A Review

Digital Evolution in Prosthodontics: Applications in Fixed Dental Prosthesis Fabrication

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Abstract

Contemporary dentistry is all about doing functionally sound, aesthetically acceptable, minimized discomfort, and less time-consuming practice.The new digital impression technique and provisional and definitive fixed prosthesis fabrication technology bring about absolute digitization to the mode of prosthodontics. It is necessary for provisional and definitive fixed prostheses to exhibit good mechanical and physical properties. Computer-aided designing and manufacturing (CAD/CAM) technology includes additive manufacturing (3D printing) and subtractive manufacturing (milling). Milled and 3D printed restorations are expected to have better results as several error-causing factors are eliminated in digital technology. This article aims to discuss the applications of different digital technologies in fixed prosthodontics.

Keywords: Digital impression; Digitalization; Intraoral scanner; CAD/CAM technology; Digital smile design; Tooth-borne prosthesis; Digital shade guide.

Introduction

The CAD/CAM technology developed in the 1950swas used for modeling, designing, and manufacturing objects in industrial processes. In the 1980s, digital technology was introduced in dentistry to produce inlay and onlay fillings, Crowns and bridges, laminates, and veneers.[1] Initially technology was designed to manufacture aesthetic ceramic restorations. Over the years, continuous improvisation of technology enabled the fabrication of inlay and onlay fillings, metal-ceramic crowns, ceramic crowns, and veneers. The establishment of digital scanners, digital designing, and manufacturing technology has been a game changer for the production of tooth-borne and implant-supported fixed dental prostheses (FDP) in a virtual environment without any physical model.[1,2]

Digital impression system involves extraoral scanners and intraoral scanners (IOS). CAD/CAM technology also involves two methods of prosthesis fabrication, subtractive manufacturing i.e. milling or additive manufacturing i.e. 3D printing or rapid prototyping.[2] Prosthodontic procedure for fixed prosthesis fabrication is a complex integration of sequential steps involving clinical steps of abutment tooth preparation, impression making and laboratory steps. CAD/CAM systems comprised of three major units: (1) a data acquisition unit for collecting data from the area of preparation and surrounding structures and then converting it into virtual impressions; (2) a designing unit for designing virtual restorations using software; (3) manufacturing unit for prosthesis fabrication by milling or 3D printing.[3]

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Search strategy and analysis

An electronic search of publications based on PICO criteria was established. Search executed on three electronic databases: PubMed, Google Scholar, and Web of Science using the following keywords. A strategic search is conducted using a combination of controlled vocabulary and free-text words. The articles were selected based on exclusion and inclusion criteria. A manual search was also conducted in the dental literature of journals.

Digital workflow of Fixed Dental Prosthesis

A. Digital Impression

Digital scanning can be done by extraoral scanners (indirect digitalization)orintraoral scanners (direct digitalization). In the early 1980s, when direct digitalization had limited accuracy, indirect digitalization was introduced which involves scanning of casts with extraoral scanners. The scanned data is stored digitally in the form of Standard Tessellation Language (STL) files. The working cast is made using conventional impression-making techniques.[3,4]On the other hand in direct digitalization, intraoral scanner directly acquire data of hard and soft oral structures in digital form and through. STL files virtual models are obtained (Fig. 1).

