EVALUATION OF IMPLANT PLACEMENT ACCURACY USING DLP VERSUS SLA SURGICAL GUIDE (An in -Vitro Study)

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ABSTRACT

Aim: This study aimed to compare the accuracy of implant placement when using tooth-supported computer-aided surgical guides manufactured by two different techniques DLP (Digital Light Processing) and SLA (Stereolithography).

Methodology: Twelve replica implants were inserted in twelve partially edentulous maxillary resin casts. Surgical implant placement was done using static SLA-printed surgical guides and DLP surgical guides. After implant placement; accuracy measurements were done using (blue Sky bio software) by superimposing the actually placed implants with the virtually planned implants, deviations between placed and planned implants were then measured according to the following definitions, and the global deviation 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 mesiodistal and buccolingual deviations and angular deviations.

Results: The results of the study revealed that the SLA guides showed a significant degree of deviation compared to the DLP guides, also DLP guides achieved the best cost-effectiveness than SLA guides.

Conclusion: From the results of the study, it can be concluded that the SLA guides can be considered a satisfactory alternative for accurate implant placement and DLP guides were satisfactory and cost-effective.

Keywords: Surgical guides; 3d printing; Scanning; Implant; Accuracy.

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Introduction

In the past, the implant site and direction were dictated by residual bone availability, and the desire for a predictable prosthesis led to the development of a newer concept of "prosthetic-guided implantology." this concept establishes the correct implant position based on the planned definitive restoration and is achieved from the early planning phase (1).

Surgical guides represent one of the latest advancements in dental implant technology which helps in applying this concept. A surgical guide is created by taking impressions with an intraoral scanner or scanning the cast with an extraoral scanner of the desired surgical implant site. Then designed by one of the implant planning software. Finally, they are manufactured in the dental laboratory by using either additive or subtractive technology. It helps the prosthodontists to place the dental implant in its ideal prosthetic position (2).

The flapless surgical technique is considered to be less invasive to the patient and could be an advantage for medically compromised patients with low healing abilities. Also, the minimally invasive surgical technique may be of advantage to patients with dental anxiety (3).

Both SLA and DLP use resin material to print 3D parts, resin can be expensive as it costs around $80 to $150 per liter, the difference in

Many different types of guides have been proposed; varying from the very simple designs, which may not provide the desired information to achieve pleasing results, to ones that are extremely complex and require a great deal of time and money to fabricate (4). Surgical guides are used to improve the accuracy of implant placement. An ideal surgical guide should be stable, rigid, of small size, transparent, and easy to insert and modify (5).

As technology advances, different 3D printing technologies were introduced. Currently, the most used and popular technologies are SLA (Stereolithography) and DLP (Digital Light Processing). These 3D printing technologies follow similar principles but produce significantly different outputs (6).

Both SLA and DLP are technologies that create a 3D model by selectively curing polymer resin layer by layer, the only difference is the light source and how it is being used in the process. SLA utilizes a UV laser beam to cure or harden the resin material, the laser beam also cures the material layer by layer, and in a series of points. DLP, on the other hand, uses a projector to flash an image across the entire platform at once (7).

their printing costs will only depend on the printer and the manufacturer of the resin material. When it comes to printing speed, DLP has the advantage since the entire layer of a 3D part is exposed to light at once, the printing process is quicker and cheaper compared to SLA, On the other hand, the SLA is more accurate as the laser beam is highly directional and coherent (8).

Materials and methods

12 dental resin scannable cast (Savoy standard resin [1]), each study model has a missing upper left central incisor. the study procedures involved; the construction of the cast model, design, fabrication of surgical guide, implant drilling, placement of the implant, scanning, superimposition & implant accuracy measurements.

A fully dentated stone cast (Figure 1) was scanned with (Extraoral scanner [2]) and the file was exported to (Meshmixer program [3]) at which tooth number (21) was removed, then the cast was made solid and converted to an accurate model to increase the resolution of the cast. finally, the cast was exported as an STL file for printing (Figure 2), after the printing procedure, the cast was cured for 15 mins in a light curing chamber and rinsed with alcohol (Figure 3).

