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Original Article

Accuracy of Implant Placement With Tooth Versus Tooth Tissue Supported Digital Light Processing Guides: Non Randomized 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 versus tooth tissue supported one manufactured by DLP (Digital Light Processing) technique.

Methodology: 21 replica implants were inserted in 7 partially edentulous maxillary resin cast. Surgical implant placement was done using static DLP printed surgical guides, Three designs of surgical guides were designed representing different type and position of support (Anterior tooth-supported, Posterior tooth-supported and posterior tooth-tissue supported) respectively when using the same number of 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.

Results : Regarding mesiodistal and buccolingual distance, lack of statistical significant difference was found between both group 1 and 2 while both show stistical significant difference in compare with (tooth tissue supported ones) . Regarding the depth results. Post tooth supported guides show a statistical significant difference over both group 1 and group 3 While the ant tooth supported guide was in statistical significant with tooth tissue supported one.

Conclusion: using 3 units of posterior tooth supported guides offer accurate implant positioning. on the other hand, using Three units anterior tooth supported surgical guides have shown less yet still satisfactory results of accuracy when compared to posterior tooth supported ones , using3 units of tooth tissue supported guides results in higher significant deviation value thus it was risky to be used even In single implant placement.

Keywords: Surgical guides ; Implants ; Support ; Accuracy

INTRODUCTION

The introduction of static guided implant surgery (SGIS) has been beneficial to optimize and facilitate the implant planning and positioning. Using three-dimensional planning software, a virtual implant treatment plan can be made and transferred to the patient via surgical templates or guides during implant surgery. The ideal implant position can be attained, and helped to avoid endangering the approximated anatomical structures .Compared to freehand implant placement, the accuracy of SGIS has been proved to be superior in different clinical situations. (Tahmaseb et al., 2018)

Many variables could affect the accuracy of SGIS fabrication from the quality of patient's record, digital planning, surgical guide manufacturing technique to the execution of the guided surgery(Vercruyssen et al., 2015) .

Accuracy of a surgical guide counts on it's good fitting to the underlying tissue and the correct seating of the surgical guide throughout the operation. Bone supported surgical guides are commonly applied to patients who need more extensive bone surgery where the reflected flap may difficult the intraoperative positioning of the guide (Raico Gallardo et al., 2017).

On the other hand mucosally supported surgical guides are mainly used for total edentulous patients. The resiliency and the thickness of the mucosa might affect the correct seating of the surgical guide.

Stabilized by the wide-ranging remaining teeth .Tooth supported surgical guides offers a rigid support and provides a sound basis for the correct intraoral seating of the guide, which is of prime importance to attain accuracy(Lin et al., 2020) .

In partially edentulous cases, the site of implant placement reflects the type of surgical guide support support.

In an in vitro model experiment using SGIS, (El Kholy et al-2019) reported that, The use of posterior teeth for guide support resulted in a statistically significant higher degree of accuracy, when compared to guides supported by the same number of anterior teeth(El Kholy et al., 2019) .In fact, there were no significant differences between mean apical or crestal deviation values, when compared to implants placed, in the same position, using full-arch guides (El Kholy et al., 2019).

On the other hand, guides supported by 3 posterior teeth expressed similar results compared to those with 4 unit support allowing for simpler and most cost effective design. On the other hand, implants placed with SGIS in distal extension cases showed significantly higher crestal and apical 3D deviations than tooth supported ones. The risk to have more deviations will rise when the extension of the surgical guide increases, due to the bending effect of the surgical guide in the posterior region .For these reasons, it is necessary to modify this unilaterally tooth-supported design to avoid the possible bending or tilting of the surgical guide during implant surgery (D'Haese et al., 2012).

The purpose of the present study is to investigate the accuracy of implant placement when using three unit supported DLP surgical guides in both anterior and distal edentulous cases compared to bilateral posterior tooth bounded cases.

