A Review

Digital Evolution in Prosthodontics: Applications in Removable Partial Denture Fabrication

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Abstract

Although computer-aided design and manufacture (CAD/CAM) technology have shown some promising applications in the fabrication of fixed prosthesis, maxillofacial prosthesis, the field of removable prosthodontics has not utilized these technologies so far. This article describes complete digital and combined analog-digital workflow of Removable Partial Denture (RPD) fabrication. In both processes surveying, framework designing and fabrication will be performed digitally. The shape of components of the removable partial denture modelled on the 3D model, using computer aided design software. The purpose of this article is providing the brief knowledge regarding utilization of digital technology in RPD fabrication in a compiled form.

Keywords: CAD/CAM framework, Digitisation, Digital maxillomandibular relation recording, Electronic surveying, Intraoral scanner (IOS), Removable partial denture.

Introduction

Rapid advancement in digital technology have opened new pathways for Removable Partial Denture (RPD) fabrication using computer aided designing and computer aided manufacturing that involves additive and subtractive method.[(1)] RPD can either be digitally designed on the conventionally poured cast or by direct digital scanning of partial edentulous ridge through which a virtual cast is produced. Digital workflows are advantageous as include simplified processes, increased manufacturing speed with precise outcomes.[(2)]

In contemporary dental practice Intraoral Scanners (IOS) are used for impression making for single crown and multi-unit prosthesis fabrication, implant and RPD frameworks and complete denture fabrication. To adequately reproduce the surface details of oral and dental tissues, accurate impression making and cast pouring is required.[(1,2)]

Digital technologies usage reduced the chances of human errors caused by laboratory technician which helps in fabricating a removable prosthesis with less distortion and better precision.[(3)]CAD/CAM frameworks can be produced by two manufacturing pathways: combined analog-digital and completely digital.[(4)] Few published articles have concluded that prosthesis fabricated from intraoral digital impressions had remarkable results over those from conventional impressions.[(5)]This article aims to discuss the role of digital technology in fabricating removable partial dentures (RPD).

Data collection and analysis

A comprehensive search was done on electronic database like PubMed/

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Medline, Scopus and Goggle scholar for the relevant studies related to fabrication of removable partial prosthesis using digital technology. After that articles were searched selected on the bases of exclusion and inclusion criteria. Articles published in English language and the article for which English translation was provided, were screened and reviewed.

Steps involved in RPD Framework Fabrication

A. Impression making

Conventional method of framework designing include clinical and laboratory procedures that involves impression making, working cast fabrication and bite registration. Back then, all these procedures were carried out manually.[4] In this era of digitisation, various digital technologies are available in dental market for alleviating patients experience and reducing practitioner's manual workload. Two manufacturing pathways can be used for CAD/CAM framework fabrication: combined analog-digital and complete digital(Fig.1).

Combined analog-digital workflow involves conventional impression making and working cast fabrication followed by digital scanning of cast and so on. This process will reduce human related errors and laboratory procedures up to some extent, as after cast fabrication rest of the steps are going to be carried out digitally.[1,4]

Completely digital workflow involves use of digital technology in the very first step, is scanning partially edentulous ridges using Intraoral Scanners (IOS). The Standard Tessellation Language (STL) files are generated by scanning the intraoral structures. Generated data sent to open laboratory CAD system for further processing.[5] Digital impression making is real cost saving as there is elimination of trays, impression material and shipping cost. One of the main advantage is that processed data can be stored for subsequent follow up during functional period and also for the future use. According to current literature prosthesis fabricated from intraoral digital impression has better marginal fit in comparison to conventional method.[4,5]

