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Integrating Digital Dentistry in Full Mouth Rehabilitation

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Abstract:
Full-mouth rehabilitation has been revolutionized by the development of digital dentistry, which offers precise diagnosis, dependable treatment planning, and efficient clinical execution. A fully digital approach for FMR is described in this paper, which includes, computer-aided design and manufacture (CAD/CAM), digital smile design (DSD), and intraoral scanning. The benefits of digital techniques such as reduced chair times, enhanced patient communication, and less intrusive procedures are highlighted. We can see how digital planning makes it easier to combine aesthetics and functional outcomes, particularly in complex rehabilitative cases with worn teeth, temporomandibular disorders, or substantial prosthodontic needs. With its emphasis on accuracy, dependability, and patient care, this digital method marks a significant shift in modern prosthodontics.
Key Word*: Digital,Full mouth rehabilitation,CAD-CAM,Surgical guide*

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I. Introduction

The goal of dentistry is to increase the life span of the functioning dentition, just as the goal of medicine is to increase the life span of a functioning individual. The word rehabilitate implies to restore to good condition or to restore to former privilege. An increasing number of people are now living longer and retaining their natural teeth into old age. With a growing number of elderly people keeping more of their teeth into old age and the increase in tooth wear with age, most dentists agree that minimal and gradual attrition of the occlusal surfaces of teeth is a normal process during the lifetime of a patient[1]. This substantial problem is likely to become even greater in the future. Extensive tooth wear is considered a potential threat to functional dentition. The management of tooth wear especially from attrition is becoming a subject of interest in the prosthodontic literature both from a preventive and from a restorative point of view[2]. The ultimate goal for every patient should be maintainable health for the total masticatory system[3].

Today, digital dentistry has revolutionized the way dental professionals provide patient care. It refers to the use of digital technologies in all aspects of dentistry, including diagnosis, treatment planning, and restoration; encompassing a range of technologies, including computer-aided design/computer-aided manufacturing (CAD/CAM), three-dimensional (3D) printing, artificial intelligence (AI), augmented reality (AR), and tele dentistry; a rapidly evolving and transformative field. Treatment planning in dentistry is a step-by-step personalized protocol designed to achieve the patients' desired oral health. In digital dentistry, a personal dental treatment plan represents the 3D model of the actual condition of the teeth and gums, as well as predictions or visualizations of the desired outcome[4]. This technology has several advantages, including accurate measurements, storage, and time-saving as well as online consultation and presentation, providing information exchange with different centres for planning and appraising medical procedures and treatments. Even teaching and research tools greatly benefited from these innovations, with software for teaching dentistry (such as 3D software for learning anatomy or 3D simulation programs for surgical procedures), digital archiving of patient records, and convenient/rapid sharing of them over the Internet, digital bibliographic assistance in dental research, or other utilities [3].

II. REASON FOR FULL-MOUTH REHABILITATION

The primary reason for undergoing a full-mouth rehabilitation is to achieve and sustain the health of the periodontal tissues. Clinical evaluations of periodontal health are compared with radiographic images to assess the severity and nature of the disease. Once periodontal disease is identified, we aim to link our observations with the function of the mouth. In reviewing the functions of the mouth, numerous factors must be taken into account[1]. The most crucial are:

Premature contact - when an upper and lower tooth makes contact that disrupts or obstructs the normal closing motion of the mandible. Equally significant, and perhaps indicative of a more severe condition, is the area that absorbs the closure force after the patient deviates from the premature contact.
Temporomandibular joint disorder - Diagnosing this condition can be challenging, and it is essential to carefully identify the underlying causes at play. Often, there exists a mismatch between the joint's articulation and its movements—a functional disharmony. Sometimes, this muscular dysfunction can stem from mal-articulation, leading to muscle spasms, which are then perceived as a joint issue.
Necessity for extensive dental work - In these cases, some teeth may be absent, others excessively worn, and there could be old fillings needing replacement. Typically, these patients experience minimal periodontal issues and do not exhibit joint problems. They are often the most straightforward cases to manage, and beginners should focus on them for full-mouth rehabilitation[1].

III. CLASSIFICATION

Various classifications have been proposed to classify patients requiring full mouth rehabilitation, however, the classification most widely adopted is the one given by Turner and Missirlian .According to them, patients with occlusal wear can be broadly classified as follows[1,4]

Category-1: Excessive wear with loss of vertical dimension of occlusion (VDO)

The patient's closest speaking space is more than 1 mm and the interocclusal space is more than 4 mm and has some loss of facial contour and drooping of the corners of the mouth. All teeth of one arch must be prepared in a single sitting once the final decision is made. This makes the increase in VDO less abrupt and allows better control of esthetics.