Materials and methods

This was a non- randomized in-vitro study in which seven 3D-digital model of a partially edentulous maxillary cast was designed and printed to receive dental implants in anterior (replacing upper central incisor),and posterior region (replacing upper first molar on both sides) using computer assisted surgical guides manufactured by DLP (Digital Light Processing) technique

First each cast was scanned with extra oral scanner. (Trios scanner Denmark) then the file was exported on the (mesh mixer program USA) for editing. Corresponding to the Federal Dentaire International (FDI), Tooth number (16, 21, 26, and 27) were selected and removed by the eraser tool then the cast was made solid from edit button and was converted to an accurate model to increase the resolution of the cast. Smoothening brushes were chosen from sculpt button to adjust sharp areas, finally the cast was exported as a (STL) file for printing.

The cast was printed, extra resin was washed and inserted in the post curing unit for 15 min.

Indentations for tissue mimic retention were manually prepared with a round bur size 4 and tissue mimic material (zhermack light body material –Italy) was placed in each position of implant placement

An index stent was fabricated to duplicate the volume of tissue mimic material in the rest of the casts

The cast was eventually scanned with tissue mimic material for designing the surgical guides.

The STL of the cast was imported in (blueskybio software-Germany) then three points were selected in the imported cast to be superimposed with the software model to align the cast.

On the edentulous areas, teeth were restored from the software library to adjust the exact implant position then Implants for tooth (21,16and26) with (diameter (4.1mm) and length (10mm) were chosen from (add implant panel) and adjusted mesiodistally and buccolingually from the top view and all directions.

Sleeves were added with dimension corresponding to the dimensions of (J-dental guided kit-Italy).

Three designs of surgical guides were designed representing different types and positions of support

A-First design is supported by FDI teeth 11, 22 and 23. Each guide was used to insert one implant (in FDI position 21)

B-Second design is supported by FDI teeth 24, 25 and 27. Each guide was used to place one implant (in FDI position 26)

C-Third design is supported by FDI teeth 14, 15 and resting on mucosa as a third supporting unit. Each guide was used to place one implant (in FDI position 16)

The STL file of the surgical guides was exported to (chetubox software-china) to add the supporting structure. Surgical guides were raised by 2 mm on the platform to make space for the supporting structure. After adding the supporting structure, guides were exported as STL file to be printed.

The printing procedure of the guides was printed in 2 hours then they were finished and cured for 15 mins in light curing chamber (PHOTON SS curing chamber)

Printed guides were inspected and ill-fitting surgical guides were discarded and replaced

Osteotomy was prepared by using the manufacturer's recommended sequence of surgical drills; to receive a 4.1 × 10 mm implant tissue level (TL)) (JD Implant –Italy)

Implant site was prepared at first with tissue punch drill to open through the tissue mimic material then sequence of drills were continued according to manufacturer instructions until implant installed

After implant placement, corresponding abutments (Zimmer Biomet -USA.) will be fixed on each implant, and a full-arch extra oral-optical-scan is captured using a trios scanner demark

Scan file was exported as a STL file to be imported in the blue sky software, each postoperative optical scan was superimposed on the preoperative virtual planning using the same anatomical sites on each study model. Using the treatment-evaluation tool in blue sky software.

The deviations between placed and planned implants were then measured according to the following definitions: (the global deviation and angular deviation).

The global deviation was divided into vertical (depth deviation) and lateral deviations according to the longitudinal axis of the planned implant. Moreover, the lateral deviation was further divided into mesio-distal and bucco-lingual deviations.

Statistical analysis

Statistical analysis was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016.

All quantitative data were explored for normality by using Shapiro Wilk Normality test and presented as minimum, maximum, median, means, standard error and standard deviation (SD) values.

Tests used:

1-Shapiro Wilk Normality test and Kolmogorov tests were used for data exploration.

2-Comparison between three groups was performed by using Independent t-test followed by Tukey`s Post Hoc test for multiple comparisons.

Results

I-Normality test

Exploration of the quantitative data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality. As Listed in table (1), it was revealed that there was insignificant difference as P-value > 0.05 which indicated that alternative hypothesis was rejected, and the concluded data originated from normal distribution (parametric data) resembling normal bell curve.

