Dean&Francis

ISSN 2959-409X

Digital solution of managing complete edentulous patient: fabrication of complete denture

Kunyuan Xue[1, *]

[1]Szeged University, Szeged, Hungary

*Corresponding author: xkynbplus@gmail.com

Abstract:

Digital technologies use high-precision three-dimensional scanning, intelligence-aided design software, and multi-axis numerical control milling or 3D printing, which can produce restorations with reliable precision and suitable function. Digital impression and CAD/CAM technology have significantly transformed prosthetic dentistry by enhancing the precision, efficiency, and overall patient experience. This paper explores the integration of these technologies, examining their impact on the accuracy of complete denture, the workflow in dental practices, and patient satisfaction. Through a review of existing literature and analysis of clinical outcomes, this study highlights the advantages and challenges associated with these digital advancements. The findings suggest that digital impression and CAD/CAM systems offer substantial benefits like better flexural strength, higher yield strength, better toughness, better color stability and less chairside time, paving the way for a more streamlined and effective approach to fabricate a complete denture. These solutions will lead a bright and promising future of complete denture in prosthodontics.

Keywords: Digital technique; CAD/CAM; Complete denture; Milling; 3D printing.

1. Introduction

The field of digital impression has seen considerable advancements in recent years [1-3], particularly with the introduction of digital impression and CAD/CAM technologies in complete denture fabrication. These innovations have replaced traditional methods that relied on physical impressions and manual fabrication of complete denture, which often led to inaccuracies and multiple patient visits or even the post-prosthetic problems like mucosal ulcers, further edentulous ridge resorption. The shift towards digital techniques has not only improved the precision of complete denture but also enhanced the overall patient experience. This paper aims to examine the role of digital impressions and CAD/CAM technology in complete denture fabrication, focusing on their impact on clinical outcomes and practice efficiency.

2. ODigital Workflow

2.1 Digital Impression

As it's named, digital impression is a new technique that replace the conventional alginate/silicone impression material in dental office by a digital scanning camera. Digital tech. use high-precision 3D scanning software, Scan the upper and lower edentulous alveolar ridges as a e-definitive cast that details can be modify on it via computer designing. For such step the problem is that in conventional impression, the impression tray and material are pushing mucosa layer, making mucosal layer in stretched state, but for digital scanning, there is no substitute, so only scan the loose mucosal layer is enough. Some research conventional impression is taken first, then scan the impression, to get the stretched state of mucosal layer.

It's still an argue that if the digital impression can significantly improve the accuracy. Some studies have shown that digital impressions offer superior accuracy compared to traditional methods, resulting in better-fitting restorations and fewer adjustments. According to multiple research papers, the use of intraoral scanners to capture digital impressions has reduced the incidence of errors related to physical impressions, such as distortions caused by improper handling or material shrinkage. But some other studies showed that there is no significant difference between the digital impression and conventional impression, some shows it does improve the accuracy greatly. These results are also depended on the type of restoration and operation of dentists. But most important for conventional impression, the development and familiarity of impression technique need time and experience; for digital impression, it requires less time, energy and experience to get same level of detail recording. There is no research to show the accuracy and details difference between conventional impression and digital technique in capturing anatomical markers (e.g. mylohyoid ridge, retromolar pad, mental tubercle of mandible; vibrating line of maxilla) in complete denture fabrication.

And for some cases, in order to duplicate the exist denture, scan cameo and intaglio surface of denture by intra-oral scanner is enough [4], then get that STL file for 3D print, it saves a lot of time and material to duplicate the denture. And for documentation of denture, there is no need to keep the impression or gypsum model, the scanned STL file can keep the information for longer time and in an easier way. Beside these for scanner is also type of artificial intelligence (AI) which means that the huge amount of training is required. This requires large amount of time, high cost and proper cases to achieve (Fig.1).