Category-2: Excessive wear without loss of VDO but with space available.

Patients typically have a long history of gradual wear caused by bruxism, oral habits, or environmental factors but the occlusal vertical dimension (OVD) is maintained by continuous eruption. It might be difficult to achieve retention and resistance form because of shorter crown length and gingivoplasty may be needed. Enameloplasty of opposing posterior teeth may provide some space for the restorative material.

Category-3: Excessive wear without loss of VDO but with limited space There is excessive wear of anterior teeth over a long period, and there is minimal wear of the posterior teeth. Centric relation and centric occlusion are coincidental with a closest speaking space of 1 mm and an interocclusal distance of 2–3 mm. In such cases, vertical space must be obtained for restorative materials. This can be accomplished by orthodontic movement, restorative repositioning, surgical repositioning of segments, and programmed OVD modification[1,4]

CLASSIFICATION BY BRECKER (1966)

Group 1:

Class I - Patients who have lost the vertical dimension of occlusion because of shifting of existing teeth caused by failure to replace missing teeth

Class II - Patients who have lost the vertical dimension of the occlusion due to the loss of all posterior teeth with one or both jaws with the remaining teeth in an inadequate occlusal relationship.

Class III Patients whose vertical dimension collapses as a result of excessive wear and tear of occlusal surfaces

Group II:

Class I Patients whose natural teeth is complete or sufficient, exhibit satisfying occlusal relationship Class II Patients with limited teeth present but in a satisfactory occlusal relationship requiring help in the form of occlusal rims.

Group III:

Patients requiring maxillofacial surgery or orthodontic treatment as an aid in restoring the last vertical dimension.

Group IV:

Patients in whom sectional treatment is required over an extended period of time because of status of health of patient, age or economic factor[5].

After evaluating and classifying the patient's existing clinical situation but before beginning the reconstruction procedure, the clinician must decide upon the occlusal approach and choose an appropriate occlusal scheme[5]

IV PHILOSOPHIES IN FULL MOUTH REHABILITATION

- Gnathological concept (McCollum, Stuart, Stallard)
- Freedom in centric concept (Schuyler)
- Simplified occlusal design (Wiskott and Belser)
- Pankey, Mann and Schyuler Philosophy (1960)
- Twin Table Technique- Hobo (1991)
- Twin stage procedure- Hobo and Takayama
- Youdelis Scheme
- Nyman and Lindhe scheme [6]

V. DIGITALIZATION IN PROSTHODONTICS

Digitalization has become an integral aspect of modern prosthodontics, with the likelihood that most treatments will be performed digitally in the coming years. Digital dentistry offers the effective, quick, accurate, and error-free manufacture of fixed prosthodontics devices. The emergence of digital radiography, as well as the first iterations of intraoral scanning and computer assisted design and computer-assisted manufacturing (CAD/CAM) crowns, sparked widespread use of digital technology in dentistry in the early nineties. Digitalization and technology have limitless potential in prosthodontics, whether in clinic or laboratory operations, they also help in discussing and displaying the treatment's success with the patient using the digital data acquired which is advantageous to the dentist as well as the patient resulting in increased acceptance and compliance. A wide range of digital solutions are known, and several are being investigated; some of them are as follows: (i) Computer-Aided Design-Computer Assisted Manufacturer (CAD-CAM) technology, (ii) Rapid prototyping, (iii) Stereolithography, (iv) CEREC system[7,8]

INTRAORAL SCANNERS

Since the eighteenth century, conventional impression techniques have been used to register the three-dimensional geometry of dental tissues. Nevertheless, volumetric changes of impression materials and expansion of dental stone seem error-prone, and thus the process requires the services of an excellent dental laboratory to overcome these difficulties, impression with IOS (intraoral scanner) was developed for dental practice. Intraoral scanner is a device consisting of handheld camera, computer and a software which aims to capture the three dimensional geometry of an object with precision. There are various digital file formats like STL file (Standard Tessellation Language), Polygon File Format, PYL files. Among which the most common used formal is the open STL or the closed STL format[11]. All camera have a projection of light which is recorded as individual image or video and is compiled by the software after recognition of the point of interest[9].