Figure1 : A fully dentated stone cast for scanning

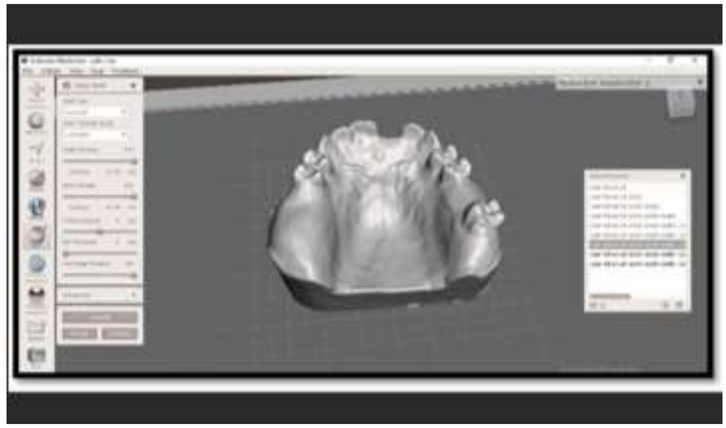

Figure 2: Editing the cast on meshmexer software .

Figure 3: The cast after printing and adding the tissue mimic material

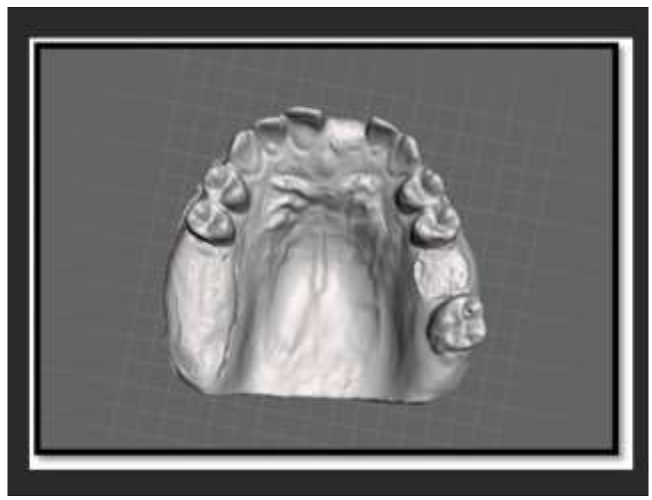

Figure 4: Scanned final cast

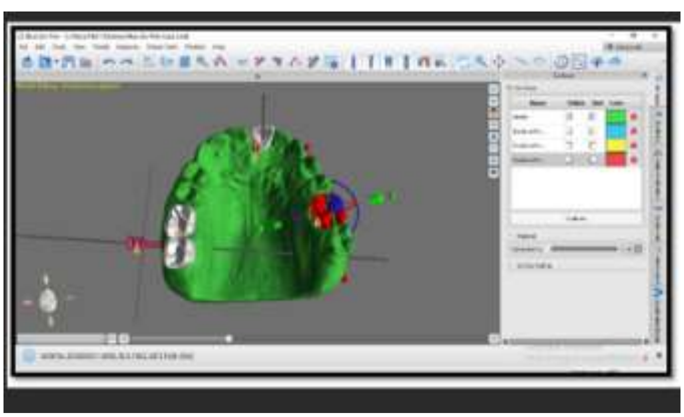

Figure 5: Tooth planning using blue sky software

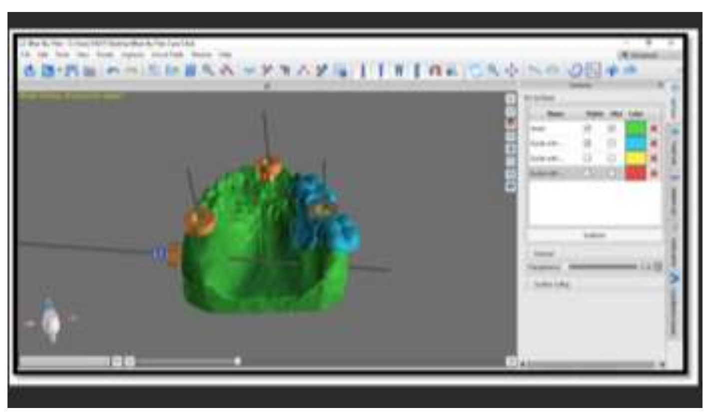

Figure 6-Surgical guides planning .