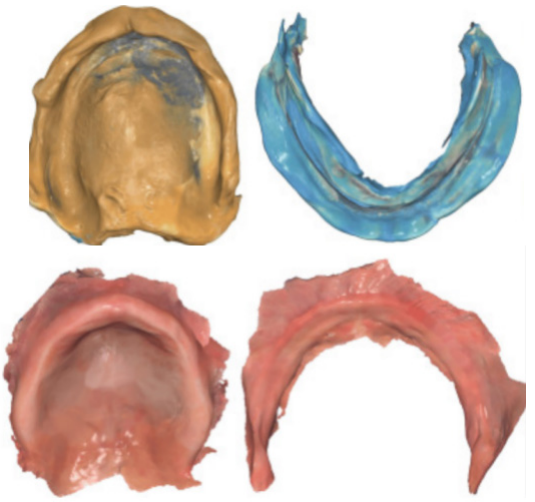

Fig.1 Digital scanning of impression and edentulous ridge

2.2 Computer Design of complete denture and reference parameters

After the capture of edentulous anatomical structure as Standard Tessellation Language (STL) file, we can scan patient's facial structures or other exist structures to capture the information from patient's oral anatomical structure, then it can be designed like 3D modeling, modify the contour of any surface which is required, like crown margin, undercut or overcut on the inner surface of crown or denture base plate, height of crown, denture base plate, flange of denture, frenum undercut and other stress bearing/relief anatomical areas. The designing includes the physical/physiological Vertical dimension of Occlusion (OVD), Centric relation (CR), centric occlusion (CO), Intercuspation (ICP) on the computer, known as Computer-Aiding Design, (CAD). compare to conventional way (measure these parameters on the mouth of patients), it saves a lot of appointments and time for dentist, laboratory worker and for patients as well. And, the computer-Aiding Design can make the procedure more precise and easier, we can see the outcome directly right after design from computer screen, instead of only relying on trial denture try in. This makes the workflow smoother and faster. We can combine it with cephalometry or other radiograph; to check and design the dynamic stress bearing area of alveolar ridge, this is a revolution of technique that can improve comfort and life time of the complete denture significantly. The designing software usually combined with scanning, currently there are a lot of such brand like 3Shape, VivaDent, Straumann, Shinning 3D. They all have the corresponding designing software (Fig.2).

ISSN 2959-409X

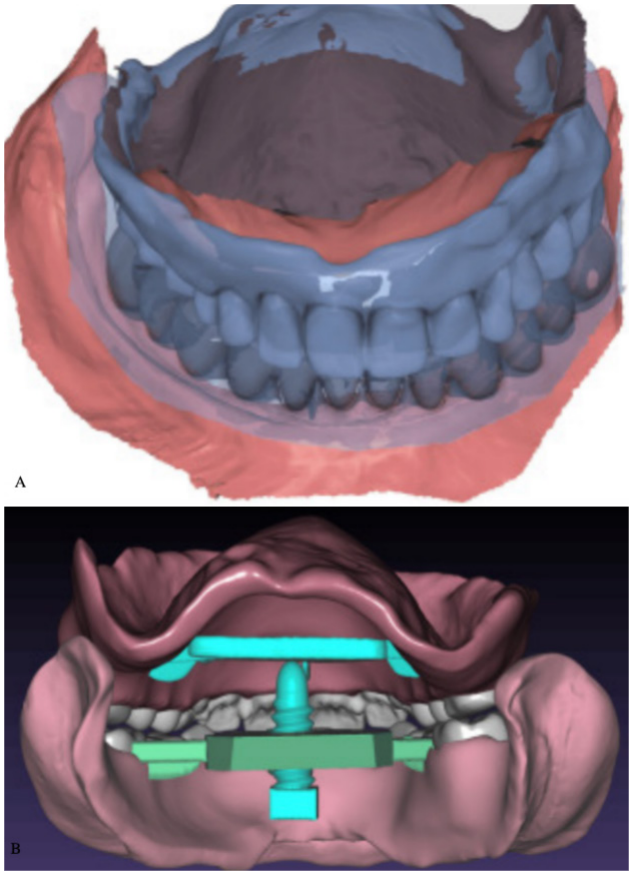

Fig.2 Computer design of complete denture. (A)Digital denture design. (B)digital height design.

2.3 Milling or additive manufacture (3D printing) to fabricate the complete denture

Milling is a Computer-Aiding Manufacture technique, the burs from machine will cut the ceramics/metal according to the 3D model obtained from scanning and designing. Additive manufacture is a technique to build up target object small portion by small portion, material is compacted into the modifiable state, then contour it by heating-injection (e.g. acrylic resin) or laser (e.g. metal powder), there are different types of additive manufacture like Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Selective Laser Melting (SLM), Electron Beam Melting (EBM), Direct Energy Deposition (DED), Powder Bed Fusion (PBF). After designing, we firstly fabricate a trial denture to try if all our designs are proper on patient, if there is no any problem, then we fabricate the final denture. They analyzed 522 articles, took 14 out of 522 as reference, got the conclusion that the denture which is fabricated by milling have better trueness compare to 3D print [5]. According to the article in 2021[6], for denture made by digital technique, generally have better adaptation and accuracy even can gain better physical properties with same material-PMMA. And for 3D print is better use to fabricate custom tray, record bases, trial/inter-rim/immediate denture instead of definitive prosthesis, according to the article [7]. Study also suggests that average denture patient, with good residual ridges and no neuromuscular problems, will function adequately with a properly fabricated complete denture regardless of the occlusal scheme [8]. Compare to conventional fabrication of denture, the digital technique in denture fabrication make the material using much easier [9] The complete denture can be made by PEEK in digital way without complication in following 1 year. Generally, CAD/CAM technology, which allows for the design and fabrication of complete denture in a single or 2 appointments, has been praised for its efficiency and ability to enhance patient satisfaction.

