



Deviation between Planned and Actual Implant Positions Inserted using Mucosa- Supported Stereolithographic Surgical Guide in Edentulous Mandible and Maxilla

Thesis

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By

Omar Mohamed Mohamed Yehia

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Supervisors

Prof. Marwa Ezzat Sabet

Head of the Removable Prosthodontics Department,
Faculty of Dentistry, Ain Shams University

Prof. Fardos Nabil Rizk

Vice Dean and Head of the Removable Prosthodontics Department
Faculty of Dentistry, The British University in Egypt

Dr. Mohamed Shady Nabhan

Lecturer of Removable Prosthodontics
Faculty of Dentistry, Ain Shams University

LIST OF CONTENTS

	<i>Page</i>
List of Tables.....	II
List of Figures	III
Introduction	1
Review of Literature	3
Implant-Supported Overdenture.....	3
Radiographic Evaluation	9
Digital Dentistry	13
Prosthetically Driven Implantology.....	23
Aim of the Study	33
Materials and Methods	34
Results.....	47
Discussion	53
Summary and Conclusions.....	62
References	64
Arabic Summary	-

LIST OF TABLES

Table No.	Title	Page
I	Mean, Standard deviation, and P value of Independent Student t-test for the comparison between angular deviation in maxilla and mandible	47
II	Mean, Standard deviation, and P value of Independent Student t-test for the comparison between coronal deviation in maxilla and mandible	49
III	Mean, Standard deviation, and P value of Independent Student t-test for the comparison between apical deviation in maxilla and mandible	51

LIST OF FIGURES

Fig. No.	Title	Page
1	Edentulous Mandible.....	36
2	Edentulous Maxilla.....	36
3	Primary impression.....	38
4	Secondary impression.....	38
5	Jaw relation.....	38
6	Try in	38
7	Delivery after occlusal adjustment	39
8	Denture scanning with Gutta Percha	40
9	Upper and Lower Surgical Guides	40
10	Surgical guide seating with bite index.....	43
11a	Mandibular Surgical guide in place.....	43
11b	Maxillary Surgical guide in place.....	43
12	Punched soft tissue	43
13	Implants drilling	43
14	Implants insertion	43
15	Postoperative and Preoperative planning implant overlap	44
16	Study attachments pick up.....	46
17	Bar chart representing mean value for angular deviation in maxilla and mandible	48
18	Bar chart representing mean value for coronal deviation in maxilla and mandible	50
19	Bar chart representing mean value for apical deviation in maxilla and mandible	52

INTRODUCTION

Dental implants are used to enhance the social wellbeing of the edentulous patients and give psychological benefits by improving the functions of the removable denture. The long-term success of the dental implant begins with proper implant planning and ideal implant placement surgery.

Nowadays, the computer guided implant placement can be either by dynamic navigation system or static surgical guides. The dynamic navigation systems, allows intraoperative bur tracking according to the preoperative planning.¹ While the static surgical guide can be manufactured by Stereolithographic technique; which is a laser dependent rapid polymerization technique using sequential layers of special polymer used to fabricate surgical guides with implant system affiliated with mounts for fixture placement, guide sleeves for fixation screw placement, drill keys for different heights, and depth controlling drills to form the osteotomies.

The surgical guide facilitates proper positioning, angulation of implants in the bone and treatment planning. In addition, using the surgical guides simplifies the surgical procedure, reduce the surgical intervention time, and reduce the postoperative sequela as the implants are placed with a minimal surgical exposure or even with a flapless technique as with the mucosal supported guides. As a result, the surgical guides decrease the laboratory and clinical complications.

The construction of the surgical guide stents is based on the following design concepts: Non-limiting design, Partially-limiting design and Completely limiting design.²

In some studies, the accuracy of the mucosa-supported stereolithographic surgical guide in completely edentulous patients was found to be influenced by number of variables such as the arch that supports the guide; maxilla or mandible. A degree of deviation was found between the planned and the actual implant position after insertion.

Therefore, the deviation between the planned and the actual implant positions in the maxilla and the mandible must be taken into consideration, to consider if the deviations occurring won't harm the surrounding anatomical structures. As safe margin should be taken while planning the implant sites to avoid damaging the anatomical structures.

However, few studies were conducted to evaluate the amount of difference in the deviation between the mandible and the maxilla. Therefore, this study was conducted, to measure the amount of deviation for the mandible and the maxilla and which arch produces less deviation from the planned position.

