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Original Article

The Effect of Distribution of Teeth Support on the Accuracy of Implant Surgical Guide In Distal Extension Cases (In-vitro study)

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Abstract

Aim: The aim of this study was to compare the accuracy of implant placement when using tooth supported surgical guide with different distributions of support manufactured by DLP (Digital Light Processing) technique.
Subjects and methods: Twenty four replica implants were inserted in twelve partially edentulous maxillary resin casts. implant placement was done using static DLP printed surgical guides. Three designs of surgical guides were designed representing different number and distribution of support (unilateral tooth support), (bilateral tooth support), and (full arch tooth support). After implant placement; accuracy measurements were done using (blue sky bio software) by superimposing the actually placed implants with the virtually planned implants.
The deviations between placed and planned implants were then measured according to the following definitions: The global deviation which was divided into vertical (depth deviation), and lateral deviations according to the longitudinal axis of the planned implants. Moreover, the lateral deviation was further divided into mesio-distal and bucco-lingual deviations and angular deviation.
Results: In the present study the most accurate group was bilateral tooth supported group as bilateral distribution of support was found to offer similar accuracy that achieved by full-arch guides but for unilateral tooth supported group not considered the best support for surgical.
The study also showed the effect of added fixation screw in the edentulous area which directly express the effect of reducing bending of the unsupported part of the surgical guides.
Conclusion: 1-Using bilateral tooth support offer same accuracy of full arch guides. On the other hand using unilateral tooth support not considered to offer the best support for surgical guides compared to similar number of support in free end saddle cases. 2-Regarding single tooth replacement in distal extension cases, using unilateral support resulted in higher significant deviation value which considered the maximum limit of the permitted errors.

Keywords: Surgical guide, CAD\CAM, Implant, Accuracy, 3D printing.

Introduction

The introduction of static guided implant surgery (sGIS) has been valuable to optimize and facilitate the implant planning, and placement. Using three-dimensional planning software a virtual implant planning can be made, and transferred to the

patient via surgical guides in implant surgery. There are many techniques for constructions of surgical guides as milling, steriolithography, 2 and digital light processing. Both three-Dimensional(3D) printing (additive manufacturing), and machine milling (subtractive manufacturing) in manufacturing of surgical guides can be used as difference in accuracy is not statistically significant **(Ahmed, et al 2019)**.
3Dimensional(3D) printing (additive manufacturing) gave better results over machine milling (subtractive manufacturing); however both types can be used in manufacturing of surgical guides as difference in accuracy is not statistically significant. Gjelvold et al have shown that The tested desktop 3D printers were able to produce surgical guides with similar implant positioning deviation records but the DLP printer proved to be more accurate concerning deviations at entry point and vertical implant position. There are many potential factors affecting the accuracy of implant placement by surgical guides such as type of support, number of support, fixation, patient limiting factors, clinician skills, and experience **(Gjelvold, 2019)**.
A distal free end situation could result in insufficient stability of the surgical guide, and could reduce accuracy of the static guided implant surgery (sGIS), so the purpose of this study was to investigate the effect of distribution of teeth support for DLP guide on accuracy of implant placement in distal extension cases.

Subjects and Methods

the cast was placed on the scanning platform then a new file in the Exocad software was created and filled with the required data (the name of the technician, the operator and whether the upper or the lower arch was to be scanned); then the order of scanning was proceeded .The file was checked for any un properly scanned areas that require rescanning. After the process of scanning was accomplished; the file was exported to the Mesh-mixer program. Tooth number (25, 26, and 27) were selected and removed by the eraser tool. Finally the cast was exported as STL file for printing.

The model was imported in (BlueSkyBio software) scanned for designing the surgical guides

JDental implants for teeth (25and27) 3.7mm in diameter, and 11mm in length were chosen, and adjusted mesiodistally, and buccolingually from the top view, and all directions.