However, challenges related to the high cost of equipment and the dynamic state of mucosal which used to attach denture base may not be recorded well in digital technique. Other forms of additive manufacture are also available for final prosthesis fabrication, but milling and 3D print are two most popular forms (Fig.3).

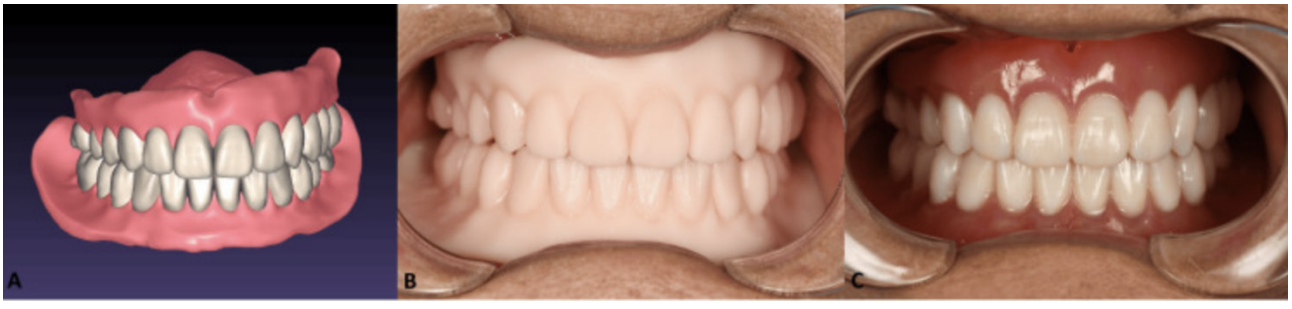

Fig.3 Final product fabrication [18]. (A)digital design. (B)trial denture try-in. (C)final fabrication

2.4 Prognosis

In single zirconia crown fabrication, digital workflow shows amazing outcomes in the 2 years [10], 3 years [11] and 5 years [12] follow up. But due to time-requiring, such follow up researches for digital complete denture are seldom carry on. And some researcher advise digital technique in complete denture fabrication, at least the inter-rim fabrication [13]. And for improper denture fit, the flabby ridge, granuloma fissurutum or epulis fissuratum (extensive fibrosis of residual alveolar ridge due to long term irritation of alveolar ridge by improper fitted denture) may rise, which may require a conventional [14] or laser [15] surgical intervention to remove. Or a tissue conditioning is required [16]. Anti-thrombin medication may be required in carbon dioxide laser treatment [17-18].

3. Discussion

The findings from the literature review and clinical case studies indicate that digital impression and CAD/CAM technologies significantly improve the efficiency of denture fabrication procedures. The ability to design and fabricate complete denture in-house using CAD/CAM systems allows for same-day procedures, which are highly valued by patients. Moreover, the adoption of these technologies has been shown to enhance patient comfort by eliminating the need for traditional impression materials; reducing the number of visits and time consumption in each appointment required to complete treatment and overcome reflex problem in conventional impression (improve patients' satisfaction). But recording the stretched state of the movable mucosa is still a problem in digital impression. The integration of digital impression and CAD/CAM technology in complete denture fabrication represents a major advancement, offering numerous benefits to both practitioners and patients. While the initial investment in equipment and training can be substantial, the long-term advantages, such as increased efficiency, and patient satisfaction, outweigh these challenges. The shift towards digital workflows is also aligned with the growing demand for minimally invasive and patient-centered care. However, ongoing research and development are necessary to address the current limitations, including the high cost and difficult accessibility of these technologies, and how to record stretched mucosa effectively is still need to be discovered.

4. Conclusion

In conclusion, digital impression and CAD/CAM technology have revolutionized the conventional fabrication procedure for complete denture, offering a more precise, efficient, and patient-friendly approach to dental care. The evidence from literature and clinical practice supports the widespread adoption of these technologies, which have the potential to become the standard of care in restorative procedures. As the field continues to evolve, further advancements are expected to enhance the capabilities and accessibility of digital impression and CAD/CAM systems, ultimately improving the quality of care provided to patients.

References

[1] Zhou YS, Sun YC, Wang Y. Clinical application and research progress of digital complete denture. Hua Xi Kou Qiang Yi Xue Za Zhi. 2021, 39(1):1-8.