Figure 7: Using surgical guide after printing for implant installation

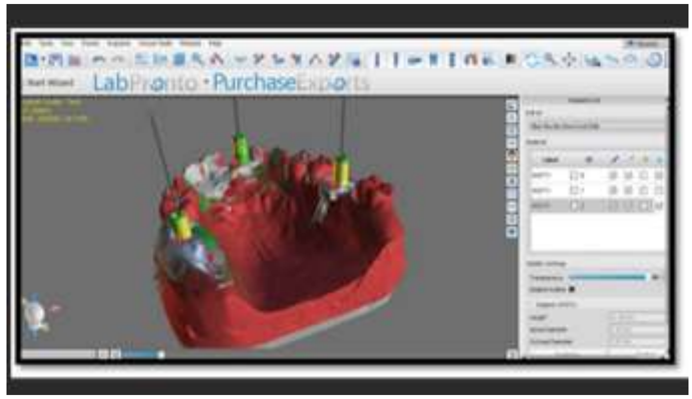

Figure8-Superimposition of postoperative optical scan on the preoperative virtual planning using the same anatomical sites on each study model

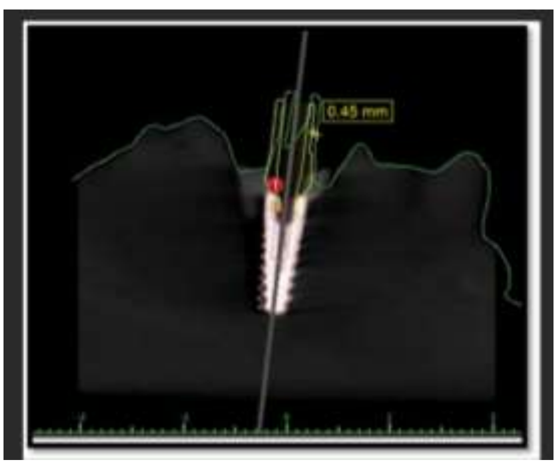

Figure 9: Global deviation measurements (MD-BL deviation) using blue sky software

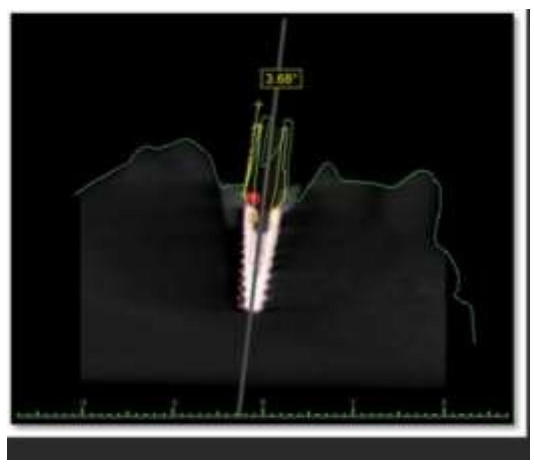

Figure 10: Angular deviation measurements us blue sky software

Table (1): Normality exploration of 3 groups:

	Group I	Group II	Group III
Mesiodistal distance	>0.05	>0.05	>0.05
Buccolingual distance	>0.05	>0.05	>0.05
Depth	>0.05	>0.05	>0.05
Angle	>0.05	>0.05	>0.05

II- Mesiodistal Deviation Measurements

Comparison between all groups was performed by using One Way ANOVA test which revealed significant difference between them as P < 0.05, followed by Tukey`s Post Hoc test which revealed significant difference between means with different superscript letters as P < 0.05, while revealed insignificant difference in means with the same superscript letters as P > 0.05. Group III was significantly the highest, while group I & II were significantly the lowest with insignificant difference between them, as presented in table (5) and figure (41).

III-Accuracy of buccolingual distance of implant placement: Buccolingual Deviation Measurements.

Comparison between all groups was performed by using One Way ANOVA test which revealed significant difference between them as P < 0.05, followed by Tukey`s Post Hoc test which revealed significant difference between means with different superscript letters as P < 0.05, while revealed insignificant difference in means with the same superscript letters as P > 0.05. Group III was significantly the highest, while group I & II were significantly the lowest with insignificant difference between them, as presented in table (9) and figure (45).

IV-Depth Deviation Measurement.

Comparison between all groups was performed by using One Way ANOVA test which revealed significant difference between them as P < 0.05, followed by Tukey`s Post Hoc test which revealed significant difference between means with different superscript letters as P < 0.05, while revealed insignificant difference in means with the same superscript letters as P > 0.05. Group III was significantly the highest with insignificant difference with group I, while group II was significantly the lowest, as presented in table (13) and figure (49).