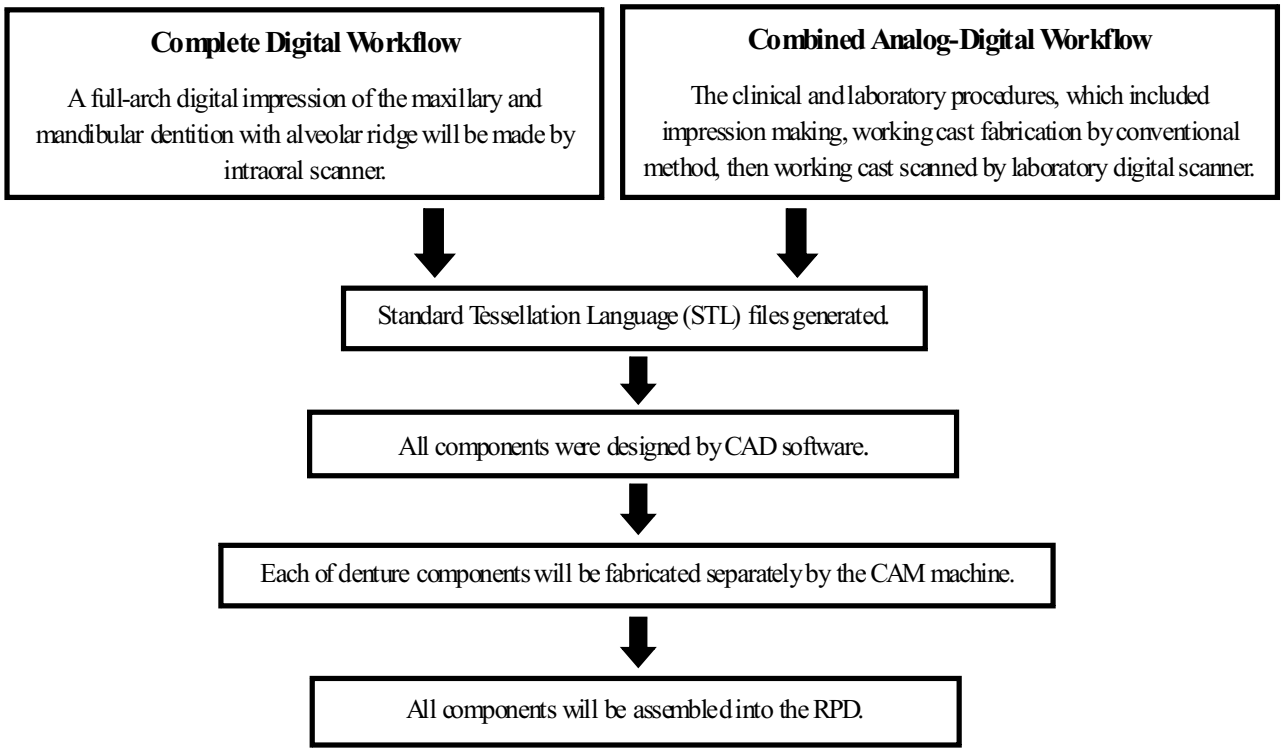

Fig. 1 Flow chart of the combined analog-digital and digital RPD fabrication workflow.

B. Working cast fabrication

This step is done in combined analog-digital workflow. After making physical definitive impression, stone cast is fabricated. The working cast is scanned to generate a digital model (Fig. 2). Generated data is acquired and sent to open system laboratory for computer aided designing of RPD components using software.[6]

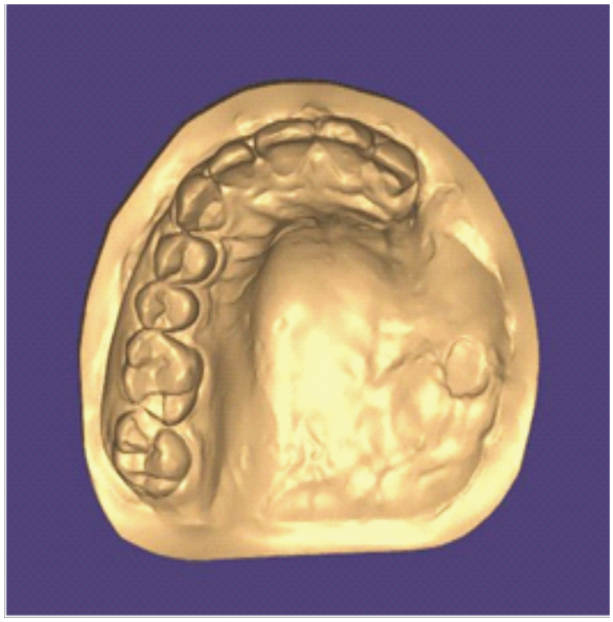

Fig. 2 Digital model of maxillary arch

C. Digital Maxillomandibular relationship recording

There are two techniques for digital Maxillo-mandibular relation (MMR) recording,using record bases with occlusion rims and without using record bases. The IOS is used for digital MMR recording, the images of teeth and gingiva captured from buccal view and maxillary and mandibular digital models are mounted on the virtual articulators.[6]In cases with small number of missing teeth and good molar occlusal support, MMR recording will be done without using record bases as it influence the occlusion with remaining teeth. In cases of distal extended partial ridges with multiple missing teeth, record bases with occlusal rims are used to set the MMR at centric relation position. The accuracy of digital MMR record associated with number and position of remaining teeth.[6,7]

