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Different workflows for fabrication of CAD/CAM complete dentures. Literature review.

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Abstract

Aim The aim of this study is to review the available literature on digital workflows used for fabrication of complete dentures and to compare them with the conventional workflow.

Materials and methods The research relied on Google Scholar and PubMed publications in English.

Resuls The introduction of CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technologies in the rehabilitation of patients with removable dentures are expected to overcome some of the drawbacks associated with conventional methods and to simplify the entire process of their fabrication by modifying the clinical and laboratory stages. Digital work protocols are becoming increasingly preferred in daily dental practice mainly because they save time. However, the analog protocol is still present alongside the digital and has not been completely replaced. Intraoral scanning is increasingly preferred for fixed prosthetic treatments, but for complete dentures, there are still some disadvantages and most of the authors think they are not good alternative to conventional impressions. Scanning is complicated by the movable non-keratinized mucosa and smooth surfaces covered with saliva.

Conclusions Despite the growing interest in digital technologies for fabricating removable dentures, some challenges remain. Opinions are still conflict on whether intraoral scanning of edentulous arches can serve as an alternative to conventional impressions. This could lead to the replacement of conventional analog protocols with semi- or fully digital ones. The time-saving and cost-effectiveness of CAD/CAM technologies, however, are undeniable.

Keywords: *CAD/CAM dentures, 3D printed dentures, Milled dentures, Digital workflow*

Introduction

The development of new technologies in dental medicine aimed at improving the quality of life for patients with removable dentures also stimulates the development of new materials and methods. The introduction of CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technologies in the rehabilitation of patients with removable dentures are expected to overcome some of the drawbacks associated with conventional methods and to simplify the entire process of their fabrication by modifying the clinical and laboratory stages. In 1990 Maeda et al. (1) were the first to use CAD/CAM for removable dentures.
Digital laboratory technologies are primarily divided into additive – adding individual layers of material (also known as 3D printing), and subtractive – removing excess material from a pre-prepared block (disc) through milling until the predetermined shape is achieved.

Aim

The aim of this study is to review the available literature on digital workflows used for fabrication of complete dentures and to compare them with the conventional workflow.

Materials and Methods

The research relied on Google Scholar and PubMed publications in English.

Results

Digital work protocols are becoming increasingly preferred in daily dental practice mainly because they save time. However, the analog protocol is still present alongside the digital and has not been completely replaced. According to Russo et al. (2), the work protocols can be divided as follows:

- Analog protocol
- Digital protocol based on an analog impression (Semidigital)
- Digital protocol based on a digital impression (Digital)

The **analog protocol** for the fabrication of complete dentures includes well-known 5 clinical and 4 laboratory stages:

1. Clinical stage: Preliminary impression with irreversible hydrocolloid for an individual tray
2. Laboratory stage: Fabrication of an individual tray
3. Clinical stage: Final impression
4. Laboratory stage: Fabrication of occlusal templates
5. Clinical stage: Determination of interjaw relations
6. Laboratory stage: Mounting the models in the articulator and arranging the teeth
7. Clinical stage: Try-in with arranged teeth
8. Laboratory stage: Fabrication of the dentures
9. Delivery of the dentures

The digital protocol based on an analog impression (Semidigital protocol) is the most widespread. Critache et al. (3) propose the following protocol:

1. Clinical stage: Preliminary impression with irreversible hydrocolloid for an individual tray

2. Laboratory stage: Fabrication of an individual tray
3. Clinical stage: Functional impression and determination of the occlusal plane (with a special indicator), interjaw relationship (with Candulor set), shape and color of the teeth, as well as the position of the anterior teeth. Additionally, the use of the Artex face bow (Amann Girrbach AG, Koblach, Austria) and the Artex®CR non-Arcon articulator
4. Laboratory stage: All gathered information is digitized with the help of an extraoral scanner and entered into the complete denture design software. The finished design is sent to the clinician and patient for approval, and the next step is the production of the denture through additive technology.
5. Clinical stage: Delivery of the complete denture and instructions

In their clinical study evaluating CAD/CAM milled and 3D printed dentures, Srinivasan et al. (4) use the following protocol:
1. Clinical stage: Preliminary impression with irreversible hydrocolloid for an individual tray
2. Laboratory stage: Fabrication of an individual tray
3. Clinical stage: Functional impression
4. Laboratory stage: Fabrication of occlusal templates
5. Clinical stage: Determination of interjaw relationship with a face bow, determination of the midline, smile line, and lip position
6. Laboratory stage: Mounting the models in the articulator
7. Clinical stage: Try-in with arranged teeth, and upon approval, proceed to the digital production of the denture
8. Laboratory stage: Scanning the try-in dentures and using design software, ensuring that the arrangement, arch shape, size, and color are identical to conventionally set parameters. Upon design approval, the denture bases and teeth are printed separately and adhesively bonded.
9. Clinical stage: Delivery of the complete denture and instructions