IMPLANT-SUPPORTED OVERDENTURE

To overcome the complete denture drawbacks which result from the continuous bone resorption leading to diminishing the denture bearing area which results in compromised denture support, retention, stability, lack of adaptation and difficult in denture functioning, dental implant overdentures are used. The function of removable dentures is improved when using implant overdentures.³

The patients using implants overdentures show decrease in the rate of bone resorption compared to the soft-tissue borne prosthesis, where the implant was found to prevent reduction in the bone mineral content adjacent to the implant site. The use of dental implants also increases the retention, stability and support of the denture, therefore it gives a psychological benefits and improves the social wellbeing of the patients.⁴⁻⁷

The placement of the dental implants in the symphyseal region between the mental foramina can increase the size and the density of the mandibular body, and it becomes more common in patients with severe resorption.⁸

Studies reported that masticatory performance showed higher increase after implant over denture treatment than after complete denture treatment. Patients were able to chew better,^{9,10} with less chewing cycles to reach equal results¹¹ and were able to eat tougher food¹².

The predictability of the osseointegration of the dental implants is closely related to adequate surgery and prosthetic handling.¹³ The long term success of the dental implant begins with proper implant planning and ideal implant placement surgery.¹⁴

Correct implant placement has obvious advantages, such as favorable prosthetic and esthetic outcomes, long-term stability of peri-implant hard and soft tissues as a result of proper oral hygiene and the potential to provide optimal occlusion and implant loading.^{15,16}

Implant placement in edentulous mandible

The totally edentulous mandible can be restored either by removable overdenture or a fixed prosthesis.¹⁷

Implant Supported Removable Overdenture

In the edentulous mandible, the greatest available height of bone is located between the mental foraminae in the anterior mandible. This region also has the optimal bone density for implant support. Therefore, implant overdenture treatment options are designed for placement in the anterior region.¹⁷

The available bone in the anterior region is divided into five equal columns of bone between the two foraminae, serving as potential implant sites and labeled A, B, C, D and E starting from the patient's right side. The treatment options can start from placing two implants in the B and D positions till the placing of five implants in the all implant labelled sites.^{17,18}

Deciding the most appropriate number for the dental implants depends on many factors such as the status of the opposing maxillary arch whether its fully edentulous or fully dentate, dental implants width and length, presence of high muscle attachments, the size and the shape of the mandibular ridge, need of improved retention, patient's biting forces and the financial status of the patient.¹⁷⁻¹⁹

Mandibular fixed prosthesis

Treatment option one (The Branemark approach) is to place four to six implants between the mental foramina, splinting the implants together and with bilateral distal cantilever.²⁰

Treatment option two is to place additional two implants above the mental foramina, which will lead to increasing the number of the implants up to seven thus increasing the total implant surface area, increasing the A-P spread thus decreasing the lever forces on the distal cantilever, and decreasing the length of the distal cantilever.¹⁷

Treatment option three is placing four to five implants between the mental foramina and connect them to additional implants in the first molar or second premolar positions or both. In this approach, only unilateral cantilever is present with increasing the A-P spread 1.5 to 2 times greater than treatment option one and two.¹⁷

Treatment option four includes placing bilateral posterior implants and not splinting them, therefore the cantilever is eliminated. This option used with patients having high forces or/and poor bone density.¹⁷

Treatment option five is depending on fabricating three independent prosthesis rather than one or two. The anterior region of the mandible may have four to five implants, and another two posterior implants for the bilateral posterior regions. This option is used if great mandibular body movement is expected because of parafunction or a small size of body of the mandible. Its disadvantage is using a greater number of implants and the need for greater bone availability for implants placement.¹⁷

Recently in restoring edentulous mandible with minimum bone and immediate loading the All on 4 treatment concept is applied. It's a surgical technique where 4 dental implants are used for the rehabilitation of a completely edentulous jaws. Given that the two posterior implants are placed with a tilt up to 45 degrees -to decrease the cantilever effect and avoid the need for bone augmentation- and two anterior axial implants. They must be well anchored, with primary stability at least 30 Ncm for the immediate loading. With this concept, it's also applicable to do a flapless computer guided surgery with minimal surgical intervention.^{21,22}

Implants placement in edentulous maxilla

Even though the frequency of using dental implants is increasing, some reviews showed that only around 0.3%-11% of edentulous patients are undergoing implant treatment. The reason for this is that usually the maxillary dentures show a higher retention than the mandibular ones, and when the patients start to complain about the maxillary denture retention this would be due to advanced ridge resorption which requires bone augmentation techniques with autogenous bone grafts. This in turn increases the risk for the patient, the patient's morbidity, the cost and the treatment time which all lead to aversion towards implant treatment.²³

Removable overdenture

For the maxillary removable over denture, only two treatment options are available. This is due to the biomechanical disadvantages of the maxilla compared to the mandible, as the bone quality and the force direction are severely compromised. In addition, maxillary attachments are usually closer to the tissues, giving a greater crown height space therefore the prosthesis is more prone to movement. For these reasons independent implants are not used for maxillary overdenture, and the cantilever bars are not recommended.^{17,24}

The first treatment option is using four to six implants for supporting a maxillary prosthesis which is partially supported by the implants and partially by the soft tissues. The key implant positions are three in the anterior region; two at bilateral canines area and one at the central incisor area. and two posteriorly at the first or the second premolar area bilaterally. The implants are always splinted together with a rigid bar following the dental arch form and slightly lingual to the anterior teeth with no distal cantilever.¹⁷