The cast was eventually scanned for designing the surgical guides by planning software (Blue Sky bio software [4]), virtual planning was done followed by the virtual dental implant in place (Figure 4)

A designed surgical guide was done on the cast with the ideal prosthetic-driven tooth position, windows were designed to verify the seating of the surgical

Figure (1)- A fully dentated stone cast was selected and prepared for scanning

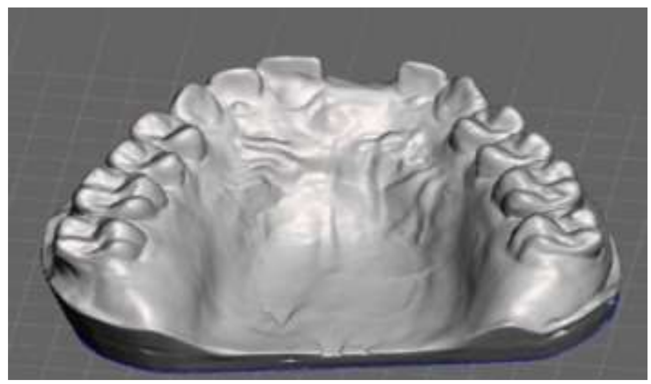

Figure (2) -Cast after edit on meshmixer

Figure (3) - Printed cast

[1] Savoy standard resin– China.
[2] Extraoral scanner, freedom – Korea.
[3] Meshmixer program, MicronDental – Korea.
[4] Blue Sky bio software– USA.

guide on casts and avoid errors. stainless steel metallic sleeves (Jdental system [5]) with a height of 4mm and diameter (internal 5mm, external 6mm) were considered in the placement of the missing left central incisor (Figure 5).

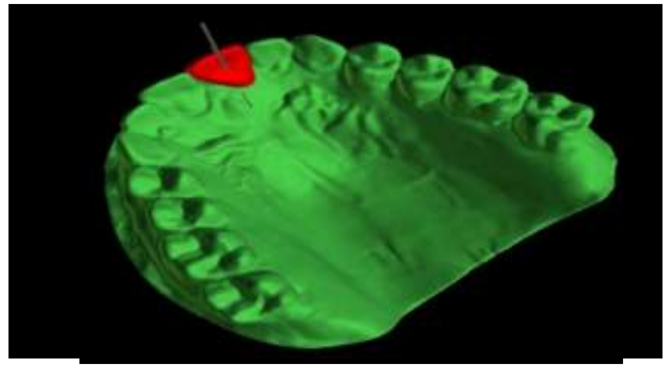

Figure (4) - Planning on blue sky bio

The planned surgical guide's STL file was printed with (Clear resin[6]) in (Form 3 Printer[7]) to produce (SLA surgical guide) (Figure 6) and with (Phrozen resin[8]) in (Mogassam Printer[9]) to produce (DLP surgical guide) (Figure 7), sleeves fitted through and seated in position by using adhesive.

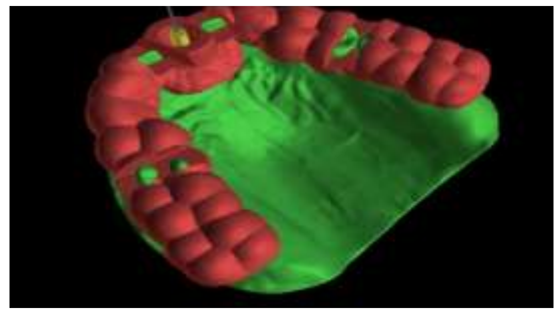

Figure (5) -Surgical guide design on blue sky bio

After the cast was seated on a lab bench, the surgical guide fitting on it and the window were inspected to verify the sitting of the surgical guide on the neighboring teeth and avoid errors, implant preparation sites were prepared by using the manufacturer's recommended sequence of surgical drills to receive a 3.7 × 10 mm implants according to manufacturer instructions.

Figure (6) -SLA surgical guide

[5] Jdental system –Italy.
[6] Clear resin– USA.
[7] Form 3 Printer– USA.
[8] Phrozen resin– Taiwan.
[9] Mogassam Printer– Egypt.

After preparing the drilling site, an implant was carried with its fixture mount and inserted through the surgical guide, insertion continued, then the fixture mount was removed, and further tightening continued manually using a torque ratchet until the top of the implant flushed, after implants insertions casts taken and a full arch extra oral optical scan is captured with scan body and superimposition is done *(Figure 8).*

Scan file exported as an STL file to be imported in the blue sky bio software, each postoperative optical scan superimposed on the preoperative virtual planning using the same anatomical sites on each study model, then using the treatment evaluation tool in blue sky software (Distance measure, angular measure) the deviations between placed and planned implants estimated.