V-Angle Deviation Measurement.

Comparison between all groups was performed by using One Way ANOVA test which revealed significant difference between them as P < 0.05, followed by Tukey`s Post Hoc test which revealed significant difference between means with different superscript letters as P < 0.05, while revealed insignificant difference in means with the same superscript letters as P > 0.05. Group III was significantly the highest then group I, while group II was significantly the lowest, as presented in table (17) and figure (53).

DISCUSSION

Accuracy measurements were made by superimposition of each postoperative optical scan on the corresponding preoperative virtual planning using the same anatomical sites on each study model. Standardization of all study elements as possible (cast material and dimension, surgical guide design, material and sleeve height, implant size and type and operator) allowed the results to focus on the nature of support provided which was the main core of the study.

Table (2): Mean and standard deviation of mesiodistal distance in all groups and comparison between them

Mesiodistal distance			
	Mean	SD	P value
Group I	0.31 a	0.07	<0.0001*
Group II	0.33 a	0.11	
Group III	0.66 b	0.05	

Means with the same superscript ;letters were insignificantly different as P > 0.05.
Means with different superscript ;letters were significantly different as P < 0.05

Table (3): Mean and standard deviation of buccolingual distance in all groups and comparison between them:

Buccolingual distance			
	Mean	SD	P value
Group I	0.32 a	0.08	< 0.0001*
Group II	0.32 a	0.05	
Group III	0.71 b	0.08	

Means with the same superscript ;letters were insignificantly different as P > 0.05.
Means with different superscript; letters were significantly different as P < 0.05

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

Depth			
	Mean	SD	P value
Group I	0.85 a	0.06	<0.0001*
Group II	0.50 b	0.07	
Group III	1.01 a	0.19	

Means with the same superscript ;letters were insignificantly different as P > 0.05.
Means with different superscript ;letters were significantly different as P < 0.05

Table (5): Means , standard deviation and p value of angle in all groups and comparison between them:

Angle			
	Mean	SD	P value
Group I	3.50 a	0.44	< 0.0001*
Group II	2.24 b	0.40	
Group III	5.62 c	0.30	

Means with the same superscript ;letters were insignificantly different as P > 0.05.
Means with different superscript ;letters were significantly different as P < 0.05