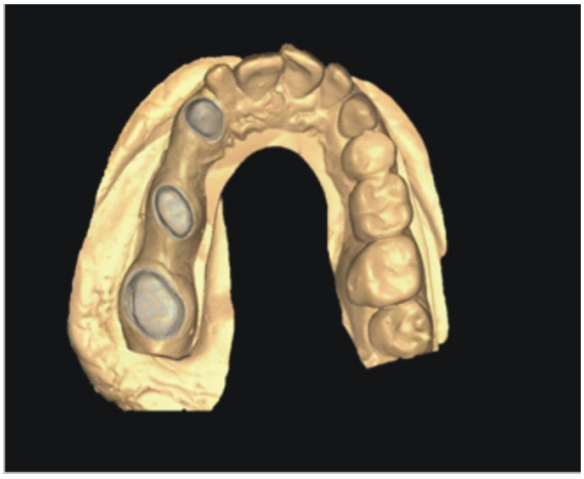

Fig.1. Digitally scanned model of prepared abutment

The standard preparation of abutment tooth is done. To expose the finished margins of preparation, a retraction cord of adequate size is placed in the gingival sulcus for approximately 5 minutes. After removing the retraction cord area is checked, if the sulcus area is adequately expanded or not.[4] The scanner tip slides towards the abutment tooth to capture the 2D images in different directions. IOS exports digital image files in an STL format. Several 2D images taken by the scanner from different angles are compiled to generate precise 3D data. Generated data sent to open laboratory CAD system for further processing. One of the main advantages is that processed data can be stored for subsequent follow-up during the functional period and also for future use.[4,5]Direct digital impressions can avoid errors that are more likely to happen in conventional impression techniques. Additionally, this digital impression-making saves time and steps for dentists and technicians. Eliminated clinical steps include tray selection, material dispensing, setting and disinfection and impression packaging and shipping. Steps eliminated in the laboratory include model fabrication, die cutting, trimming, and articulation.[5]

B. Digital Smile Designing

Digital Smile Design (DSD) is an innovative dental treatment planning tool which permits to design of the smile of a patient digitally from a series of pre and post-digital smile design photographs. DSD software helps dental practitioners to educate patients regarding the improvement of smiles that can be done and also helps in fulfilling patients' preferences and requirements.[6] Intraoral scanner is used for making the digital impression of bothjaws. Then impressions are uploaded on CAD/CAM processing machine for 3Dprinting. High-resolution full-profile photographs and videos that record the dynamic changes in lips, teeth, and facial muscles during smiling and talking are essential. Three basic photographs that are important for smile design include: 1) a full facial view with a natural smile, 2) a resting face, 3) a view representing a non-occluding maxillary and mandibular arch.[7]

C. Digital shade guide

Due to the increasing esthetic needs of patients tools used for shade matching are developing continuously. Vitapan Classical and Vita 3D-Master are the most commonly used shade-determination tools. These two are visual shade matching methods which have several limitations eye fatigue, highly depend on the personal experience of the practitioner, inter-examiner variability and lack of standardised surrounding conditions. With advancements in technology a new shade determination tool which is Vita Easyshade guide is introduced in the dental market. Previous studies concluded that digital spectrophotometers have greater reliability than visual shade-matching methods.[8]

D. Prosthesis fabrication

After scanning is completed, the prosthesis is designed in software using STL files. Special kinds of software are used for designing different types of dental restorations. Initially, software was designed to produce aesthetic all-ceramic restorations (Fig. 2). With improvisation in technology some systems also offer to design full anatomic crowns, inlays, and inlay retained FPDs. Until a definitive prosthesis is delivered, a provisional prosthesis needs to be fabricated for the interim phase.[9,10,11] A virtual design of restoration is created using the software. The designed virtual restoration was sent to the processing unit to produce a physical prosthesis.

