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Evaluation Of Computer Guided Zygomatic Implant Placement Stability Using Customized Drill Guides In Severely Atrophic Maxilla (Clinical Case Series Study)

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Abstract:
Background*: Zygomatic implant is a proven modality for treating completely and partially edentulous patients, the reconstruction of missing teeth in the posterior area of the jaw has been always hampered by limited bone availability and insufficient bone quality and may require additional surgical intervention to augment bone levels. The aim of this work was to evaluate the stability of computer-guided zygomatic implant placement associated with customized drill guides.*
Materials and Methods*: This study was carried out on 6 patients, both sexes, with severely atrophic edentulous upper arch (Cawood class IV, V, VI) could not be restored with other type of treatment have at least 8-12 mm vertical bone height in anterior maxilla to allow installation of at least 2 conventional implants are classified as ZAGA 3 patients: (The anterior maxillary wall is very concave), or ZAGA 4 patients: (The maxilla and the alveolar bone show extreme vertical and horizontal atrophy), are motivated for zygomatic implant are medically free patient and lost their was due to caries or trauma.*
Results*: The present study was conducted on 6 patients: 3 males (50%) and 3 females (50%). The mean with a mean age of 48.75 years old. Each patient received two to four zygomatic implants and two conventional implants. Regarding implant stability the minimum was (61), the maximum was (73), while the mean ± standard deviation (67.33 ± 5.32).*
Key Word*:Zygomatic implant, Guided surgery, Computer aided implantology.*

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I. Introduction

The number of edentulous or toothless patients who seek full mouth rehabilitation has increased over the last decades. Traditionally, patients with edentulous maxillae and mandibles are treated with conventional complete denture to restore aesthetics, function and comfort. But the denture wearers always report dissatisfaction due to lack of comfort, insufficient masticatory function and accelerated bone loss[1].

The maxilla is a difficult arch to restore with Osseo integrated dental implant because of its morphology and configuration. Therefore, many different techniques have been described to treat atrophic maxilla. including using tilted implants in the para sinus region, implant in pterygoid apophysis, grafting the maxillary sinus floor, the use of short wide implant and the zygomatic implant[2].

Zygomatic implant is a proven modality for treating completely and partially edentulous patients, the reconstruction of missing teeth in the posterior area of the jaw has been always hampered by limited bone availability and insufficient bone quality and may require additional surgical intervention to augment bone levels[3].

Branemark system has introduced an alternative of utilizing zygomatic implant to overcome these problems by anchoring the implants to bone region free from bone generation and remodeling. The original purpose of zygomatic implant was to rehabilitate patients who had undergone maxillectomy due to tumor resection, trauma or congenital defect. The function of this implant has been expanded for the rehabilitation of patients with edentulous resorbed maxilla[4].

In addition of placement of bilateral zygomatic implants in the molar/premolar regions of the maxilla, the placement of 2 to 4 conventional dental implants in the anterior maxilla allows cross arch bar fabrication and stabilization, which provides mechanical stability and retention for implant supported fixed hybrid prothesis[5].

A minimally invasive surgical procedure has been defined in general surgery as a procedure that is carried out with the smallest damage possible to the patient.

Currently minimally invasive procedures are growing as a standard treatment. Computer-planned, template-guided surgery is one of the new approaches for implant treatment. It includes a combination of computed tomography (CT) high resolution image, 3-dimensional planning software and a computer aided design / computer aided manufacture (CAD_CAM) generating surgical template[6].

The aim of this work was to evaluate the stability of computer-guided zygomatic implant placement associated with customized drill guides.

II. Material And Methods

This study was carried out on 6 patients, both sexes, with severely atrophic edentulous upper arch (Cawood class IV, V, VI) could not be restored with other type of treatment have at least 8-12 mm vertical bone height in anterior maxilla to allow installation of at least 2 conventional implants are classified as ZAGA 3 patients

Study Design:clinical case series study

Study Location: The study was done after approval from the Ethical Committee Cairo University Hospitals, Egypt. An informed written consent was obtained from the patients.