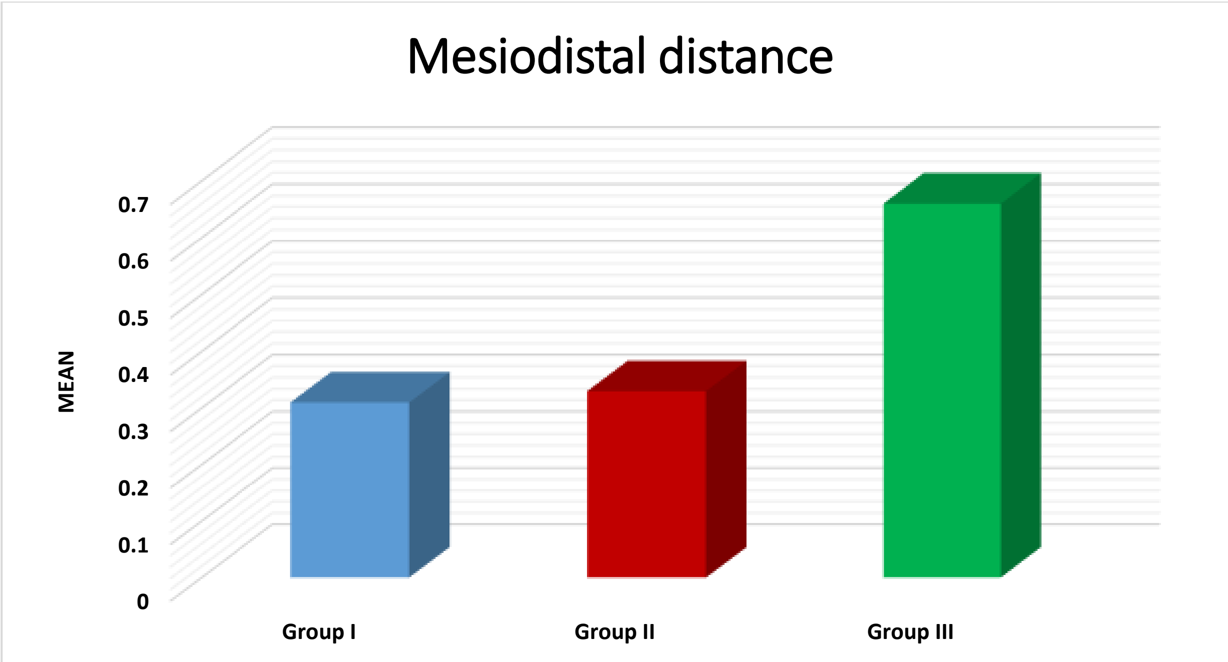

Figure (11): Bar chart showing Mean of mesiodistal distance in all groups and comparison between them.

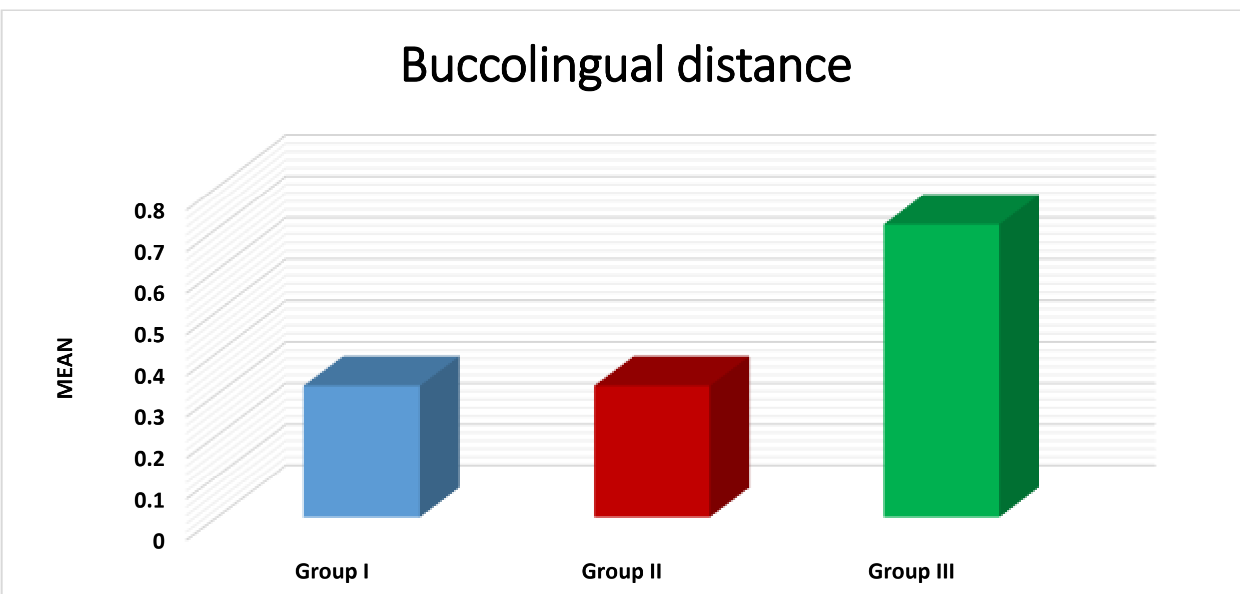

Figure (12): Bar chart showing Mean of buccolingual distance in all groups and comparison between them.

