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

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DEVIATION BETWEEN PLANNED AND ACTUAL IMPLANT POSITIONS INSERTED USING MUCOSA-SUPPORTED STEREOLITHOGRAPHIC SURGICAL GUIDE IN EDENTULOUS MANDIBLE AND MAXILLA

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ABSTRACT

Purpose: estimate the deviation between the planned and the actual implant inserted using a mucosa-supported stereolithographic surgical guide in different edentulous arches and determine the effect of the arch (mandible or maxilla) on accuracy.

Materials and Methods: 16 implants were placed in completely edentulous arches and divided into two groups. **Group (A):** Eight implants were placed in four patients in the mandible using completely limiting mucosa-supported stereolithographic (SLA) surgical guide during implant insertion. Two implants were placed in each patient intraforamina. **Group (B):** Eight implants were placed in Two patients in the maxilla using completely limiting mucosa-supported stereolithographic (SLA) surgical guide during implant insertion. Four implants were placed in each patient in the anterior maxilla. Then the deviation between the planned and the actual implant positions was calculated.

Results: For the maxilla, the mean angular deviation 3.2mm with standard deviation ±0.384, the mean coronal deviation 1.88mm with standard deviation ±0.37 and the mean apical deviation 1.712 with standard deviation ±0.24. For the mandible, the mean angular deviation 3.197mm with standard deviation ±0.578, the mean coronal deviation 1.56mm with standard deviation ±0.38 and the mean apical deviation 1.509 with standard deviation ±0.173.

Conclusion: insignificant difference in the deviation between the planned and the actual implant positions between the mandible and the maxilla placed by stereolithographic surgical guide.

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.

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Nowadays, the computer guided implant placement can be either by dynamic navigation system or static surgical guides. Dynamic navigation systems, which allow intraoperative bur tracking according to the preoperative planning.[1] The static surgical guide can be manufactured by Stereolithographic technique; it's 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. Also, 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 position in the maxilla and the mandible must be taken in consideration. And the values of the deviations must be paid attention to, to consider if the deviations occurring won't harm the surrounding anatomical structures, or care must be considered, and a safe margin should be taken while planning the implant sites to avoid damaging the anatomical structures.

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

MATERIALS AND METHODS

16 implants were placed in completely edentulous arches. From the outpatient clinic of the Faculty of Dentistry Ain Shams University.

The implants were divided into 2 groups; Group A where implants placed in the mandible and Group B where implants placed in the maxilla. Each group consisted of 8 implants.

Patients were medically free from any systemic diseases or neurologic disorders that may affect bone metabolism, complicate surgical procedures or delay the post-operative healing. Their age ranged from 55-65 years, with good oral hygiene. Patients were exhibiting Angle class I maxillo-mandibular relationship and sufficient inter-arch spaces, the residual alveolar ridge was covered by firm healthy mucosa and free from any inflammation signs and history of edentulism at the area of implant placement is more than 6 months.

Conventional methods were used for fabrication of the complete denture. Then a double scan protocol was followed for mucosa-supported stereolithographic surgical guide construction.

Gutta Percha markers were inserted on several random positions and in different axial planes on the polished surface of the denture, then a CBCT was made to the patient while wearing the denture. Then another scan was made for the denture only. Figure (1)

Fig. (1) Denture scanning with Gutta Percha.

The OnDemand3D computer software was used to select the implant sites according to the optimum site anatomically and functionally, for the maxilla, the implants are placed in the anterior maxilla. While for the mandible they are placed intra-foraminae, also the location of the three anchor pins were selected to be at three widely separated positions to be used for fixation of the guide.

Once the planning was done, the OnDemand3D software created the guide from the scanned denture design and was saved as ".stl" file (Standard triangular language) to be sent to the Envisiontec stereolithographic digital dental 3D printing machine to fabricate a clear surgical guide* with metal sleeves inserted to guide the implant drilling in the desired implant sites.

The upper and the lower denture were inserted at the patient's mouth then a wax bite was taken at the centric relation of the patient to be used as surgical index for proper guide seating. The surgical guide was seated using the opposing denture and the wax bite as index. Vertical pressure was applied in the centric position to seat the guide accurately for the anchor pin insertion.

After the surgical guide was accurately positioned with good stability, the opposing denture and the wax bite were removed. Figure (2)

The gingival tissue under the sleeve is removed with a tissue punch found in the surgical kit.