Figure (7) - DLP surgical guide

Figure (8) - Cast scan with scan body

Results

A-Primary outcome:

1-Mesiodistal distance

Comparison between both groups:

Comparison between both groups revealed an insignificant difference between them as P > 0.05, (Group I was insignificantly higher than Group II), as presented in Table (1) and *(Figure 9).*

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

Mesiodistal distance			
	Mean	SD	P value
Group I (DLP)	0.36	0.02	0.11
Group II (SLA)	0.34	0.02	

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

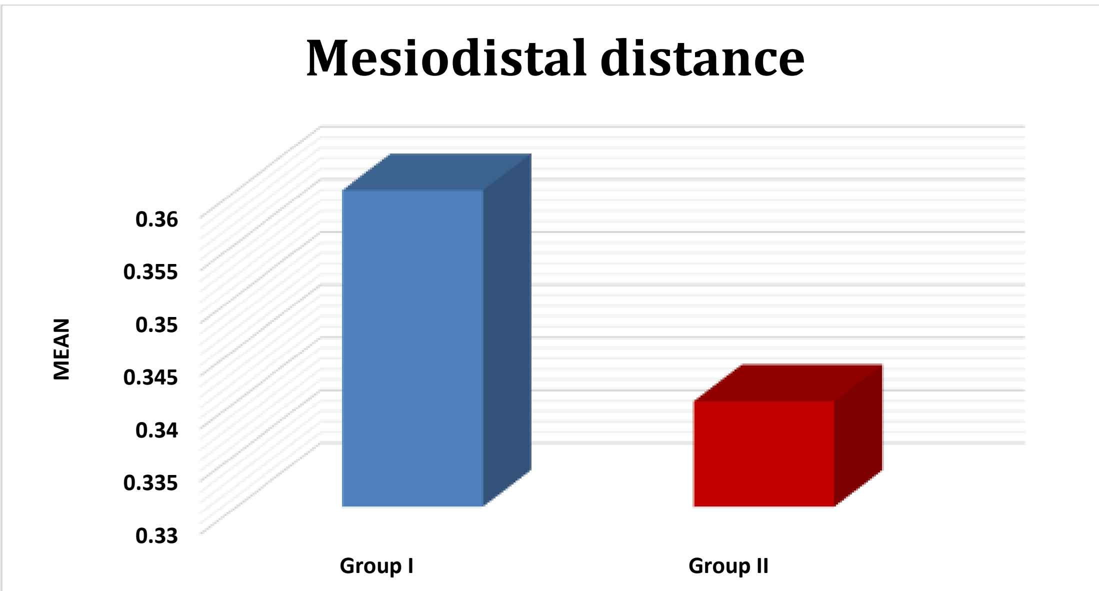

Figure (9): Bar chart showing mesiodistal distance in both groups.

2-buccolingual distance

Comparison between both groups:

Comparison between both groups revealed a significant difference between them as P < 0.05, (Group I was significantly higher than GroupII), as presented in Table (2) and *(Figure 10).*

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

Buccolingual distance			
	Mean	SD	P value
Group I (DLP)	0.37	0.02	0.0003*
Group II (SLA)	0.32	0.01	

Means with the same superscript; letters were insignificantly different as P > 0.05.
Means with different superscript; letters were significantly different as P < 0.0