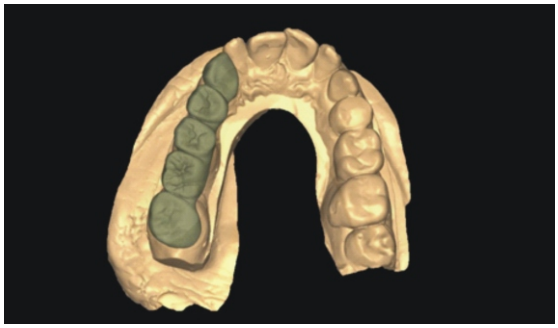

Fig. 2. Digitally designed fixed dental prosthesis

Computer-aided manufacturing can be done by milling or subtractive manufacturing and 3D printing or additive manufacturing. For CAM processing, construction data produced with CAD software is converted to milling strips and finally loaded into a milling device.[12]Various materials used for processing by CAD/CAM like metals, resin materials, and silica-based ceramics depending upon the respective production system. 3D printing or Additive manufacturing is a process in which there is layer-by-layer deposition of material to produce a 3-dimensional product and is also referred to as rapid prototyping.3D printing includesvarious types of technologies based on their processing, Stereolithography (SLA), Selective Laser Sintering (SLS), Powder Binder Printers (PBP), and Fused Deposition Modelling (FDM).[13] Provisional and definitive prosthesis is fabricated digitally using any one of the technologies (Fig. 3). The prosthesis fabricated by digital technology are less likely to have human-related errors. As several clinical and laboratory steps are eliminated in the complete digital workflow. According to some studies3D printed and milled crowns have better mechanical and physical properties than conventional fabricated ones.[14]

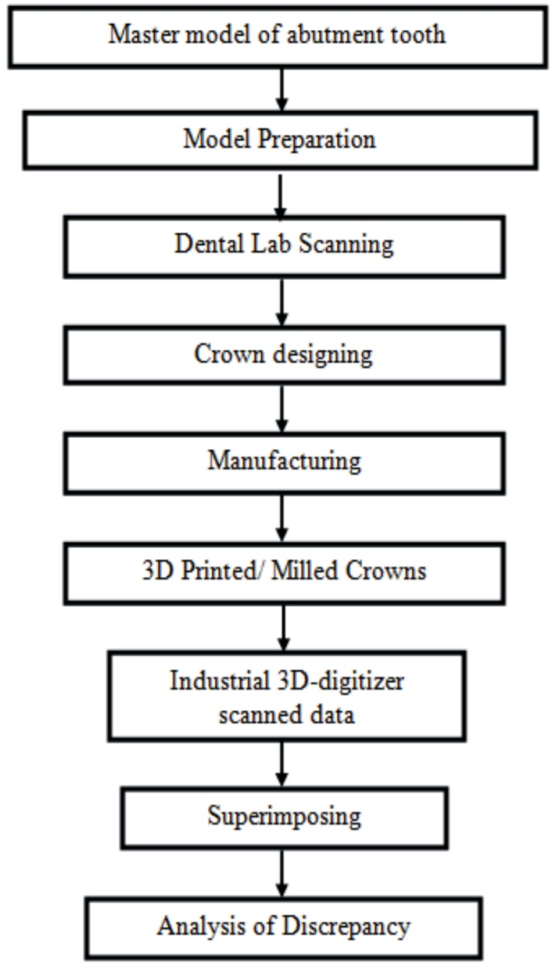

Fig. 3. Flowchart of the digital workflow of fixed dental prosthesis fabrication.

E. 3D Superimposition analysis

After completion of the processing phase, crowns are analysed digitally using an industrial 3D digitizer. Quantitative methods to analyse the accuracy of fabricated crowns have been developed. The discrepancy between the inner surface of the crown and the corresponding abutment tooth is measured using GOM Inspect software. The corresponding area of the abutment and inner surface of the crown will be superimposed using manual and automatic alignment functions.[15] They are considered advantageous, as they are more objective and provide more accurate estimations. However, the utilization of such methods is complicated and time-consuming. The validation of these methods for providing true values has not been adequately investigated.[16,17]

Conclusion

Digital technology advancement is bringing a revolutionary change in modern-day dental practice. Computers are making all manual tasks easier, faster, cheaper and more predictable.

Technology is improvising at its best, but still, there is a big challenge in the research of dental materials that are suitable and acceptable for human use. CAD/CAM and 3Dprinting are two digital technologies that are popular nowadays. According to current literature,both of the technologies are improvising one or the other properties of fixed restorations. Still, there is need of more studies and experiments need to be done for the betterment of technology as well as overcome its shortcomings.

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