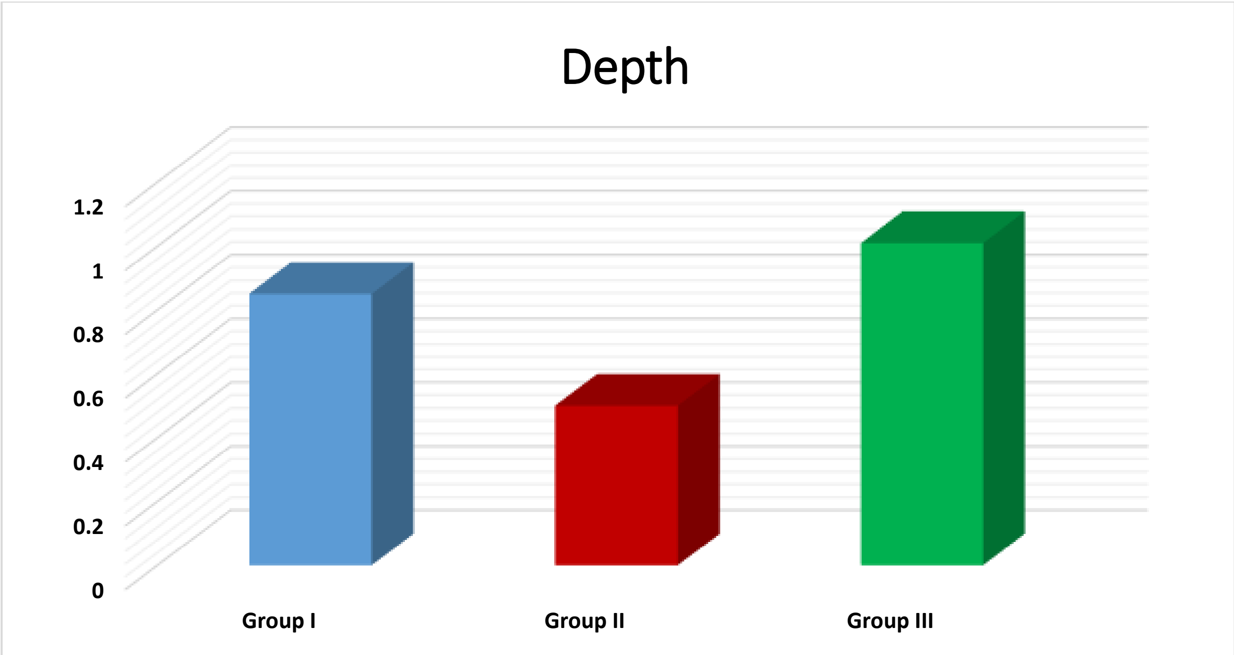

Figure (13): Bar chart showing Mean of depth in all groups and comparison between them.

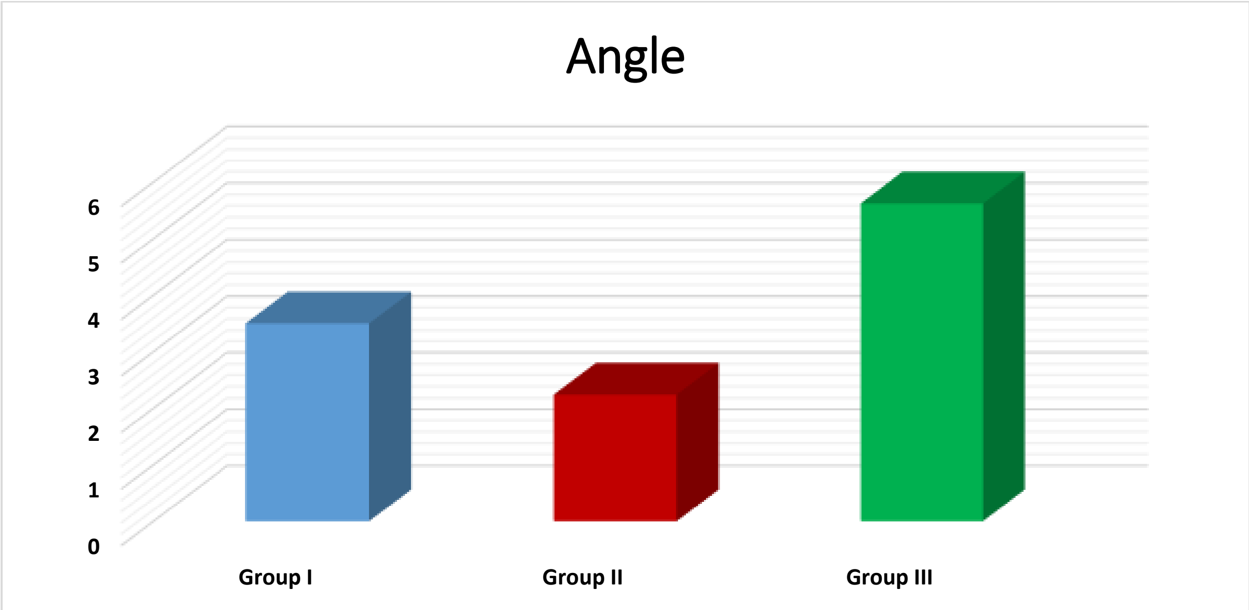

Figure (14): Bar chart showing Mean of angle in all groups and comparison between them.

