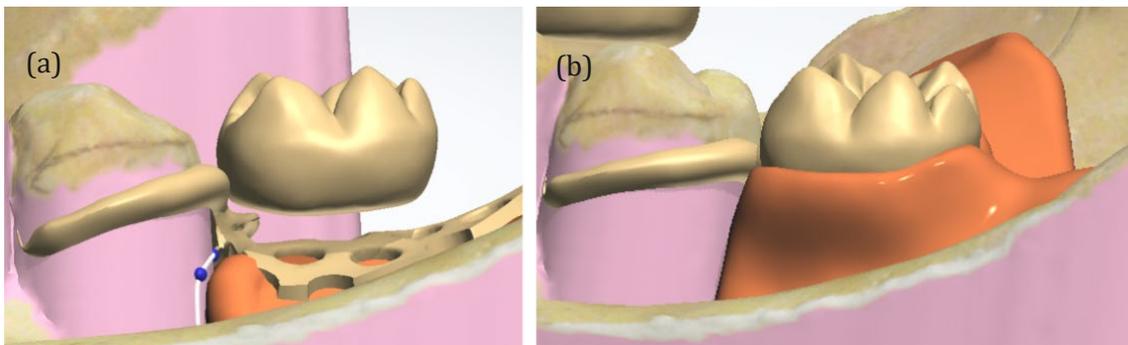


Figure 4. (a) Initial design (b) Utilizing the sculp toolkit, the space between the artificial teeth and framework is filled, with the artificial teeth aiding in sculpting the gingival anatomy.

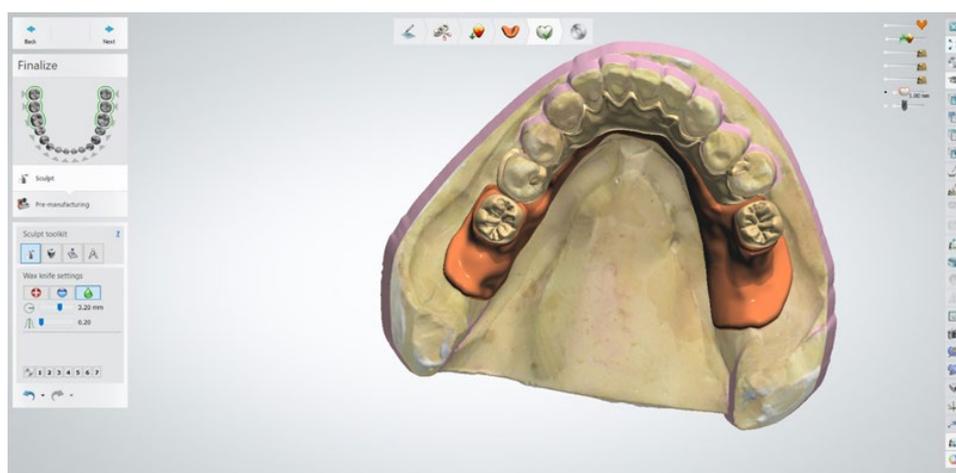


Figure 5. The final design.

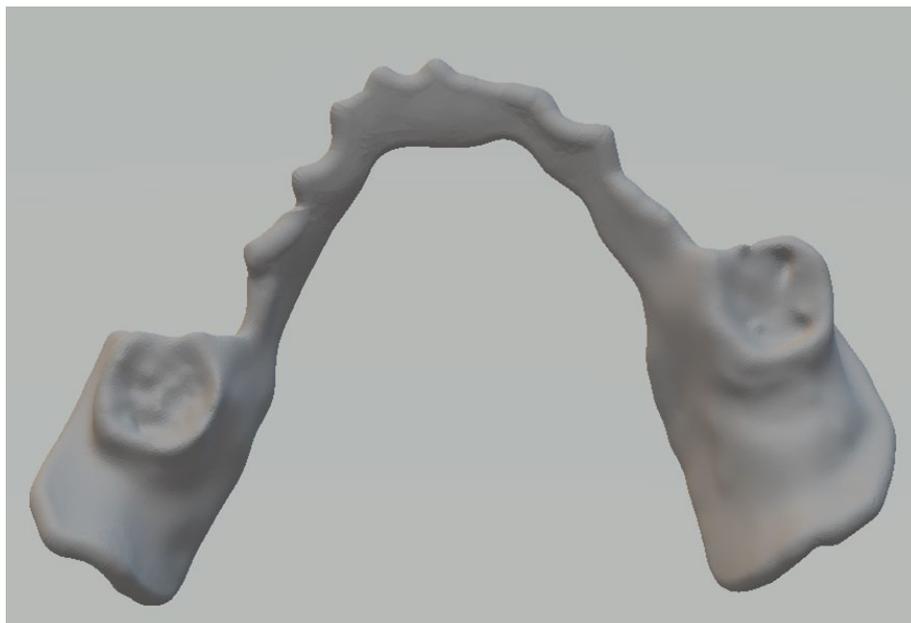


Figure 6. The final design of the flanges, which can be manufactured using either subtractive or additive methods.

Discussion

In the absence of a dedicated function within CAD software for designing flanges within RPD frameworks, traditional methods have typically been relied upon. However, in our study, the alternative approach was employed, utilizing the “custom tray” order function guided by the arrangement of abutment teeth and framework. While traditional methods necessitate manual adjustments and shaping, our utilization of new technology offers an alternative method to fully utilize the digital technology system. Despite the current lack of a dedicated command, our findings highlight the potential for software updates to enhance CAD capabilities in this regard.

A recent systematic review makes two main suggestions: first, it is important to create automatic CAD software that can make framework designs while taking into account the condition of the abutment teeth; second, it is important to create software that can plan predictable prosthetic treatments (Takaichi *et al.*, 2022). Only one study has currently presented a novel software application that automates the creation of RPD designs. The software

integrates artificial intelligence (AI) technology with clinical decision support principles to generate comprehensive two-dimensional diagrams that illustrate the RPD design. These findings offer valuable insights into the potential for AI-driven solutions in prosthodontic practice (Chen *et al.*, 2020).

Through digital fabrication, flange design becomes precisely controllable and adjustable using CAD software, offering numerous advantages. Consequently, this enables more consistent and precise flange shaping, ultimately leading to enhanced comfort and stability for the patient. Moreover, the customization of artificial teeth based on digital data ensures a more precise occlusal surface, enhancing both aesthetics and function compared to the standardized nature of conventional methods (Bilgin *et al.*, 2016). Apart from reducing manual labor and potential errors, digital fabrication facilitates easier storage and retrieval of design data, fostering enhanced collaboration (Fueki *et al.*, 2014).

However, transitioning to digital workflows may entail certain challenges. Training technicians to proficiently utilize CAD software requires time and investment,

while initial setup costs for software and hardware can be significant (Villias *et al.*, 2021). Moreover, technological dependencies may introduce vulnerabilities, such as software compatibility issues or reliance on external support services. To address these challenges and enhance digital workflows, particularly in the domain of flange design, software developers could focus on improving user interfaces for in-built navigation and incorporating features specifically tailored for flange design, such as automated algorithms for contouring based on anatomical parameters which can further enhance accuracy. Furthermore, ongoing software updates and technical support services can help mitigate potential vulnerabilities and ensure smooth operation within digital workflows.

Conclusion

Even though RPD framework designs are often performed digitally, the manual arrangement of artificial teeth and flanges continues because there is a scarcity of appropriate CAD software. This article introduces a different approach to designing flanges using the 3Shape Dental System's CAD software, initially developed for custom tray design with the help of artificial teeth, abutment teeth and the framework.

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