D. Electronic cast Surveying

As author is discussing about digital workflow for RPD framework fabrication, its necessary to include electronic method of surveying of digital models.[7] This step is of great importance as followed by framework designing. Electronic surveying of scanned cast enables computer aided designing of pattern for metal framework fabrication according to RPD designing principles using relevant software. Programs will be written for identifying thesurvey lines using software which reads the triangular facetted surface models.[8] By electronically identifying the closest and farthest points relative to the straight line, connecting them together will step-by-step produce the survey lines. After marking the survey lines, undercut area will be marked and depth of undercut will be calculated automatically.[7,8]

E. Computer aided Framework designing

After completion of surveying part, depth of undercut is copied from definitive digital models to model the shape of components of RPD framework on the scanned 3D surface model using CAD software (Fig. 3). The framework designing using CAD/CAM technologies will reduce the human error encounter in the traditional laboratory steps, hence produce RPD frameworks with higher accuracy and better fitness.[8] Detailed verification is must at each step, such as providing adequate amount of relief throughout the design process and setting optimal parameters. Actual RPD design must consider the physiological conditions and occlusal condition of the abutment teeth and the residual ridge as well as the oral habits and esthetic requirements of the patient.[9]

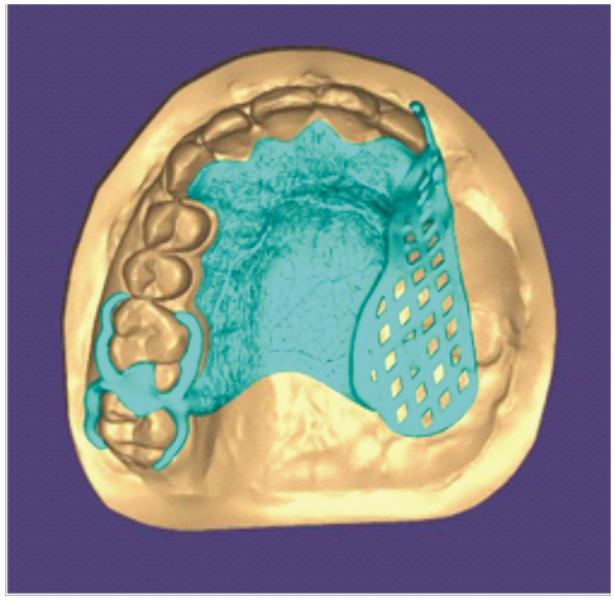

Fig. 3 Framework designing using Computer-aided Designing (CAD) software.

F. Digital RPD framework fabrication

Digital RPD framework is fabricated from CAD model into a physical product, which undergoes processing, finishing and polishing before inserted into patient mouth. CAD/CAM involves subtractive manufacturing (milling) or additive manufacturing (rapid prototyping, 3D printing). The subtractive manufacturing is based on processes in which desired 3-dimensional geometry is achieved by cutting the material by computer programmed power driven machine tools with sharp cutting tools.[9] On the other hand additive manufacturing (rapid prototyping)is a process in which there layer-by-layer addition of material to produce a 3-dimensional product. Additive technology further involves several techniques like Direct Metal Laser Sintering (DMLS), Selectively Photocuring (3SP), Poly-Jet, Stereolithography (SLA) and Direct Light Projection (DLP). The digital manufacturing eliminates time and material consumed in investment-casting process and also provides a product with better precision and proper fit.[10]

Conclusion

There is limitless scope of digital technology in prosthodontics. Every day science is one step ahead in terms of advancement of technology as well as its beneficial applications. Still, some of the fields of prosthodontics have not been digitally explored and needs technology advancement. The results of MMR recording and electronic surveying are not satisfying, as the full digital workflow is limited to cases with Kennedy class III/IV partially edentulous arches with several missing teeth. Further studies on durability, accuracy, cost effectiveness of digital RPDs will improves the understanding about field for betterment of patient care.

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