Digital Technology and Artificial Intelligence in Prosthodontics

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Abstract

The paper addresses the prosthodontic problems and challenges associated with the fabrication of complete dentures. It also highlights the advances in digital technology in prosthodontics, artificial intelligence in dentistry in general and on the systems introduced to improve the dental health care system.

Keywords: Digital Technology, Complete Dentures, CAD CAM Technology, Artificial Intelligence.

1. Introduction

Complete edentulism is a state of loss of all permanent teeth, and its consequences has been linked to risk of developing co-morbid systemic conditions such as asthma, cardiovascular diseases, diabetes, dementia in a edentulous patient, along with reduced masticatory efficiency, dietary intake and social stigma of anterior tooth loss. [1] Globally, the incidence of edentulism has been reported to be 7-69% in developing and developed countries in the age group of 60 years and above.[2] Epidemiological studies on the prevalence of edentulism in India, has been discrete with sparse regional reports on the prevalence of partial or complete edentulism and poor public awareness on the edentulous state.[3–11]

Prosthetic rehabilitation of complete edentulous patients is commonly done through exemplary complete denture therapy. Implant retained overdentures, as minimal standard treatment option for edentulous patients, have been successful in reducing the residual alveolar bone resorption.[1] Currently, India has 7.6% of geriatric population and 40% of its elderly community live below poverty line. With the formidable barriers of insufficient dental workforce for the rural population, high cost of dental implants and the growing disparities of dental care due to socio-economic conditions with no health insurance, there is an assertive need to address the problems of rural population in accessing dental health care services.[12,13]

The process of denture fabrication with heat polymerized polymethyl methacrylate resins (PMMA) is technique sensitive and consists of a number of laboratory steps, crucial to the clinical performance of the denture. A coordinated interaction of prosthodontists and laboratory personnel is essential to deliver quality dentures. While treating a large number of edentulous patients in outreach programs and relying on skills of laboratory personnel with manual methods for fast paced delivery of dentures, occurrence of ill-fitting dentures is frequent and patient feedback on denture satisfaction after outreach denture programs are often underreported. [14]

2. Clinical Challenges in Denture Fabrication

While the conventional technique of complete denture fabrication have the inherent advantage of its clinical predictability, but it does have the limitations of additional patient visits, cost and technique sensitive laboratory procedures. It essentially consists of clinical steps of primary, master impressions followed by recording jaw relations, trial of the denture base and denture insertion. Laboratory techniques consist of preparation of patient model, denture base fabrication, occlusal rims, articulation, teeth arrangement and denture processing. [15]

Simplified techniques of clinical procedures have been advocated for faster delivery of dentures especially in private dental clinics, saving both time and cost. Simplified techniques such as making alginate primary impression in a stock tray, eliminating the custom tray border molding procedure and following the usual procedures of denture fabrication have been proposed.[16] Impressions in denture camps, are also made following the traditional molded compound tray technique with zinc oxide eugenol or alginate wash impression.

However, the above techniques may only be effective in patients with well-formed ridges, normal jaw relations and alginate impressions or tray impressions can often result in overextended borders and is subject to clinicians'skill.[16] In poorly resorbed ridges, use of modeling compound or putty silicone elastomer with zinc oxide eugenol is generally followed.

Other clinical techniques such as SET technique consists of multi-layer impression trays with polysulfide impressions, light cure resin base, bite silicone, with upper paper anterior teeth. Denture template technique consists of hard and soft relining the thermoplastic templates, adapting to patient models. However, the techniques do not address the challenges of lip support and recording occlusal plane in patients and are limited to anecdotal case reports.[17]

Recording jaw relations is generally done with auto-polymerized acrylic resins or shellac base plate temporary denture bases. The adaptability of the temporary denture base often depends on the dimensional stability and manipulation of the materials by the laboratory personnel. Often, shellac base plates, known for its thermoplastic nature can be subject to warpage and the insufficient time given for polymerization of auto-polymerized acrylic resins can subject it to distortion, resulting in inaccurate jaw relations and trial.

The cumulative effect of errors during impression making, cast preparation, base plate adaptation can levy a high risk of denture failure.

3. Laboratory Challenges in Denture Fabrication

Compression molding, injection molding and fluid resin technique are some of the conventional laboratory techniques of denture processing/ fabrication. Compression molding technique essentially consists of investing the waxed denture bases in dental plaster, creating molds by dewaxing in hot water bath and packing the molds and polymerizing the heat activated PMMA in hot water bath. There are technical challenges associated with the above techniques such as prosthetic teeth shifting, air entrapment, denture porosity, polymerization shrinkage and poor bonding between denture base and teeth.[18] Systematic organization of patient casts and dentures by laboratory personnel through numbering or coding system is followed and is critical for the success of the denture camp.