DIAGNOSTIC WAX-UP

After obtaining the diagnostic intraoral scans, the next crucial component to computer-guided implant planning and execution is the diagnostic wax-up, which allows to create a three-dimensional communication tool that guides the prosthetically driven implant planning and placement. These wax-ups can be virtually designed by using dental laboratory software. This will allow the clinician and patient to visualize the case before treatment and do the required modifications in tooth shape, size, or morphology by using the tools within the software. Once the final design is accomplished, the wax-up can be produced via digital manufacturing[8].The sequence of digital wax-up include[10]:

First, the patient's extraoral examination should be carried out in which the patient's age, general physical condition, facial form, symmetry, facial height, and smile lines can be evaluated.

The patient's extraoral, and intraoral photos have to be taken followed by a conventional diagnostic impression which would be further scanned then the 2D images and 3D scan files are merged into a 3D digital design software. From this software, a digital smile template can be selected from its library and overlaid on the patient's smile images which were captured previously. The software also allows us to choose individual teeth depending on their shape, size, position, marginal adaptation, occlusal, and proximal contacts which can also be adjusted and then verified. By this it's possible to see the initial and final situation overlaid on a single image[10].

FACIAL SCANNERS

The ongoing evolution of digital technologies has brought significant advancements in dental procedures and workflows. The integration of intraoral scanners and CAD/CAM technology for tooth restorations and dental implants is now standard practice. Recently, facial scanners have emerged as a valuable addition to the digital dental process. This technology employs optical scanning methods to digitally obtain and display a comprehensive three-dimensional model of a person's face and head. The gathered data can be used for various analyses, including treatment planning, diagnosis, and communication with patients. Using a facial scanner to capture a patient's natural rest position, maximum smile, and various smile lines can permit a virtual setup of teeth with a 3D model that allows for the digital assessment of tooth alignments, shapes, and colors in immediate dentures. Computer-aided surgical simulation for orthognathic surgery is achievable by integrating the patient's CBCT DICOM file with the STL file from the intraoral scan, enabling careful and detailed pre-operative planning[11]

SCANNING MECHANISM:

There are four techniques employed by facial scanners: photogrammetry, stereophotogrammetry, structured light scanning, and laser scanning. Among these techniques, there are two approaches: passive and active. In passive approaches, a patient's facial features are captured using two or more images (photogrammetry and stereophotogrammetry). In the active approach, 3D sensors are utilized to record light patterns through active triangulation (using laser beams and structured light). Regardless of the scanning technique employed, photogrammetry, stereophotogrammetry, laser-beam scanning, and structured light scanners offer benefits as they are noninvasive, precise, and reproducible[12].

DIGITAL ARTICULATOR

The variety of articulators that can be utilized in a digital setting has grown and diversified alongside the advancement of CAD software packages.

There are three forms of digital articulation present in the digital workflow:

Mechanical articulation with a digital interface: This involves the use of class III or class IV articulators, where plaster casts are secured on detachable plates of the mechanical articulator before scanning is conducted using a desktop scanner to integrate them into the CAD software[8].

Simple digital articulation consists of two approaches:

- IOS scanning: This technique employs an intraoral scanner to capture the occlusal surfaces, which are then imported into the CAD software. It is typically used for sectional scans of the dental arch as opposed to complete arch scans.
- Model scanning with an occlusion medium: This method allows for an analysis of occlusion and is limited to restorations that replicate the final anatomy from existing occlusal morphology.
- Virtual digital articulation: This method facilitates the assessment of both static and dynamic jaw movements through the use of virtual reality technology. Jaw movement recording systems are offered in three categories: ultrasound-based, voltage division method, and optoelectronic systems[8].

DIGITAL IMPLANT PLANNING SOFTWARE

Digital implant prosthetic planning offers various intriguing insights regarding diagnostics, personalized treatment plans, and precise surgical and prosthetic execution, provided the appropriate conditions are met. The benefits of digital implant planning and guided surgery are quite clear. Three-dimensional visualization of the maxillary sinus or unique bony characteristics can be evaluated more effectively and addressed during the procedure. Comprehensive preoperative planning instills confidence in surgeons, resulting in fewer spontaneous decisions or deviations from the planned surgical approach[13,] Digital implant planning necessitates three-dimensional radiographic data (DICOM: digital imaging and communications in medicine) as well as STL data (STL: standard tessellation language) obtained from an intraoral scan template post-radiological imaging.

