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Original Research

Evaluation Of Efficacy Of Thermoplastic Versus 3D Printed Surgical Guides For Implant Placement- An Original Research

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ABSTRACT:
Aim: The purpose of this study was to evaluate the accuracy of placed implants using two different guided implant surgery materials: thermoplastic vs. 3-D printed surgical guides. **Methodology:** Twenty duplicate mandibular models, ten thermoplastic and ten 3-D printed surgical guides were used. Twenty implants were placed following the guided surgery protocol. Cone beam computed tomography scans of placed implants and the control implant were superimposed to measure deviations. **Results:** The thermoplastic group showed average deviations of 3.4 degrees, 1.3mm at the head, and 1.6mm at the apex of the implant compared to 2.36 degrees, 0.51mm, and 0.76mm for the 3-D printed group; $p = 0.143$, $p < 0.001$, and $p < 0.001$ respectively. **Conclusion:** There is a significant difference in the accuracy of the location of the implant head and apex between thermoplastic and 3-D printed surgical guides.
Keywords: Implant, surgical guide, thermoplastic, CBCT.

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INTRODUCTION

Recent studies on the clinical success of dental implants have indicated a high implant survival rate.[1] Nevertheless, the inadvertent association of most surgical and prosthetic complications with improper diagnosis and implant placement has also been documented.[2] These factors play a crucial role in the long-term predictability and success of implant prosthetics. Surgical guide templates not only assist in diagnosis and treatment planning but also facilitate proper positioning and angulation of the implants in the bone.[3] Moreover, restoration driven implant placement accomplished with a surgical guide template can decrease clinical and laboratory complications.[4] Hence, increasing demand for dental implants has resulted in the development of newer and advanced techniques for the fabrication of these templates. Surgical guide template fabrication involves a diagnostic tooth arrangement through one of the following ways: (1) a diagnostic waxing, (2) a trial denture teeth arrangement, or (3) the duplication of a pre-existing dentition/restoration.[5]Three-dimensional (3-D) planning of the implant location allows for manipulation of individual implant positions with regard to depth, mesio-distal angulation and positioning, and labio-lingual angulation and positioning.[6] It also encourages interdisciplinary communication between restorative dentists and surgeons allowing for multiple variations of treatment plans to be evaluated and critiqued until the optimal treatment plan is attained and implemented for superior esthetic results.[7-9] The evolution of 3-D implant planning has also had an effect on the surgical placement. The steps required for execution of the 3-D plan surgically is indicated as the most complicated step in the process of guided implant surgery.[10] 3-D planning and computer-aided design/computer-assisted manufacture technology (CAD/CAM) has made it possible to transfer these virtually planned implants to the surgical site with fabrication of surgical guides.[11] CBCT scans are accurate and cost effective to achieve the desired clinical outcome; however it is important to understand the limitations of such procedures.In a recent study surgically placed implants with different types of guides were evaluated for location of the implant head and apex, angle of implant, and depth in comparison to the 3-D plan. A simulated clinical scenario using epoxy edentulous mandibles measured the divergence between planned implants and actual location of surgically placed implants comparing two different surgical guides, the CAD/CAM stereolithographic surgical fabricated guide and a conventionally produced guide from a scannographic template. In the scannographic template group the difference between the planned and placed implant head was an average of 1.5mm, 2.1mm at the apex, with an angular deviation of 8 degrees. In the stereolithographic guide group the difference between the location of the planned and placed implant was an average of 0.9mm at the head and 1.0mm at the apex with an angular deviation of 4.5 degrees.[12] The accuracy of the position of the metal guide sleeves of two different guided implant surgery materials, 3-D printed surgical guides and thermoplastic guides, was compared using 3-D printed jaws. The vertical deviation for the 3-D printed guide was 0.35mm with an angular deviation of 0.81 degrees, while the thermoplastic guide had an average of 0.22mm vertical deviation and 1.46 degrees of angular deviation.[13]

AIM OF THE PRESENT STUDY

The aim of this study is to evaluate the accuracy of 20 implants placed with the two different surgical guides: thermoplastic surgical guides versus 3-D printed surgical guides. The null hypotheses are that there is no difference in angular deviation, deviation at the head, or deviation at the apex of implants placed using two different surgical guides, thermoplastic vs. 3-D printed.

METHODOLOGY

Twenty implants with a diameter of 4.3mm and length of8.0mmwere placed, one into each mandibular model utilizing 10 of each type of guide according to the manufacturer recommendation. A CBCT scan, utilizing one scanner was then acquired of each printed jaw model with the placed implant and the control implant. The scan setting was a field of view of 6 cm x 6 cm, 75µm voxel size, 110 kVp output, 0.55mA, 2.99mAs, and 5.4s managed by capture optimum dose algorithms in the machine. A total of 21 scans were obtained and the same setting was used for all of the scans. The data was saved as digital imaging and communications in medicine (DICOM) file volumes, and loaded into the DICOM viewer software (Invivo5, Anatomage; San Jose, CA). The superimposition function in the software was then utilized to important the DICOM file volumes of a test implant and manual manipulation was completed to approximate the scans into the superimposition position. Once the images were digitally fused together and saved with the corresponding files, the maximum mutual information (MMI) was used to determine the deviation at the head of the implant, the deviation at the apex of the implant, and the angular deviation with parallel lines through the center of the implants in the software.The Mann-Whitney u test was used to test the null hypotheses at an alpha level of 0.05 and confidence interval of 95%. Descriptive statistics were used for the average ± standard deviation.