Sample size: 6 patients.

Subjects & selection method: The present study was conducted on 6 patients who had severely atrophic edentulous upper arch, to be treated with 12 zygomatic implants, at least 8-12 mm vertical bone height in anterior maxilla to allow placement of 2 conventional implants, ZAGA 3 or ZAGA 4 patients, both sexes, medically free patient.

Inclusion criteria:

1. Patients who had severely atrophic edentulous upper arch, to be treated with 12 zygomatic implants, at least 8-12 mm vertical bone height in anterior maxilla to allow placement of 2 conventional implants,
2. ZAGA 3 or ZAGA 4 patients.
3. Both sexes.
4. Medically free patient.

Exclusion criteria:

1. Patients with any systemic illness/medications that interfere with the treatment.
2. Radiation therapy to the head and neck region.
3. Bisphosphonates medication.
4. Heavy Smoking.
5. Pregnant and lactating women.
6. Alcohol/ drug addiction.
7. Maxillary sinusitis.

Procedure methodology

Virtual planning and surgical guide fabrication

After accepting the virtual implant position, the virtual guide was designed with blue sky plan software and the guide was fabricated. The virtual implant file was sent to the additive manufacturing machine for guide fabrication and 3D printing. A reduction guide was designed and fabricated to aid in excess bone removal and plateauing of the jaw before surgery if needed, a mid-face was 3D printed and zygomatic implant surgical guide was seated on it for zygomatic implant surgery simulation with the respect to all vital structures.

Identify implant trajectory and starting point for drilling

Zygomatic implant was performed using three sequential drills (2.8mm twist drill, 3.2mm twist dill, 3.6mm twist drill), Every drill has a specially designed “customized drill guides” that was slightly larger than drill diameter. E.g. (the inner diameter of the customized drill guide was 3mm for the 2.8mm drill, the inner diameter of the customized drill guide was 3.25mm for the 3.20mm drill and the inner diameter of the customized drill guide was 3.65mm for the 3.60mm drill).Each twist drill with length 60mm was covered by 3 customized drills guide each one of them with total length 15 mm and having two fixation screws and with outer surface diameter 4.95mm to pass through surgical guide sleeves with inner diameter 5.00mm.

A 2.8 mm twist drill covered by 3 customized drills guide that passes first through the sleeve in surgical guide and perforate the alveolar bone, maxillary sinus (if the intrasinus cavity was considered in the plan) to reach the inferior surface of the zygomatic process and make sure that it makes a penetrating point for the following drills guided by the stent followed by the zygomatic drill 3.2 mm twist drill covered by 3 customized drills guide that was used for drill through the same path to the zygomatic process guided by the stent and proceeded through the inferior border to reach zygomatic process superior border to achieve bicortical stabilization of the zygomatic implant and to make sure of the final confirmation of the zygomatic path through

zygomatic process, 3.6 mm twist drill covered by 3 customized drills guide was used as a final drill to reach proper diameter bed for the zygomatic implant drilling through the same path of past drills especially in dense bone.

After the final drilling and surgical guide removal the length of the desired implant was measured by using zygoma depth indicator which was mostly the same as previously selected length in the plan. The implants were carried out by one of the following methods: JDtorque dynamometric key or the surgical engine or the surgical driver.

Evaluation of primary stability

Primary stability is a static and purely mechanical parameter, which is determined at the time of implant placement and is associated with resistance or friction between the bone and the implant upon insertion, after implant placement, we recorded the implant stability quotient (ISQ) values using the OSSTELL® system. The ISQ was measured at 4 sites to simulate the mesial, distal, vestibular/buccal and palatal/lingual positions. A Smartpeg was mounted onto the implant using its driver and with maintain a distance of approximately 1- 3 mm, angle of 90 degrees, and 3 mm above the soft tissue and screwed into place with a torque wrench and a screwdriver using 68 Ncm of force, as recommended by the manufacturer.