The second treatment option is placing six to ten implants for a total implant supported rigid prosthesis. This treatment option is preferred as it preserves greater bone volume, provides improved confidence and security to the patients and eliminate the need of grafting for compromised width of premaxilla for proper lip support as the fixed prosthesis. The key implant positions are bilateral canines, bilateral distal half of first molar -which usually need sinus lifting-, bilateral premolar site and at least one anterior implant between the canines.¹⁷

Maxillary Fixed Prosthesis

The full mouth rehab of edentulism by means of fixed prosthesis has always been the main target for prosthodontics. The first long term results for the fixed prosthesis were recorded in the 80s.²⁵⁻²⁸

Usually, the maxilla needs more number of implants than the mandible for supporting a fixed prosthesis; this may be due to the lower quality of the bone of the maxilla.²⁹

Six or more implants can be used for the support of a maxillary fixed prosthesis. They can be distributed posteriorly and anteriorly, which often requires alveolus or sinus grafting. With this approach, a high survival rate for the full arch fixed prosthesis was provided.^{30,31}

To reduce surgical cost, invasive surgical procedures and bone grafting, the all on four treatment concept for the maxilla has evolved. Where the implants are placed as the following, two anterior axial implants and two posterior implants tilted up to 45 degrees.^{21,31}

In severely resorbed maxilla, it's always hard to place the posterior implants, the zygoma was found to be a site for the placement of the posterior implants. The zygoma implants are extended length titanium fixtures, placed through the posterior resorbed maxilla transantrally into the zygoma compact bone. Its initial stability is gained from contacting four cortical bones; the crest of the ridge, the maxillary sinus floor, the maxillary sinus roof and the superior border of the zygoma.³²

Another option for the posterior implants in severely resorbed maxilla, is the pterygoid implants. They are placed behind the maxillary sinus. They are inserted in the tuberosity region with an oblique mesiocranial direction proceeding upwards between the wings of the pterygoid process of sphenoid bone. This implants can be placed under local anesthesia, unlike the zygoma implants which require general anesthesia.³³

RADIOGRAPHIC EVALUATION

Successful dental implant treatment requires precise preoperative analysis to evaluate the local anatomical risk factors of a given patient. The use of a proper radiographic imaging is based on the primary clinical examination and the dentist's need for additional anatomical information to plan the implant surgery.

The radiographic examination should provide appropriate information to achieve the following goals: recognize the anatomical characteristics of the alveolar ridge including bone density and volume at potential implant site, detect the orientation of the residual alveolar ridge to evaluate morphological characteristics that jeopardize alignment of the dental implant in respect to the prosthetic treatment plan, identify local pathological or anatomical boundaries within the residual alveolar ridge limiting the implant placement.^{34,35}

Cone Beam Computed Tomography

Computed Tomography (CT) enables a non-destructive three dimensional images of internal structures.^{36,37} It has been applied widely in many fields, biomedical imaging^{38,39}, clinic diagnosis⁴⁰⁻⁴², security inspection^{43,44} and industry non-destructive testing⁴⁵⁻⁴⁷.

It has been developed a lot since its introduction in 1970s. From the early development of the first generation; pencil-beam translate/rotate CT scanner to the 5th generation; electron-beam CT scanner.⁴⁸

CT can be divided into two categories based on the x-ray beam geometry; fan beam and cone beam.⁴⁹

In fan-beam machines, an x-ray source and solid-state detector are mounted on a rotating platform. Data are collected using a narrow fan-shaped x-ray beam passed along the patient. The patient is imaged in slices, usually in axial plane, and the reading of the images is achieved by accumulating the slices to get a multiple 2D images. The used detector element linear array in the fan-shaped machines is usually a multi-detector array. Allowing the machines to acquire up to 64 slices simultaneously, leading to generation of 3D images with decreasing the imaging time and the radiation dose than the single detector.^{49,50}

The Cone-beam CT (CBCT) machines are based on volumetric tomography, with a 2D digital array providing an area detector combined with a 3D x-ray beam. The CBCT technique uses a single 360 Degrees scan where the x-ray source and the reciprocating detector rotates around the stabilized patient's head synchronously producing a series of multiple slices. Then a computer software reconstruct these images to generate a 3D volumetric data to provide a 3D image in 3 orthogonal planes; axial, coronal and sagittal.^{51,52}

There are a lot of advantages for the CBCT over the conventional CT in maxillofacial imaging. It reduces the size of the irradiated area by collimating the x-ray beam to the area of interest thus minimizing the radiation dose, uses isotropic voxel resolution therefore increasing the image accuracy, very rapid scan time as it acquires all basis images in a single rotation, shows a low level of metal artifacts especially in secondary reconstruction of jaws and teeth.^{49,53}