Three designs of surgical guides were designed representing different numbers of teeth support unilateral, bilateral, and full arch support. A- The first design is supported by teeth No. 21, 22, 23, and 24. Each guide was used to insert two implants (in teeth position 25, and 27**). (fig2)** B- The second design is supported by teeth No. 24, 23, 22 21, 11, 12, 13, 14, 15, 16, and 17. Each guide was used to insert two implants (in teeth position 25, and 27). **(fig.3)** C- The third design is supported by teeth No. 24, 23, 13, and 17. Each guide was used to insert two implants (in teeth position 25, and 27) **(fig.4)**.

The guides were exported as STL file to be printed. After printing of the guides, they were finished and cured for 15 minutes. The resulted guides were inspected and ill-fitting surgical guides were discarded and replaced **(fig.5)**.

Then with the surgical guides in place on the models; prepared sites received 3.7 × 11.5 mm implants

Implant installation was inserted **(fig.6)**.

After implant placement, the corresponding scan-bodies will be fixed on each implant, and a full-arch extra-oral optical scan is captured using a 3shape TRIOS scanner. The scanned STL file was imported in the BlueSky software. Each postoperative optical scan was superimposed on the preoperative virtual planning using the same anatomical sites on each study model.

Then, using the treatment-evaluation tool in the BlueSky software (Distance measurement, angular measurement), the deviations between the placed, and the planned implants were estimated **(fig.7)**.

The deviations between the placed, and the planned implants were then measured according to the following measurements: The 3D distance of the center of the implant platform/apex between the planned and placed implants was defined as the global deviation at the implant platform/apex, and the 3D angle between the planned and placed implant axis was defined as the angular deviation.

Results

I. Mesiodistal distance:

Comparison between mesiodistal deviations in all groups:

Comparison between all groups revealed statistically significant difference ($P<0.05$) in the mean mesiodistal deviation in group I (unilateral supported guides) as compared to group II (bilateral supported guides). However the difference in the mesiodistal deviation between group II and group III (full arch supported guides) was statistically insignificant. Group III was significantly the lowest, while group I was significantly the highest, as presented in table (1) and (*fig.8*).

II. Buccolingual distance:

Comparison between buccolingual deviations in all groups:

Comparison between all groups revealed statistically significant difference ($P<0.05$) in the mean buccolingual deviation in group I (unilateral supported guides) as compared to group II (bilateral supported guides). However the difference in the buccolingual deviation between group II and group III (full arch supported guides) was statistically insignificant. Group I was significantly the highest, while Group III was significantly the lowest as presented in table (2) and (*fig.9*).

III. Depth:

Comparison between depth deviations in all groups:

Comparison between all groups revealed statistically significant difference ($P<0.05$) in the mean depth deviation in group I (unilateral supported guides) as compared to group II (bilateral supported guides). However the difference in the depth deviation between group II and group III (full arch supported guides) was statistically insignificant. Group I was significantly the highest, while group II was significantly the lowest, as presented in table (3) and (*fig.10*).

IV. Angle:

Comparison between angle deviations in all groups:

Comparison between all groups revealed statistically significant difference ($P<0.05$) in the mean angle deviation in group I (unilateral supported guides) as compared to group II (bilateral supported guides). However the difference in the angle deviation between group II and group III (full arch supported guides) was statistically insignificant. Group I was significantly the highest then group II was significantly the lowest, as presented in table (4) and (*fig.11*).

Fig.1 The cast was eventually scanned for designing the surgical guides.

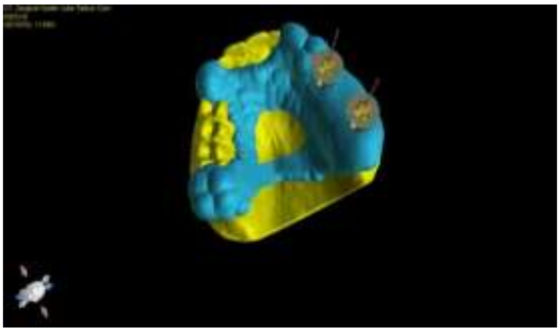

Fig.4- Third design is supported by FDI teeth 24, 23, 13, and 17.