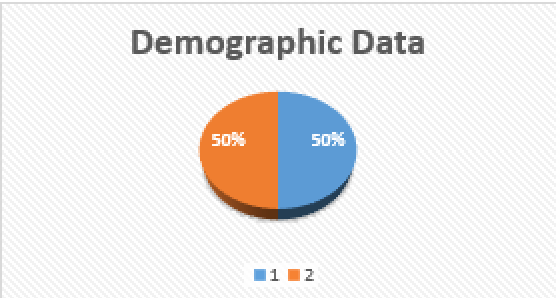
Statistical analysis

Statistical analysis was done by SPSS v20. Quantitative variables were presented as minimum, maximum, means and standard deviation (SD) values and were compared by Shapiro Wilk and Kolmogorov Normality test. A two tailed P value < 0.05 was considered significant.

III. Result

The present study was conducted on 6 patients: 3 males (50%) and 3 females (50%). The mean with a mean age of 48.75 years old. Each patient received two to four zygomatic implants and two conventional implants. Figure 1

Figure 1: Demographic data



Zygomatic implant dimensions are shown in table 1

Table 1: Zygomatic implant dimensions

Implant number	Implant size (mm)	
	Diameter	Length
1	4.3	40
2	4.3	47.5
3	4.3	37.5
4	4.3	60
5	4.3	57.5
6	4.3	45
7	4.3	50
8	4.3	60
9	4.3	52.5
10	4.3	55
11	4.3	57.5
12	4.3	47.5

That data originated from normal distribution (parametric data) resembling normal Bell curve in all groups. Table 2

Table 2: Normality exploration of all groups:

	P value	Indication
M-D angle degrees	>0.05	Normal data
B-L angle degrees	>0.05	Normal data
Coronal Linear deviation mm.	>0.05	Normal data
Apical Linear deviation mm.	>0.05	Normal data
Vertical deviation	>0.05	Normal data

*P value is significant P<0.05 (non-parametric data) Ns: non-significant p value P>0.05 (normal data)

Regarding implant stability the minimum was (61), the maximum was (73), while the mean ± standard deviation was (67.33 ± 5.32). table 3, figure 2

Table 3: Minimum, maximum, mean and standard deviation of implant stability:

	Implant stability
Minimum	61.00
Maximum	73.00
Mean	67.33
Std. Deviation	5.32

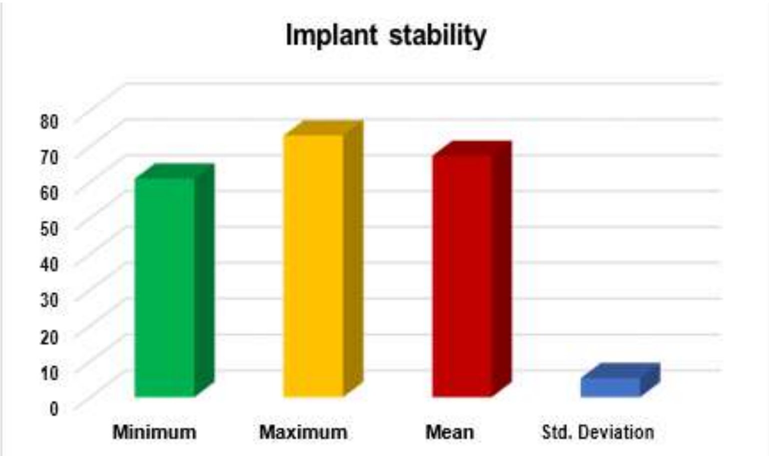


Figure 2: Bar chart representing minimum, maximum, mean and standard deviation of implant stability.