4. Digital Technology and Artificial Intelligence in Prosthodontic Rehabilitation

Digital techniques such as CAD CAM (Computer Aided Design and Computer Aided Manufacturing) have been advocated in the fabrication of fixed dental prosthesis and complete denture prosthesis. Digitization of data of prepared teeth through intraoral or extra oral scanners, with virtual designing of dental crown and automated milling has currently been successful in the dental market. CAD CAM dentures have been proposed through pre-polymerized PMMA blocks and 5 axis milling with computer software. [18] The advantages of CAD CAM dentures are lesser clinical visits, milling pre-polymerized dentures eliminating occurrence of porosities with better denture fit.[15] The clinical steps however, in the current CAD CAM system follow the conventional procedures. Thermoplastic or custom impression trays are used to record the denture bearing areas, peripheral limiting structures, neutral zone and phonetic positions for teeth arrangement. The impressions are then scanned and virtual teeth arrangement is performed on virtual casts. Dentures on virtual casts are milled with recesses to accommodate denture teeth for further bonding. [19] CAD CAM technological innovations

in laboratory steps have made an impact in the form of milling or 3 D printing. Denture base adaptations, retention of CAD CAM dentures have been found to be comparable to the conventional dentures. Few of their limitations range from need to bond the denture teeth to denture bases, difficulty in digitizing impressions and the need to compare the true treatment outcomes than surrogate treatment end points. [15]However, the present CAD CAM systems may only cater to the elite group of edentulous patients due to their high cost. Adapting technology to denture outreach programs targeting at mass production of cost-effective quality dentures for rural population customized to Indian settings is the need of the hour.

Digital technology has been applied in the specialty of prosthodontics, particularly in smile designing. Comprehensive assessment of facial and dental structures, are essentially done through facial, dental and dentogingival analysis through software applications. [20] The advantages of virtual smile designing are patient involvement, treatment plan visualization and its prediction. Medical reverse engineering technology, obtains patient data or existing biomedical devices to reconstruct 3 dimensional models or innovative biomedical devices. The application of technology consists of data acquisition, data processing and analysis. Data is acquired from patients, patient's casts or models and biomedical objects.

Clinical decision support systems (CDSS) is a system of network of medical information and inferencing mechanism that works on logic modules and algorithms to extract relevant information, thus simplifying the process of diagnosis. CDSS uses a large amount of clinical data and can predict susceptibility to dental diseases, helping in accurate diagnosis and treatment planning. [21] Artificial Intelligence (AI) has been used in decision making and radio-imaging in medical oncology and urology.[22, 23] AI has approach methods such as neural fuzzy logic, artificial neural networks and has been compared to statistical methods. Artificial neural networks are a complex network of computer processors similar to the human neurological systems. Based on this technology, Dr Frank Rosenblatt developed Perceptron a multilayer feed forward mechanism. Many layers of computer processors perform parallel computations for data processing for the function of such networks. Each of these interconnected units is known as "neurons", each of which has a link and numerical weight associated with it. The computer network learns though repeated adjustments of these weights.[24] Paul Werbos in 1974 introduced "back-propagation" learning. The computer machines can learn from newer information to understand diseases, diagnose them early, and to treat them effectively.[25] Application of AI in dentistry can range from use of collection of patient data, radiological image analysis and predicting disease patterns such as dental caries.[26,27] AI can also integrate the CBCT and MRI imaging, and can help detect minor abnormalities of the human body, which the human eye can never detect. In the field of orthodontics, AI can help predict orthodontic movement based on patient ethnicity and anthropological background. With the development of automation, robotics and artificial intelligence, focus must be on eliminating the technical challenges involved in denture fabrication at the rural settings.[21] Robotic systems for teeth arrangement, tooth ablation, chewing robot for testing dental materials and dental implant placement have been explored.[28–30]

5. Conclusion

Though artificial intelligence have made tremendous inroads in engineering and medicine, they however lack a subjective sense of human empathy and moral judgements. While it is true that research in medicine is in the best interest of human health, caution must be exercised to avoid having presumed assumptions based on certain technology, in the process, we may grossly neglect the basic human intuition and the normal biological outliers in the complex human body.

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