RESULTS

The angular deviation, deviation at the head of the implant, and deviation at the apex of the implant were measured for each of the 10 implants placed utilizing the 10 thermoplastic surgical guides and each of the 10 implants placed utilizing the ten 3-D printed surgical guides compared to the control implant. The results show that implants placed with the thermoplastic guides had a range of angular deviation of 1.25 – 5.31 degrees with an average of 3.40 ± 1.23degreeswhile the implants placed with the 3-D printed surgical guide had a range of angular deviation of 0.49 – 4.40 degrees with an average of 2.36 ± 1.38 degrees. The angular deviation of implants placed with the thermoplastic guides is not statistically different from the implants placed with the 3-D printed surgical guide, at $p = 0.143$.Implants placed with the thermoplastic guides had a deviation of 0.71 – 1.72mm with an average of 1.33 ± 0.30mm and implants placed with the 3-D printed surgical guide had a range of deviation of 0.18 – 0.95mm with an average of 0.51 ± 0.24mm at the head of the implant. The deviation at the head of implants placed with the two different surgical guides is statistically significantly different, at $p < 0.001$.The results show that implants placed with the thermoplastic guides had a deviation of 1.06 – 2.07mm with an average of 1.60 ± 0.29mm at the apex of the implant and implants placed with the 3-D printed surgical guide had a range of deviation of 0.24 – 1.29mmwith an average of 0.76 ± 0.36mm. The deviation at the apex of implants placed with two different surgical guide materials is statistically significantly different, at *p*< 0.001. (Table 1)

Table 1- Measurements of deviations

Surgical guide	Angular deviation (degrees)	Deviation at head (mm)	Deviation at apex (mm)
T-1	2.75	0.71	1.06
T-2	2.75	1.64	1.74
T-3	4.71	1.43	1.76
T-4	3.10	1.42	1.64
T-5	3.49	1.13	1.47
T-6	2.43	1.39	1.52
T-7	3.50	1.59	1.75
T-8	4.74	1.72	2.07
T-9	1.25	1.22	1.23
T-10	5.31	1.09	1.71
Standard deviation	**1.23**	**0.30**	**0.29**
3D-1	3.29	0.61	0.93
3D-2	0.49	0.18	0.24
3D-3	3.70	0.51	0.99
3D-4	1.41	0.27	0.41
3D-5	1.58	0.50	0.66
3D-6	4.40	0.95	1.29
3D-7	2.04	0.33	0.57
3D-8	1.63	0.62	0.85
3D-9	4.06	0.78	1.24
3D-10	1.00	0.34	0.42
Standard deviation	**1.38**	**0.24**	**0.36**
P-value	**0.143**	**<0.001**	**<0.001**

DISCUSSION

Several studies measured the accuracy of each 3D printing technology, concerning the capability to reconstruct the virtual 3D models into the exact physical surgical guides. In the dental field, the common measurement to evaluate the accuracy includes the deviation of angle, entry point, and apex, which are influenced by layer thickness, material quality, cast orientation, 3D model shape, and software and hardware capabilities. Although the effect of each printing factor currently remains unclear, especially in dentistry, many of them can be controlled by the user to ensure the finest quality of a printed model. [14-17]The results of this study accept the null hypothesis that there is no difference in the accuracy of implant angulations when using a thermoplastic surgical guide or 3-D printed surgical guide. The results also reject the null hypotheses; there is a significant difference in the accuracy of the implant head and implant apex when using thermoplastic surgical guides and 3-D printed surgical guides. The measurements of deviations found in this study are consistent with published data from other studies with regards to stereolithographic surgical guides. Previous studies showed 1.72-4.50 degrees of angular deviation, 0.27- 0.90mm deviation at the implant head, and 0.37-1.30mm deviation at the implant apex.[13-17]The second distinctive feature between the thermoplastic surgical guides and the 3-D printed surgical guides was their handling properties during actual implant placement into the models. The surgical drill kit from the manufacturer has a ledge on the drill that acts as a depth stop when it comes into contact with the metal guide sleeve. On several occasions the metal guide sleeve could be detected both visually and tactilely moving in the apical direction while placing implants employing thermoplastic surgical guides. The inherent characteristic of the thermoplastic guides being less rigid may result in more error of the location of the implant head and apex compared to the planned implant than those placed with the 3-D printed surgical guide.More studies should be performed to compare and evaluate the accuracy of implants placed using different guided surgical materials. These studies should include surgical guides for partially edentulous areas requiring multiple implant placements, as well as, fully edentulous cases.

CONCLUSION

Within the limits of this study, it is concluded that there is no significant difference in the angular deviation of implants using a thermoplastic surgical guide versus 3-D printed surgical guide following the manufacturer surgical guide protocol. However, it can also be concluded that the locations of the head of the implant and apex of the implants placed utilizing a thermoplastic surgical guide are less accurate than those of implants placed using a 3-D printed surgical guide.

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