Presently, all that is necessary for this process is the DICOM data alongside the three-dimensional surface data from the intraoral scans. This indicates that the procedure can be adjusted at any point to fit a particular implant system or the associated software. The timeline of digital diagnosis, planning, implant placement, and chair side provisionalization include treatment phases such as Diagnostic phase, Planning phase, Surgical phase and Restorative phase[14]

The digital workflow encompasses:

- Collection of fundamental data - essential data can be gathered during a single appointment. Alongside the DICOM data collected from cone-beam computed tomography (CBCT) or conventional computed tomography (CT), STL data representing the intraoral clinical scenario through an intraoral or model scan is necessary.
- Data processing- Data fusion - The surgical template is created based on the STL surface data of the clinical situation. To facilitate this, the two datasets (STL and DICOM data) are imported into the implant planning software and overlaid (or 'registered'). Most planning software requires the marking of specific points, preferably on residual dental hard tissue, to achieve alignment of the collected data.
- Fabrication of the final prosthesis – includes CAD designing and manufacturing of 1)Virtual prosthetic set up where the prosthesis is planned for its final position and characteristics,2) implant placement ,3) drill guide design and 4) central or in office drill guide production either through milling or 3D printing

This principle also holds for digital implant planning and guided surgery[14,15,16].

DESIGNING THE SURGICAL TEMPLATE

After determining the future implant locations, they are incorporated into the design of the surgical template. A partially guided approach can be utilized, where only the pilot drill is guided by the template, or a fully guided procedure that includes specialized guide sleeves tailored to the chosen implant system within the surgical template. Once the implant planning is validated, the software generates a planning report detailing the type, size, and location of the intended implants. The 'drilling protocol' equips the surgeon with essential technical information regarding the proper use of the system-specific surgical instruments[17].

FABRICATING THE SURGICAL TEMPLATE

After the design phase is finished, the data set can be exported as an STL file and directly transformed into the physical surgical template using either additive or subtractive CAM techniques. Commonly employed methods for this purpose include 3D printing or rapid prototyping technologies, particularly stereolithography (SLA), digital light processing (DLP), or selective laser sintering (SLS). The integration of guide sleeves is done manually, as well as the extraction of holding or support structures and the finishing touches on the template[17].

With these technologies, digital dentistry has revolutionized prosthodontic practice by enhancing precision, efficiency, and predictability. Prosthodontists now routinely integrate digital procedures across diagnosis, planning, and treatment delivery. These tools enable accurate visualization of anatomical structures, personalized prosthetic design, and minimally invasive workflows.

IV. Conclusion

In addition to improving clinical precision and efficiency, the move to digital technologies in full-mouth therapy has significantly improved patient comfort. Conventional dental procedures can be painful, involve a number of appointments, dirty impressions, and prolonged chair time. However, the patient experience has been completely transformed by digital technological breakthroughs such as guided implant surgery, CAD/CAM systems, and intraoral scanners. Intraoral scanners provide quick and accurate digital models for treatment planning while doing away with the need for conventional impressions, which reduces patient anxiety and helps prevent the gag reflex. By ensuring that restorations blend in well with the patient's natural facial proportions and minimizing the need for frequent revisions, facial scanners further improve comfort. chairside modifications and interventions. Virtual articulators enable dentists to assess occlusion digitally, which cuts down on unnecessary chairside interventions and adjustments. This leads to a more streamlined workflow with fewer manual modifications, resulting in a more seamless and predictable rehabilitation process.

By reducing surgical invasiveness, digital implant planning has also greatly improved patient comfort. With the help of precise computer simulations, guided implant surgery ensures exact placement with less trauma, resulting in a quicker recovery, less discomfort after surgery, and fewer complications. Compared to conventional methods, the choice of flapless or minimally invasive techniques improves recovery and significantly reduces discomfort.

By eliminating the need for numerous appointments and temporary prostheses, which can be unpleasant and inconvenient for patients, CAD/CAM technology enables same-day restorations. Digital workflows allow

for unparalleled precision in custom-designing restorations, reducing post-placement discomfort and guaranteeing a natural sensation. Additionally, by enabling people to see their future smiles before to treatment, digital smile design (DSD) reduces anxiety and aligns expectations, which increases patient confidence. By predicting treatment outcomes and streamlining operations, artificial intelligence and machine learning have also helped to improve patient comfort by reducing needless procedures and problems. In conclusion, by decreasing discomfort, accelerating treatment timeframes, and enhancing procedural accuracy, digital dentistry has made full-mouth rehabilitation more patient-friendly. In addition to ensuring improved functionality and aesthetics, this shift to a purely digital approach provides patients with a far more pleasant and hassle-free experience.

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