Digital protocol based on digital impressions (Digital protocol). Thanks to the evolving digital technologies in dentistry, analog impressions are being replaced by digital ones (5). To transfer information from the oral cavity to the digital environment, intraoral scanners (Intraoral scanner – IOS) are used, with the following main advantages:
- Reduced clinical time;
- Reduced patient discomfort;
- Reduced risk of infections;
- Ability to evaluate the digital impression in real-time;
- Ability for selective scanning;
- Lower cost;
- Less waste;
- Storage of each patient's file;

Intraoral scanning is increasingly preferred for fixed prosthetic treatments, but for complete dentures, there are still some disadvantages (6). Scanning is complicated by the movable non-keratinized mucosa and smooth surfaces covered with saliva. On the other hand, successful treatment with complete dentures mainly depends on two clinical stages – functional impression and registration of interjaw relations.
According to Mai and Lee (7), scanning cannot capture the mobility of the mucosa to replace the conventional functional impression. D'Arienzo and Borracchini (8) share the same opinion, noting significant differences when comparing analog and digital impressions, especially in the valve zone. They recommend intraoral

scanning to be used only for preliminary impressions and fabrication of individual trays until a way is found to functionally imprint and shape the denture edges. Hack et al. (9) made the same comparison between conventional impressions and intraoral scans, observing significant deviations in the valve zone, soft palate, sublingual area, and vestibular surfaces of both jaws. Chebib et al. (10) also compared the intraoral scanning with conventional impressions for edentulous maxilla and their results show that the conventional impressions lead to better retention than intraoral scanning for milled and 3D printed dentures.

According to Goodacre B. and Goodacre C. (11), intraoral scanning is suitable and could be used as an alternative to conventional impressions for the upper jaw, but not for the lower jaw, due to the inability to determine the denture borders.

According to Fang et al. (12), using special soft tissue retractors can optimize scanning results and lead to satisfactory outcomes. Russo and Salamini (13) suggest the same, using a U-shaped soft tissue retractor to scan the prosthetic field of the upper edentulous jaw.

In another study, Russo et al. (14) propose a methodology that allows digital visualization of the arranged teeth and the future denture. This becomes possible by combining an intraoral scan of the edentulous alveolar ridges, peri-oral scans of the lip, chin, and nose area made with an intraoral scanner, and facial scanning that can be performed with a special mobile phone application.

In their systematic review Srivastava et al. (15) evaluate if intraoral scanners provide clinically acceptable accuracy in capturing completely edentulous arches for the fabrication of complete dentures. Digital intraoral scanning is not advised for cases with unfavorable ridge anatomy or when denture retention require tissue compression. When scanning the vestibule, it is crucial to capture the entire area in a single scan to avoid errors that may arise from rescanning missed sections. While intraoral scanners can digitize edentulous arches, careful case selection remains essential.

According to Jamjoom et al. (16) the scanner type and scanning strategy can significantly impact the accuracy of the digital scans of completely edentulous arches.

According to the results of another systematic review from Wang et al. (17) direct digital impressions using IOS cannot replace conventional impressions for completely edentulous arches in vivo. Digital impressions of edentulous arches taken with IOS showed poor accuracy in peripheral areas with mobile tissues, such as the soft palate, vestibular sulcus, and sublingual region.

According to Peroz et al. (18) and their study comparing the oral-health related quality of life (OHRQoL) of patients treated with conventional and digital dentures there is no significant difference between the protocols. The main difference is the time that the digital protocol can save - 1 hour chair time and 5 hours laboratory time.

Thu KM et al. (19) have the same results - OHRQoL and patients' satisfaction with the treatment were similar between conventional, milled and 3D printed complete dentures.

Conclusion

Despite the growing interest in digital technologies for fabricating removable dentures, some challenges remain. Opinions are still conflict on whether intraoral scanning of edentulous arches can serve as an alternative to conventional impressions. This could lead to the replacement of conventional analog protocols with semi- or fully digital ones. The time-saving and cost-effectiveness of CAD/CAM technologies, however, are undeniable.

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