World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 5.088

USE OF CAD/CAM TECHNOLOGY IN DENTAL IMPLANT

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Article Received on 15/05/2018 **Article Revised on 05/06/2018** **Article Accepted on 26/06/2018**

ABSTRACT

Despite the predictable longevity of implant prosthesis, there is an ongoing interest to continue to improve implant prosthodontic treatment and outcomes. One of the developments is the application of computer-aided design and computer-aided manufacturing (CAD/CAM) to produce implant abutments and frameworks from metal or ceramic materials. The aim of this narrative review is to critically evaluate the rationale of CAD/CAM utilization for implant prosthodontics. To date, CAD/CAM allows simplified production of precise and durable implant components. The precision of fit has been proven in several laboratory experiments and has been attributed to the design of implants. Milling also facilitates component fabrication from durable and aesthetic materials. With further development, it is expected that the CAD/CAM protocol will be further simplified. Although compelling clinical evidence supporting the superiority of CAD/CAM implant restorations is still lacking, it is envisioned that CAD/CAM may become the main stream for implant component fabrication.

KEYWORDS: Predictable longevity, prosthodontics, CAD/CAM.

INTRODUCTION

Prosthetic replacement of missing teeth with implants has become a predictable procedure. However, numerous clinicians are encountering difficult cases, with insufficient amount of bone. This has created an increasing demand for advanced presurgical imaging procedures, which enables the clinician to evaluate the osseous and vital anatomic structures adjacent to the implant site prior to surgical intervention.[1] Various cross-sectional imaging techniques.[2] and innovative software programs[3] have been developed to help create an accurate presurgical plan. Thus, advancing technology permits us to make use of computer-aided design and computer-aided manufacturing (CAD/CAM) technology to overcome the above mentioned difficulties and to enable a precise surgery.[4]

Advantages and Disadvantages of CAD/CAM Technology

CAD/CAM technology employs a non-invasive three-dimensional (3D) imaging system.[5] A radiographical template employed during this procedure provides a means to integrate the restorative determinants with the presurgical plan. This allows the treatment to be optimized from a restorative point of view and further enables the implant surgeon and the restorative dentist to define the most suitable surgical requirements, to predict prosthetic outcome options and to deal more effectively with patient needs and concerns.[6] CAD/CAM technology facilitates minimally invasive surgical procedures. These procedures aid in reducing healing time, postoperative discomfort, swelling and pain. It also reduces impact on the patient's morbidity.[7] Furthermore, it aids in the preservation of hard and soft tissue, maintains blood circulation to the surgical site and facilitates immediate loading by allowing the presurgical construction of master cast and provisional restorations.[8] Accuracy of CAD/CAM technology in dental implant planning and predictable transfer of the presurgical plan to the surgical site has been documented.[9-12] Even though, it has been established that computer-guided template-based implant placement exhibit a higher implant survival rate, a considerable number of technique-related complications were observed. Deviations were mainly related to the system and reproducibility errors. Hence, the various complications[13] that occur in this procedure can be related to inaccurate planning, radiographical stent error and intrinsic errors during scanning, software planning, rapid prototyping the guide stent and transferring information for the prosthetics. Nevertheless, it has been documented that if the clinician recognizes these sources of inaccuracy, efforts can be made to minimize the error and to optimize patient treatment.

Procedure

The use of CAD/CAM technology in dental implant planning can be divided into the follow steps.

- Fabrication of the radiographic template.
- The computerized tomography scan procedure.
- Implant planning using interactive implant surgical planning software.
- Fabrication of the surgical drill guide.

Fabrication of the radiographical template

The radiographic template is an exact replica of the desired prosthetic end result. It allows the clinician to visualize the location of planned implants from a restorative standpoint.[14] It can be either fabricated de novo from a diagnostic wax up or by duplicating an existing denture. Various radiopaque markers such as gutta percha balls and stripes, metal pins and tubes, radiopaque varnishes, lead foil or barium sulfate in resin powder aid in determination of the implant location. One technique involves placing radiopaque markers in a staggered pattern at different levels to the occlusal plane on the buccal flanges and palatal/lingual surfaces of the template.[15] Another technique involves fabricating an acrylic or vacuum-formed thermoplastic template, with barium filled in the edentulous portion of the template.[6] Alternatively, barium sulphate denture teeth can also be used.[14,16] There are some basic requirements that need to be considered during the fabrication procedure, which are as follows: It should be fabricated at the patient's appropriate centric position and occlusal vertical dimension; the teeth should be appropriately positioned according to phonetics and aesthetics; it should have soft tissue adaptation with exact fit to the underlying mucosa and well-extended flanges that will help provide proper stabilization during the scanning process.

After fabrication of the template, a vinyl polysiloxane centric occlusion index (interocclusal index) is fabricated to stabilize the template during the CT scanning procedure. This can also be used to stabilize the surgical guide at a laterstage.[17]

The computerized tomography scan procedure

Computerized tomography (CT) was founded by Sir Godfrey Houndsfield and Allen M. Cormack in 1972.[16] Multi-planar reformatting (MPR) CT allows to reformat a volumetric dataset in axial, coronal, and sagittal cuts and to build multiple cross-sectional and panoramic views. CT is considered to be more accurate than conventional tomography, since it exhibits uniform magnification. Furthermore, it provides multi-planar views and three-dimensional (3D) reconstruction, facilitates simultaneous study of multiple implant sites, and has shorter acquisition time.[18] These advantages make dental CT, the most precise and comprehensive radiological technique for dental implant planning. Nonetheless, CT exposes the patient to higher doses of radiation than conventional radiographic techniques.[19,20] It produces scatter artefacts of metal restorations; it is expensive to patients; transferring information from a surgical template is difficult and needs additional image processing software programs; the interpretation of images is difficult without prior training; and the chance of patient movement during exposure is likely.[1]

Introduction of helical CT[5] (spiral or volume acquisition CT) has dramatically improved the application of CT imaging in implant dentistry. Helical CT, along with advancements in stereolithography, has allowed for the development of a CAD/CAM processed surgical guide to be placed directly on the bony site. Helical CT scanning involves simultaneous patient translation and X-ray exposure, generating data specific to an angled plane of section with each rotation of the X-ray tube. Rapid acquisition of data set eliminates respiratory misregistration artefacts and prevents discontinuities in the reconstructions due to the minimization of motion artefacts. In addition, helical CT scanning allows production of overlapping images without additional radiation exposure.

Recently, cone beam CT[21-24] has been recommended for dental implant imaging, as it presents with several advantages in the identification of anatomical landmarks, provides high accuracy and has low-radiation exposure levels. CBCT machines rotate around the patient only once, capturing the data using a cone-shaped X-ray beam and it uses a low-energy fixed anode tube. These changes allow for a less expensive, smaller machine that causes less radiation exposure as compared to a helical CT.[25] Furthermore, true 3D images of bone or soft tissue surfaces can be generated. Although its use seems promising in the near future, the availability of cone beam CT is still restricted in routine use[21] as this technology still needs research to identify its practical applications and to determine its superiority to existing modalities. Thus, cross-sectional imaging like spiral tomography continues to play an important role in clinical practice.

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