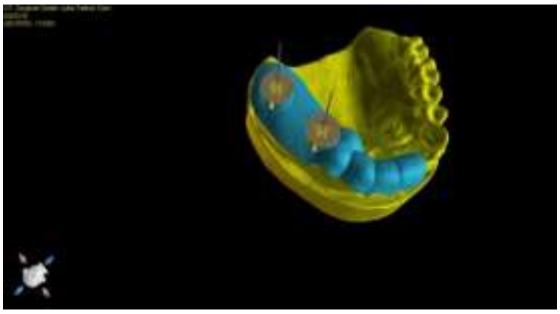

Fig.2- First design is supported by FDI teeth 21, 22, 23, and 24.

Fig.5- Third design is supported by FDI teeth 24, 23, 13, and 17.

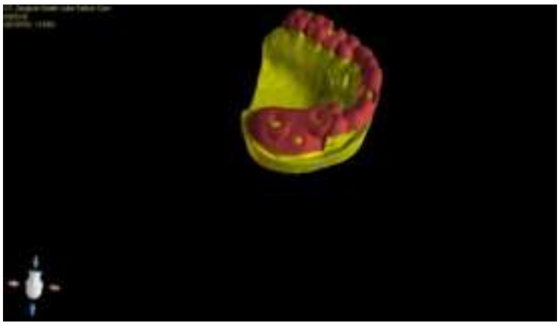

Fig.3- Second design is supported by FDI teeth 24, 23, 22 21,11, 12, 13 ,14, 15, 16, and 17.

Fig.6- Implants inserted in prepared sites.

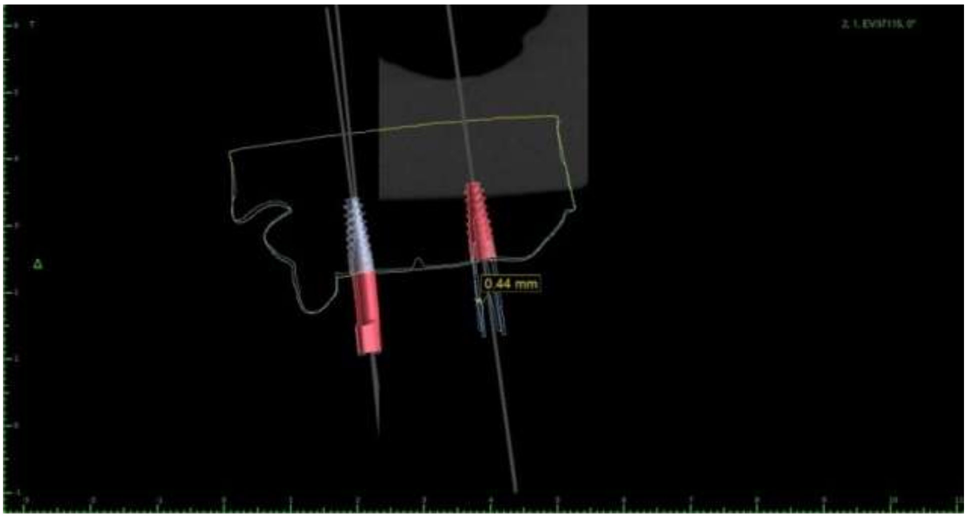

Fig.7- Mesio-distal, and bucco-lingual deviation between the postoperative connected scan body and the preoperative virtual scan body measured by millimeters.