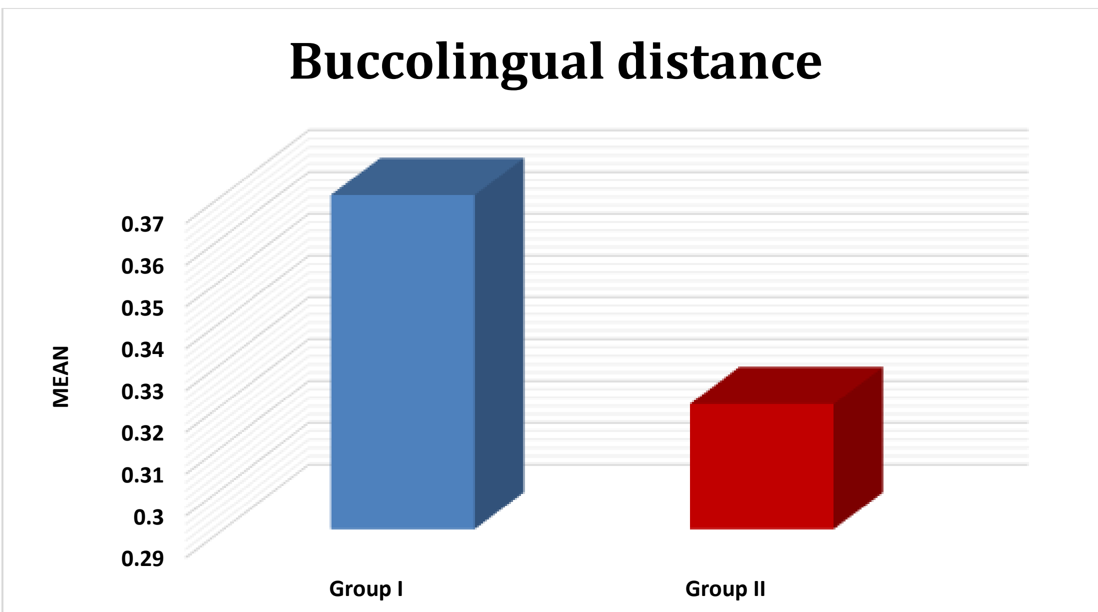

Figure (10): Bar chart showing buccolingual distance in both groups.

3-Depth

Comparison between both groups:

Comparison between both groups revealed a significant difference between them as P < 0.05, (Group I was significantly higher than GroupII), as presented in Table (3) and *(Figure 11)*.

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

Depth			
	Mean	SD	P value
Group I (DLP)	0.89	0.03	<0.0001*
Group II (SLA)	0.57	0.04	

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

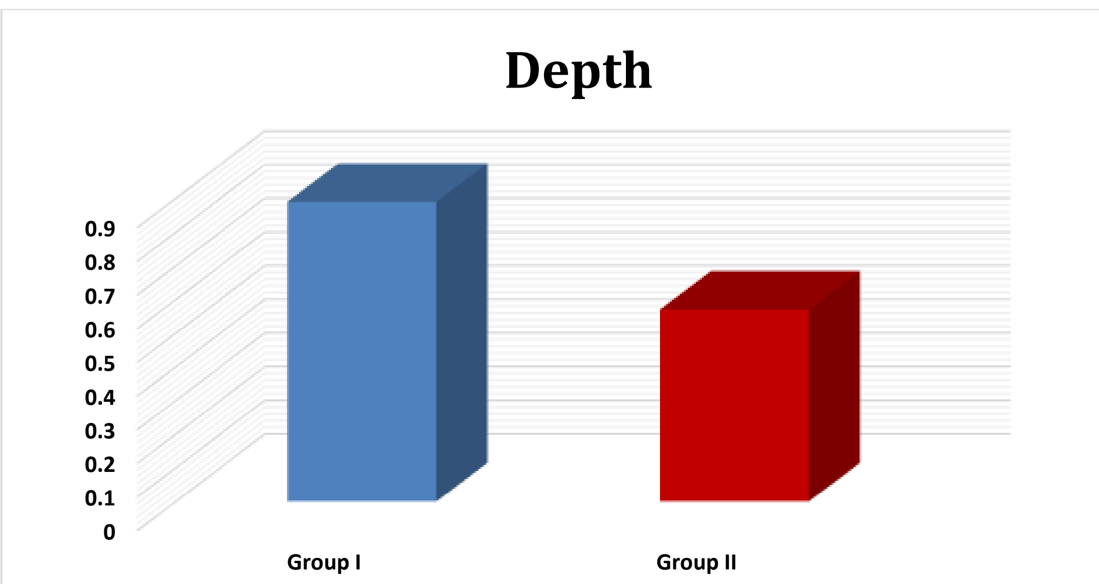

Figure (11): Bar chart showing of depth in both groups and comparison between them.

4-Angle

Comparison between both groups:

Comparison between both groups revealed a significant difference between them as P < 0.05, (Group I was significantly higher than GroupII), as presented in Table (4) and (Figure 12).