[2] Srinivasan M, Kamnoedboon P, McKenna G, Angst L, Schimmel M, Özcan M, Müller F. CAD-CAM removable complete dentures: A systematic review and meta-analysis of trueness of fit, biocompatibility, mechanical properties, surface characteristics, color stability, time-cost analysis, clinical and patient-reported outcomes. Journal of Dentistry. 2021, 113:103777.

[3] Li Y, Han W, Cao J, Iv Y, Zhang Y, Han Y, Shen Y, Ma Z, Liu H. Design of Complete Dentures by Adopting CAD Developed for Fixed Prostheses. Journal of Prosthodontics, 2018, 27(2):212-219.

[4] Oyamada Y, Yonezawa Y, Kondo H. Simple Duplication Technique of Complete Denture Using an Intraoral Scanner. Journal of Prosthodontics, 2021, 30(5):458-461.

[5] Wang C, Shi YF, Xie PJ, Wu JH. Accuracy of digital complete dentures: A systematic review of in vitro studies. Journal of Prosthetic Dentistry, 2021, 125(2):249-256.

[6] Baba NZ, Goodacre BJ, Goodacre CJ, Müller F, Wagner S. CAD/CAM Complete Denture Systems and Physical Properties: A Review of the Literature. Journal of Prosthodontics, 2021, 30(S2):113-124.

[7] Anadioti E, Musharbash L, Blatz MB, Papavasiliou G, Kamposiora P. 3D printed complete removable dental prostheses: a narrative review. BMC Oral Health, 2020, 20(1):343.

[8] Goldstein G, Kapadia Y, Campbell S. Complete Denture Occlusion: Best Evidence Consensus Statement. Journal of Prosthodontics, 2021, 30(S1):72-77.

[9] Ding L, Lu W, Chen X, Xi Q, Wu G. Complete denture fabrication with polyetherketoneketone as a framework material: A clinical report. Journal of Prosthet Dentistry, 2022, 127(6):823-826.

[10] Pontevedra P, Lopez-Suarez C, Pelaez J, Garcia-Serdio S, Suarez MJ. Prospective Clinical Evaluation of Posterior Monolithic Zirconia Fixed Partial Dentures Using a Complete Digital Workflow: Two-Year Follow-Up. Journal of Prosthodontics, 2021, 30(4):298-304.

ISSN 2959-409X

[11] Pontevedra P, Lopez-Suarez C, Rodriguez V, Pelaez J, Suarez MJ. Randomized clinical trial comparing monolithic and veneered zirconia three-unit posterior fixed partial dentures in a complete digital flow: three-year follow-up. Clinical Oral Investigations, 2022, 26(6):4327-4335.

[12] Pontevedra P, Lopez-Suarez C, Rodriguez V, Tobar C, Pelaez J, Suarez MJ. Digital workflow for monolithic and veneered zirconia and metal-ceramic poterior fixed partial dentures: A five-year prospective randomized clinical trial. Journal of Prosthodontics Research. 2024, 68(1):78-84.

[13] Kang YJ, Oh KC, Kim GY, Moon HS. Comparative evaluation of digitally fabricated complete dentures versus conventional complete dentures: A randomized, single-blinded, cross-over clinical trial. Journal of Prosthetic Dentistry, 2024, 132(2):408-418.

[14] Khalifa C, Bouguezzi A, Sioud S, Hentati H, Selmi J. An innovative technique to treat epulis fissuratum: A case report. SAGE Open Med Case Report, 2021, 9:2050313X211063135.

[15] de Arruda Paes-Junior TJ, Cavalcanti SC, Nascimento DF, Saavedra Gde S, Kimpara ET, Borges AL, Niccoli-Filho W, Komori PC. CO(2) Laser Surgery and Prosthetic Management for the Treatment of Epulis Fissuratum. ISRN Dentistry, 2011, 2011:282361.

[16] Widad EG, Nadia M, Jihane SH. Prosthetic management of an epulis fissuratum with simple conditioning tissue: A case report. International Journal of Surgery Case Report, 2024, 122:110130.

[17] Monteiro LS, Mouzinho J, Azevedo A, Câmara MI, Martins MA, La Fuente JM. Treatment of epulis fissuratum with carbon dioxide laser in a patient with antithrombotic medication. Brazilian Denttal Journal, 2012, 23(1):77-81.

[18] Garcia E, Tung TW, Jaramillo S, Gutierrez A, Alvear J, Tinajero M. Full-Arch Rehabilitation With Mucosa-Supported Prostheses Utilizing a Digital Workflow: A Case Report. Cureus. 2024, 16(7):e64941.