Table (1): comparison between mean and standard deviation of mesiodistal distance in all groups:

Mesiodistal distance			
	Mean	SD	P value
Group I	0.48 a	0.05	<0.0001*
Group II	0.36 b	0.03	
Group III	0.24 c	0.04	

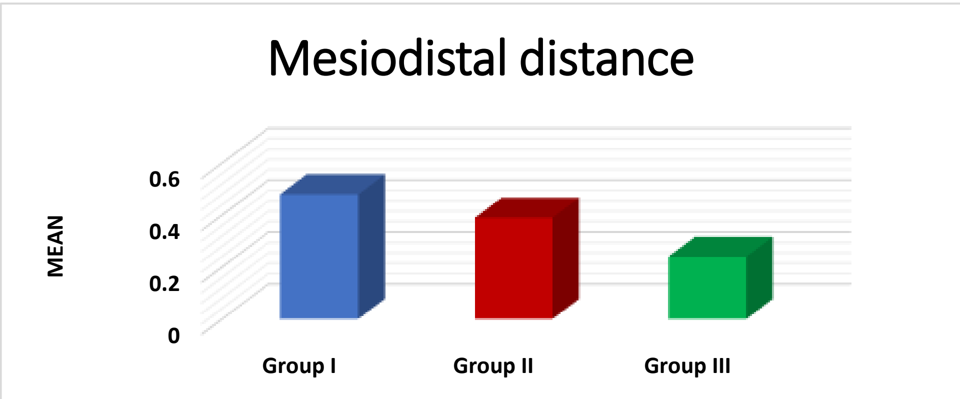

Fig.8 - bar chart showing comparison between mean and standard deviation of mesiodistal distance in all groups.

Table (2): comparison between mean and standard deviation of buccolingual distance in all groups:

Buccolingual distance			
	Mean	SD	P value
Group I	0.39 a	0.04	<0.0001*
Group II	0.31 b	0.03	
Group III	0.21 c	0.05	

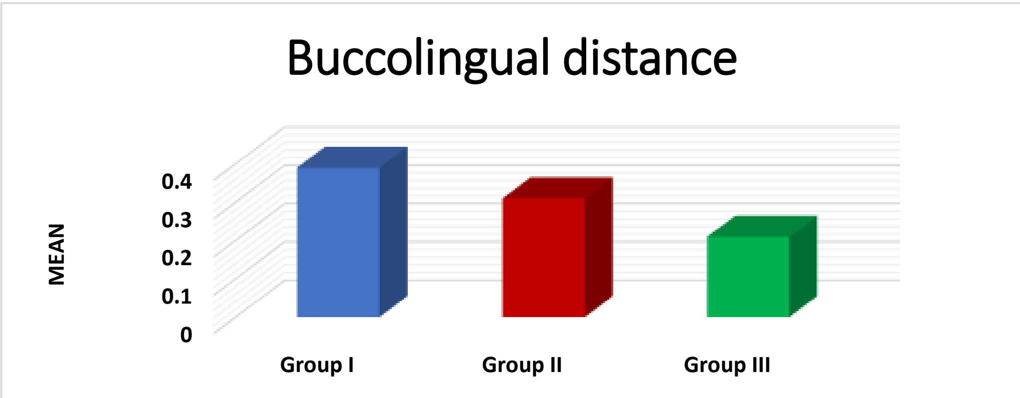

Fig.9 - bar chart showing comparison between mean and standard deviation of buccolingual distance in all groups.

Table (3): comparison between mean and standard deviation of depth in all groups:

Depth			
	Mean	SD	P value
Group I	0.89 a	0.03	<0.0001*
Group II	0.59 b	0.04	
Group III	0.38 c	0.05	