Group1, 2 &3 represents anterior tooth supported (ATS), posterior tooth -supported (PTS) and posterior tooth tissue supported respectively. (PTT)

Mesiodistal and Buccolingual deviation

Statistical insignificance was found among the three groups. ATS showed slightly lower deviation in mesiodistal direction(0.31 ± 0.07)compared to PTS (0.33 ± 0.11)this slight insignificant difference may be due to the operator way in initial drilling together with the site of drilling on the cast ; when the operator drill from the front of the cast every time any operator movement would most probable occur in mesiodistal direction on both sides and in buccolingual direction in the anterior area ,this might also explain the slight increase in buccolingual deviation on ATS (0.32 ± 0.08), when compared to PTS(0.32 ± 0.05).these results conforms with the permissible errors results from initial drill tilting within the sleeves (Apostolakis and Kourakis, 2018)

PTT had shown the highest deviation records in both mesiodistal (0.66 ± 0.05)and buccolingual direction(0.71 ± 0.08), counting on elastic tissue structure for posterior support had almost doubled the deviation distance in both directions ,however being for a short distance had limited the massive increase in deviation.

Depth and angle of deviation

The depth of deviation in PTS (0.50, ± 0.07) had shown statistically significant difference when compared to both ATS (0.85 ± 0.06) &PTT (1.01 ± 0.19), with slight nonsignificant improvement for the results of ATS over PTT.

Regarding the angle of deviation, a significant improvement was recorded in PTS (2.24 ± 0.40) over ATS (3.50 ± 0.44) which in turn significantly improved over the PTT (5.62 ± 0.30)

The significant improvement in PTS results might be predominantly due to the dental anatomy of the posterior tooth support ,best support was always gained from a hard flat surface parallel to the underlying tissue this was best applied with the cuboidal configuration of the posterior teeth ,although the PTT was supposed to offer broader support, yet the resiliency of the tissue and difference between it and its anterior tooth supporting element had permitted more deviations on different perspectives .(El Kholy et al., 2019)

ATS gained its support from the surrounding anterior teeth, considering the sliding relatively tapered anatomy of anterior teeth, they are not considered the best support for surgical guides compared to similar number of support in posterior tooth supported ones.

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

The type of tissue mimic material corresponds to the mechanical properties of average oral mucosa, the resulted deviation was considered the maximum limit of the permitted errors for surgical guide (Goodacre et al., 2003)

This finding rendered it risky to adopt three unit of support in tooth tissue supported guides even in single implant placement , although with an added fixation screw in the edentulous area, or under firm keratinized mucosa better results are expected.(Re et al., 2015)

In the present study the most accurate group was group PTS as 3 units of support was found to offer similar accuracy that achieved by full-arch guides. (El Kholy et al., 2019)

This finding was consistent with the results of (El khouly et al) that found using guide supported by 3 posterior teeth lead to same accurate results when compared to implants placed in the same position, using full-arch guides. On the other hand, guides supported by 3 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.(El Kholy et al., 2019)

CONCLUSSION

1-Digital light processing surgical guides are proved to be an accurate tools for implant placement.
2-Regarding single implant placement, using 3 units of posterior tooth supported guides offer the most accurate implant positioning. on the other hand, Three units anterior tooth supported surgical guides have shown less yet still satisfactory results of accuracy in single implant placement when compared to posterior tooth supported ones .
3-In distal extension cases, implant placement using 3 units of supported guides (one of which was the posterior mucosa) results in higher significant deviation value which was considered the maximum limit of the permitted errors thus it was risky to be used even in single implant placement.

Role of study sponsors and funders

The study occurred in the Department of Prosthodontics, Faculty of Dentistry .Cairo University and self-funded with no external influence on the study design or conduct, data collection, analysis or even data interpretation.

Conflict of Interest

The authors declare on conflict of interest.

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