IV. Discussion

Because of the anatomical conditions, the curve of the lateral wall of the sinus and of the posterior wall of the zygoma can have a sinusoid shape, making the insertion of the fixture difficult. For these reasons, a 3D reconstruction of the maxilla and the zygoma and a preplanned positioning of the implants are required to achieve a reliable treatment outcome. From a radiological point of view, 3D CT is the primary preoperative examination for indications that benefit from treatment by zygomatic fixtures [7].

In this study, an innovative system used for accurate placement of zygomatic implant a customized drill guides fabricated for each drill and well fitted with inner surface of guided sleeves placed in entry area of printed surgical guide, each implant was carefully planned, starting from a virtual plan, based on a 3-D CT-scan, using a specific software (bluesky bio)

The success of a guided procedure mostly depends on the precise position of the guide on the hard or soft tissues. Particularly, in cases of severe atrophic maxilla, it might be quite difficult to maintain the stability of the surgical guide throughout the whole drilling procedure [8].

A surgical guide for the placement of zygomatic implants fabricated in the same manner as conventional dental implants is considered less reliable, as these implants are significantly longer (35–60 mm) compared to conventional dental implants. Due to this fact, a slight error in the drill path direction and in the angular deviation can significantly alter the trajectory, the positions of the apex and the divergence at the exit point. In the event of deviations in zygomatic implant placement, the consequences can be much more serious than the complications of conventional implantology [9, 10].

The guided templates for conventional implants, even the most advanced, provide occlusal sleeves to guide burs during osteotomy. The length of the above- mentioned sleeves usually ranges from 4 to 6 mm and they are suitable for implants within 15 mm. Besides, a 35 mm to 60 mm zygomatic sleeve would be exposed to the consistent risk that the bur may get stuck and may reduce handling. This is why in our study we used 3 sleeves with 15mm length inside the guide.

According to this study it was found that coronal linear deviation minimum 1.3˚ and maximum 3.3˚, while mean standard deviation was (2.18˚ ± 0.69˚) was more accurate compared with Daniel Van et al study on cadaver for measuring (Accuracy of drilling guides for transfer from three-dimensional CT-based planning to placement of zygoma implants) found coronal linear deviation minimum 3.1˚ and maximum 6.9˚ These angular differences resulted in a measurable deviation of the implant position in the horizontal and/or vertical direction, while according to Naitoh et al. [11] found angular deviations between planning and placement ranging from 0.5˚ to 14.5˚ with an average of 5.0˚. The guides used in such a study were teeth-supported. In comparison to Vrielinck et al [12] study (Image-based planning and clinical validation of zygoma and pterygoid implant placement in patients with severe bone atrophy using customized drill guides. Preliminary results from a prospective clinical follow-up study) found that implant apical deviation was 7.77 mm (range: 1.1 to 16.1). the average angle deviation between the planned and the actual implant was 10.18˚ (range: 1.7˚ to 18.0˚). while in our study it was found that apical standard angle deviation was (2.57˚ ± 1.17˚), with maximum angle deviation 4.50 ˚ and minimum angle deviation 1.20˚, distance between planned and actual implant was 3.7mm (range: 1.6 to 10.4) mm.

From experience gained in this study, deviation between the planned and post-operative position of zygomatic implant could be attributed to more than one factor: The multiple steps including hardware, software, and surgery procedure which affected the accuracy. The shift of long zygomatic drill within the customized sleeves during drilling with difficulty in manipulation and working under stress because of posterior location of point of entry at premolar molar area especially with patient with limited mouth opening or patients who have teeth in the lower jaw. Minute deviation between the drill and the customized sleeves with the long drills used for zygomatic implants, this small deviation in the coronal area due to easy insertion of the drill in the guide sleeves which may be reflected with relatively larger deviation in the apex. The nature of the zygomatic bone (compact bone and its shape) leads to the slippage of the initial drill at the zygomatic surface.

V. Conclusion

The reconstruction of the atrophic maxilla using 2 zygomatic implants in conjunction with 2 conventional implants under the guidance of virtual computer planning allowed for precise, safe, graft-free, minimally invasive surgery and high patient satisfaction.

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