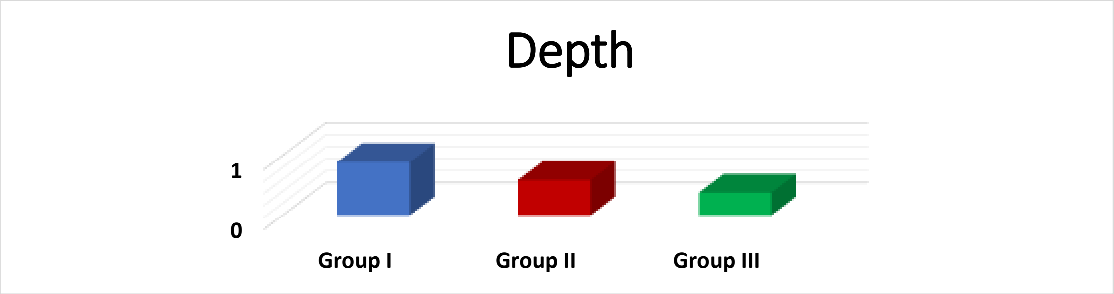

Fig.10 - bar chart showing comparison between mean and standard deviation of depth in all groups.

Table (4): comparison between mean and standard deviation of depth in all groups:

Depth			
	Mean	SD	P value
Group I	3.90 a	0.37	<0.0001*
Group II	2.85 b	0.23	
Group III	2.16 c	0.32	

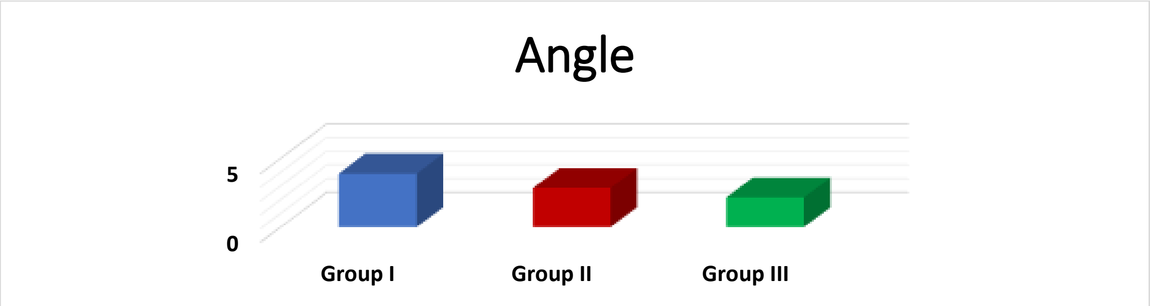

Fig.11- bar chart showing comparison between mean and standard deviation of depth in all groups.

DISCUSSION

Digital light processing (DLP) technique was used for manufacturing the casts and surgical guides. DLP printers were proved to be more accurate concerning deviations at entry point and vertical implant position when compared to SLA printers **(Gjelvold, 2019).** DLP printing was also considered as a cost-effective option since it uses a shallow resin vat and utilizes solutions within the vat for each printing. Costs will be lower as a result, and waste will be reduced **(Masri, and Driscoll, 2015).**

Four units of teeth support were used as the minimal number of support the use of surgical guides supported by only 2 teeth demonstrated significantly higher deviation values than implants placed using surgical guides supported by 4 teeth or more **(El khouly et al., 2019).**

Three designs of surgical guides were designed representing different number and distribution of support (unilateral teeth support), (bilateral teeth support), and (full arch teeth support).

The full arch supported surgical guide is the control group as it is the gold standard for support to gain the most accurate implant placement position, and choosing the distal extension because the most missing teeth are the posterior teeth which are also close to vital structures.

Pin fixation was used because implants were inserted in a free end saddle which will permit a little movement that could influence the stability of surgical guide and affect the implant deviation.

Statistical insignificance was found only between BTS, and FTS groups, but there is statistical difference between UTS, and FTS. In case of mesio-distal deviation, UTS group shows the highest deviation (0.48 ±0.05) compared to BTS group that show a deviation of (0.36 ±0.03) which nearly approaches the standard deviation of FTS group (0.24 ±0.04). mesio-distal deviations are low in all groups although the highest amount was in unilateral group due to less teeth support compared to the maximum support in the full arch group, and the advantage of distribution of teeth support in the bilateral teeth support.

