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Digital Workflow of Complete Removable Dentures – A Review of the Literature

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ABSTRACT: The utilization of computer-aided design and computer-aided manufacturing (CAD/CAM) techniques for creating complete dentures (CDs) has garnered significant interest. This article aims to provide a summary of the current understanding regarding digital CDs and the associated technology. Additionally, it seeks to showcase the practical application of this new technology in a case involving dental care for an elderly patient. Initially, the paper outlines the difficulties related to digitizing the oral mucosa, which acts as a foundation for the inner surface of the dentures. In conclusion, the new digital technology offers evident benefits, although its successful implementation necessitates careful preparation. The digital workflow proves to be adaptable and versatile in practice.

KEYWORDS:3D Printing, complete removable dentures, CAD/CAM, Removable Dentures, Denture Base Materials

I. INTRODUCTION

While the primary objective of modern dentistry is to conserve natural teeth, as individuals age, the likelihood of experiencing tooth loss increases statistically [1]. This, combined with longer life spans, has led to a growing demand for both partial and complete dentures (CDs) [2].

Emerging in the 1980s, digital dentistry, an offshoot of digital technology and robotics, has transformed various aspects of dental practice, including the creation of CDs [3]. For over 25 years, computer-aided design and computer-aided manufacturing (CAD/CAM) methods have been employed in crafting CDs [4]. Currently, the use of CAD/CAM techniques for CD fabrication has garnered substantial attention within the industry, driving advancements in both design and manufacturing realms [5]. This new technology holds the potential for faster and higher-quality outcomes [6]. This article aims to succinctly outline current knowledge regarding digital CDs and showcase the technology's application through a case study.

Various approaches yield acceptable outcomes when using digitally produced CDs. The initial challenge involves accurately capturing the shape and dimensions of alveolar ridges, hard palate, border seal's functional depth and width, and post-palatal seal [7]. Ensuing steps include precise recording of maxillomandibular relations, establishing appropriate vertical occlusion dimension, and satisfying aesthetic criteria. This data guides cameo surface design, the area for artificial teeth, and functional and aesthetic tooth arrangement, ultimately culminating in successful denture creation [8].

Protocols for digitizing denture tissue surfaces are still evolving and depend on the system used. However, two general options exist [9]. One involves directly scanning supporting tissues using an intraoral scanner, while the other entails indirect scanning of a stone cast or impression using a laboratory desktop scanner or intraoral scanner [10]. Intraoral scanning offers advantages over conventional impressions, such as enhanced patient comfort (reduced gag reflex, less chairside time, fewer appointments) and streamlined laboratory procedures (easier cast preparation, handling, and shipping) without physical casts [11]. Additionally, intraoral scans

have demonstrated dimensional accuracy for CD fabrication. If an intraoral scanner is unavailable, scanning of physical casts or impressions becomes necessary.

II. MATERIALS AND METHODS

The methodology encompassed the utilization of a search approach, the identification of pertinent research, and the synthesis of information to succinctly present the outcomes. The search terms employed were "Denture," "Removable Dental Prostheses," "Removable Denture," "Complete Denture,""Three-dimensional printed," "CAD/CAM," "CAD-CAM," "Computer Aided Design and Computer Aided Manufacturing," "Milled," "3D Printed" OR "Printed," and "Digital Denture."

The search strategy for this review was structured in three stages: initial scrutiny of titles, subsequent evaluation of abstracts, and ultimate selection of publications for comprehensive text analysis. Articles extracted from the database search were individually reviewed by four assessors, and any divergences in selection were resolved through discussion to reach a consensus.

III. RESULTS

Regarding the Computer Aided Manufacturing (CAM) aspect of the new method for producing CDs, there are currently two main approaches: additive and subtractive. However, both methods require the necessary three-dimensional (3D) denture design CAD files [12].The additive approach, also known as rapid prototyping, was developed in 1981 and is commonly referred to as 3D printing [13]. This additive manufacturing technique encompasses a group of methods that construct a 3D object layer by layer using the corresponding CAD file [14].

Rapid prototyping has a wide range of applications in engineering and the broader field of medicine [4]. In essence, the concept of 3D-printed denture production involves printing the denture base in a pink material, followed by printing the teeth individually or as complete arches using tooth-colored materials. The printed products are then processed to eliminate any excess unpolymerized material, often through the use of ultrasonic baths with alcohol [15]. Subsequently, the printed teeth are affixed to the denture bases using liquid material from the printer's reservoir and finally cured with light to ensure complete polymerization. The outcome boasts high detail and a smooth surface [16].

The final steps involve removing supports and meticulously polishing the denture. Alternatively, commercially available denture teeth from the CAD software's digital library can be chosen and bonded to the printed base [17].While numerous additive manufacturing systems exist, not all are suitable for CD production due to either the lack of compatible materials or the absence of sufficient building volume. A survey of the market revealed a selection of systems viable for CDs' production, both within laboratory settings and chairside applications [18].

The subtractive approach involves the milling of the denture base using an industrially manufactured resin disk tinted in red [19]. The fabricated teeth can be milled or chosen from a pre-made series and then affixed to the denture base [10]. Several CNC/milling CAM systems are available, designed for use in laboratories or chairside applications. Nevertheless, for the system to be suitable for CD fabrication, it must be able to work with the appropriate milling blanks. In Table 2, a brief description of certain options suitable for CD production through the subtractive method is provided [11, 12].

IV. DISCUSSION

There are additional motives to embrace digital transformation. Traditional removable prosthodontics necessitate practitioners with progressively developed skills and experience, given the technique-sensitive nature of the process, where errors can accumulate across multiple manufacturing stages [15]. Finding experienced dental technicians proficient in crafting high-quality removable dentures poses a challenge. Moreover, conventional methods lack efficient tracking and documentation for post hoc quality control and procedural refinement, which could greatly benefit both patients and dentists [17].

Transitioning to the digital era mandates prudent financial planning from the dentist's perspective, who also assumes the role of an entrepreneur [20]. In busy practices, chair time is viewed as a valuable resource to maximize business revenue [21]. However, understanding and appreciating the new technology necessitates a business-minded approach. The move to the digital realm requires a different mindset, involving substantial initial investment, ongoing maintenance expenses, skill development, and the acknowledgment of new risks [5].

Furthermore, there's a multitude of possible amalgamations between traditional treatment procedures and digital approaches [22]. The selection of a CAD/CAM denture fabrication system and the integration of conventional and digital workflows depend on the dentist's

prosthodontic expertise and patient-specific needs. Compatibility issues between CAD software, CAM systems, and materials are still being debated, given the rapid evolution of the technology [3].

Despite the numerous advantages of digital transformation, it doesn't necessarily yield profits in all business models [23]. It's most suitable for busy practices or dental technician labs with substantial demand for prostheses, established markets with developed logistical networks, and a well-trained workforce [8]. An expedited and extensive digital transformation without comprehensive planning and robust support from both the entrepreneur and the market could yield undesired outcomes. Consequently, despite its practical benefits, digital transformation necessitates market knowledge and is akin to an investment that should be examined not only technically but also financially before making a commitment [24].

V. CONCLUSION

In summary, the utilization of digital technology in the fabrication of complete dentures demonstrates versatility, allowing for the integration of the established traditional approach in clinicalpractice with the recent advancements in CAD/CAM techniques within laboratory settings. This emerging digital technology offers fresh and optimistic prospects, potentially elevating the dental field to new heights. Nonetheless, embarking on this route requires thoughtful deliberation and meticulous preparation.

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Conflicts of Interest
The authors declare no conflict of interest.

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