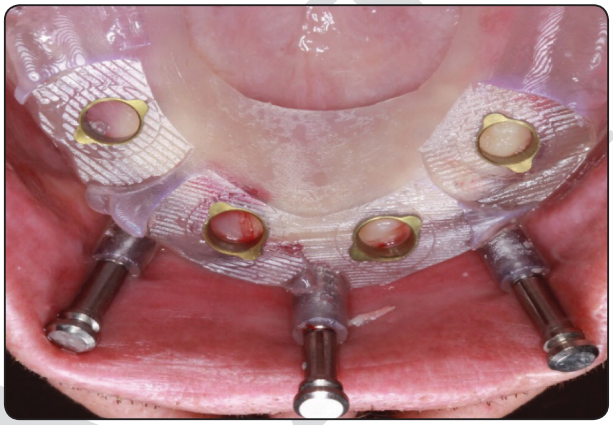

Fig. (2): Surgical guide in place.

The pilot drill was inserted through a drill key with a 2mm opening, followed by the next drill while changing the drill key according to the corresponding diameter of the drill in this order 2.5, 2.8 for the mandible and 2.5, 2.8, 3, 3.3 for the maxilla until the whole osteotomy was done. The surgical guide was removed then the implant was inserted free hand with a torque not more than 40 N. After the complete insertion of the implant it was covered by the healing abutment.

CBCT was taken following implant insertion to compare between the virtual implant location during the planning and the post insertion implant location in the patients' mouth.

For calculation of the deviation between the planned (virtual) implant and the placed (actual) implant, the preoperative CBCT with the planned implant sites and the post-operative CBCT were aligned together for the automatic superimposition

* E-Shell 600, Envisiontec GMBH, Germany.

by the fusion module in the OnDemand3D software until finding the best overlap of the two images, then the comparison was done automatically by the software Fig (3).

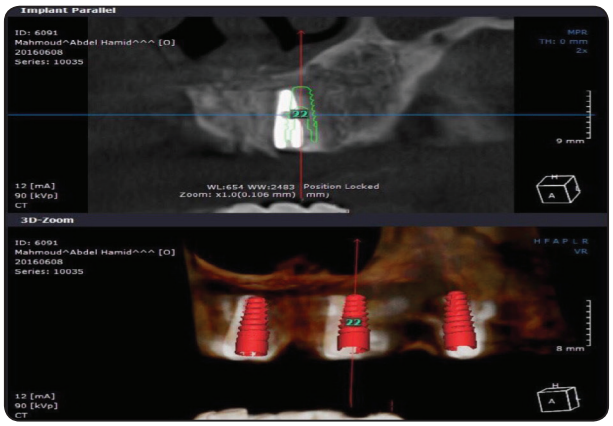

Figure (3): Postoperative and Preoperative planning implant overlap. White implant is the actual implant position after insertion, while the red implant is the planned implant position

The difference between the planned and the actual implants in three-dimensional view was calculated and is called the total sum of the coronal and apical differences. In addition, the angular deviation which is the three-dimensional angle between the long axis of the planned and the actual implant was calculated, tabulated and statistically analyzed. Figure (3)

RESULTS

Concerning the angular, coronal and apical deviation, it was found that the maxilla was a little higher than the mandible.

However, by using the independent student t-test, it showed statistically insignificance difference between the mandible and the maxilla.

TABLE (I): Mean, Standard deviation, and P value of Independent Student t-test for the comparison between angular deviation in maxilla and mandible

Group	Mean	±SD	Median	Min.	Max.	95% CI		*P*-value
						Lower bound	Upper bound	
Maxilla	3.2	0.384	3.17	2.7	3.8	2.845	3.555	0.97
Mandible	3.197	0.578	3.19	2.34	3.97	2.714	3.680	

Significant at P ≤ 0.05

TABLE (II): Mean, Standard deviation, and P value of Independent Student t-test for the comparison between coronal deviation in maxilla and mandible.

Group	Mean	±SD	Median	Min.	Max.	95% CI		*P*-value
						Lower bound	Upper bound	
Maxilla	1.88	0.37	1.66	1.51	2.33	1.541	2.225	0.12
Mandible	1.56	0.38	1.5	1.15	2.1	1.245	1.875	

Significant at P ≤ 0.05

TABLE (III): Mean, Standard deviation, and P value of Independent Student t-test for the comparison between apical deviation in maxilla and mandible.