Because of the same reasons: there is statistical insignificance between BTS, and FTS groups in bucco-lingual direction. bucco- lingual deviations are highest in UTS group (0.39 ±0.04), lower in BTS (0.31±0.03), and lowest in FTS group (0.21 ±0.05) **(Apostolakis ,and Kourakis, 2018).**

The depth of deviation in UTS (0.89 ±0.03) showed statistically significant difference when compared to both BTS (0.59±0.04) and FTS (0.38 ±0.05) with slight insignificant improvement for the results of FTS over BTS.

Regarding the angle of deviation, a significant improvement was recorded in FTS (2.16 ±0.32) over BTS (2.85 ±0.23) which in turn significantly improved over the UTS (3.9 ±0.37).

The significant improvement in FTS results might be predominantly due to the increased number of teeth support compared to the UTS which has less tooth support while the improvement in case of BTS is due to the better distribution of teeth support **(El khouly et al 2019).**

UTS showed the maximum deviation in depth and angle that may reach up to 4 degrees. Although this is within the permitted range of error but considered risky in approaching critical anatomical landmarks eg: inferior alveolar canal, and maxillary sinus floor especially with the absence of soft tissue simulation **(Apostolakis, and Kourakis, 2018).**

In unilateral tooth supported group; there was a slight less deviation in the implants near the teeth side of the edentulous area than the implants away from the teeth side due to lack of support from the free end away from the teeth.

The study also showed the effect of decreased number of support for unilateral tooth supported guide which indirectly express the effect of bending of the unsupported part resulted from the difference between anterior tooth support, and posterior unsupported part.

That results rendered it risky to adopt unilateral support in free end saddle cases even In multiple implants placement, even with an added fixation screw in the edentulous area **(Re et al 2015)**

In the present study the most accurate group was group BTS as wide distribution of support was found to offer similar accuracy that achieved by full-arch guides **(El khouly et al 2019).**

This findings are consistent with **El khouly et al 2019** as they found that when using guide supported by four posterior teeth there were no significant differences found between mean apical ($p = .471$) or crestal ($p = .818$) 3D deviation values, when compared to implants placed, in the same position, using full-arch guides.

On the other hand, guides supported by three anterior teeth had significantly higher mean apical and crestal 3D deviation values 1.44 ± 0.19 mm and 0.6 ± 0.07 mm, respectively, when compared to implants placed in the same position using full-arch guides 0.62 ± 0.05 mm and 0.35 ± 0.02 mm, respectively ; taking in account that in my study the unilateral group is mainly supported by anterior teeth from one side only**.**

Also consistent with **Ozan et al.2009** study which compared the accuracy of three different types of computer-guided implant templates, which were the tooth- Supported, bone-supported, and mucosa-supported types and suggested that the tooth-supported type were more accurate. Although mucosa supported templates had less error than the tooth-supported type (1.12 mm vs. 1.64 mm, respectively) in the apical total dimension, significant differences were not found in the other dimensions**.**

The results are not consistent with the findings of **Arısan et al 2010** which examined the deviations of implants that were placed using bone, tooth, and mucosa-supported stereolithographic surgical guides, and he found that The biggest mean deviations were found in implants put with bone-supported guides, while the lowest deviations were seen in implants placed with mucosa-supported guides (2.9 degrees ± 0.39 degrees angular, and 0.7 ± 0.13 mm and 0.76 ± 0.15 mm for implant shoulder and tip, respectively**.** On the other hand these results coincide with the findings of **(Cassetta et al 2011)** which compared the accuracy, according to the type of supporting anatomical structure (bone, mucosa, and teeth supported). 111 implants inserted, the study result shown that bone-supported guides had better accuracy when compared to mucosa-supported guides regarding apical total deviation. Teeth-supported guides demonstrated better accuracy compared to the mucosa-supported guides specific to apical ($P = 0.013$) and coronal ($P = 0.014$) deviations.

And consistent with **Turkyilmaz et al (2012)** that found that there was no statistically significant difference among the three types of guides when comparing angular deviations.

Conflict of Interest: The authors declare no conflict of interest.

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