Group	Mean	±SD	Median	Min.	Max.	95% CI		*P*-value
						Lower bound	Upper bound	
Maxilla	1.712	0.24	1.8	1.4	1.9	1.49	1.94	0.082
Mandible	1.509	0.173	1.5	1.24	1.77	1.36	1.65	

Significant at P ≤ 0.05

DISCUSSION

The purpose of this study was to evaluate the influence of the arch type on the accuracy of the implant placement using mucosa supported stereolithographic surgical guide in completely edentulous patients.

A few studies have reported the difference in deviation between the mandible and the maxilla. One study reported that the deviation in the mandible was larger than that of the maxilla due to the smaller surface area of the mandible which will affect the support and the stability of the guide.[3]

Ozan et al[4] found that there's a significant difference between the maxilla and the mandible in the angular deviation and the linear deviation at the neck, but this may be due to the lack of using direct attachment between the guide and the jaw bone. Where other studies reported that there was no significant differences between the maxilla and the mandible in the angular and the linear deviations.[5,6]

From this study, data revealed that during implant placement whether in the mandible or maxilla, there was no significant difference in the accuracy between using maxillary mucosa supported SLA guide and the mandible Mucosa supported SLA guide regarding the angular and the linear deviations. This goes with the studies of Arisan et al and Pettersson et al.[5,6]

Regarding the Angular Deviation that was found during implant placement in the maxilla using Maxillary mucosa supported SLA guide was 3.2±0.384 degrees while in the mandible using mandibular mucosa supported SLA guide was 3.197±0.578 degrees. D'haese et al[7] found that the angular deviation in the maxilla was 2.6±1.6 degrees while Sun et al[8] found 2.73±1.17 degrees in the maxilla while the angular deviation in the mandible was 4.05 ± 3.07 degrees. Ozan et al[9] found that the angular deviation in the maxilla was 3.91± 1.2 degrees, while in the mandible was 3.55±1.08 degrees.

Regarding the coronal deviation, it was found that the accuracy of the implant placement in the maxilla was 1.88±0.37mm in the maxilla and in the mandible was 1.56±0.38mm. Cassetta et al[3] found 1.68±0.51mm in the maxilla and 1.64±0.71mm in the mandible. D'haese et al[7] found 0.91±0.44mm in the maxilla. Ozan et al[4] found a mean coronal deviation of 0.95±0.5 mm in the maxilla and 1.28±0.9 for the mandible.

Regarding Apical deviation, it was found that the accuracy of implant placement in the maxilla was 1.712±0.24mm while in the mandible was 1.509±0.173mm. Cassetta et al[3] found the apical deviation in the maxilla was 2.12±0.78mm in maxilla, while in the mandible was 2.25±0.88mm. D'haese et al[7] found 1.13±0.52mm in the maxilla.

Ozan et al[4] found a mean apical deviation of 1.41±1 mm for the maxilla and 1.4±0.9 for the mandible.

From this study, there was no significant difference in deviation between the maxilla and the mandible in the angular and linear measurements despite the anatomical differences between the two.

This insignificance was attributed to the accurate fit of the guide to the edentulous jaws and the residual bone and biting on an occlusal index during seating of the guide to ensure seating in its optimum position.

The little increase in the deviation of the maxilla than in the mandible which is insignificant maybe attributed to the removal of the surgical guide and placement of the implant by free hand. Which may result in more deviation in the maxilla due to the lower bone density, in addition to the implant type which is self-threading implant.

There are many factors that can affect the accuracy of any surgical guides to transfer it correctly as planned such as the amount of the available bone, bone density, mucosal thickness, non-ideal radiographic stent, acrylic resin shrinkage, patient movement and improper orientation of the jaws during radiographic scanning, the osteotomy drills are not well adapted to their keys and the fixation tubes are smaller than the fixation screws. So, despite the safety of using 3D guidance system, there would be 3D deviation that would occur during implant placement, so consider putting a 2mm safety zone so decreasing the expected deviation from the original plan which affects the surgical and the prosthetic outcome.[10,11]

CONCLUSION

No statistically significant difference between the amount of deviation from the planned and the actual implant positions placed by stereolithographic surgical guide either in the mandible or the maxilla.

Using stereolithographic surgical guide in the edentulous mandible and maxilla is very important specially in the areas near the anatomical boundaries as it decreases the amount of deviation between the planned and the actual implant positions to less than 2mm in all directions.

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