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

Depth			
	Mean	SD	P value
Group I (DLP)	3.91	0.42	0.0004*
Group II (SLA)	2.85	0.26	

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

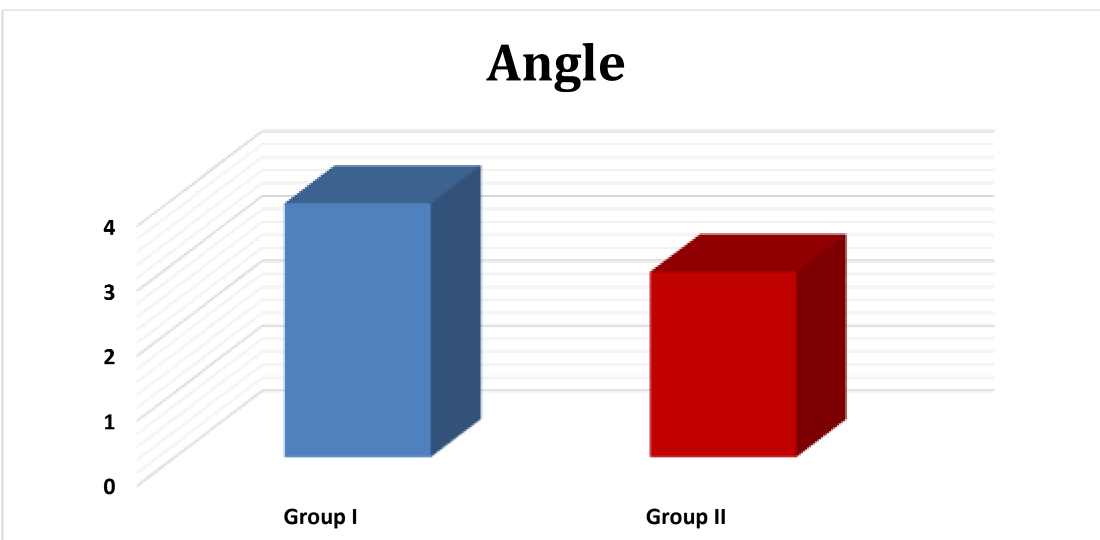

Figure (12): Bar chart showing of angle in both groups.

B-Secondary outcome:

1-Cost Effectiveness

The direct cost of the DLP surgical guide is nearly half the price of the SLA surgical guide for the same case. (Figure 13).

DLP surgical guides	82.8 $
SLA surgical guides	166.2 $

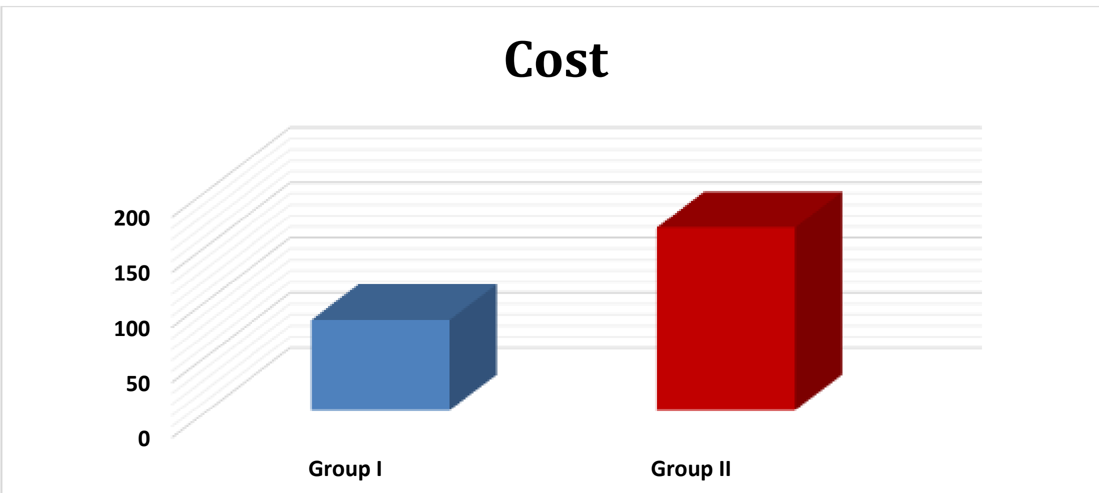

Figure (13): Bar chart showing of cost in both groups.

Discussion

This is a non-randomized in vitro study, in which two types of teeth-supported DLP and SLA surgical guides were used for implant placement solid resin models of a partially edentulous maxillary cast, which was planned in planning software "blue sky bio" and after implants were inserted scan bodies attached to implants and superimposition done with the planned implants to evaluate the accuracy of implants placements in terms of "mesiodistal angles, buccolingual angles and depths".

Randomization was invalid for this study because all the interventions could not be masked.

Standardization for all samples is assured, and all samples were done by a single operator.

Blinding was impossible for the same reason, except for the statistician who received the resulting data in the form of group number 1&2 to minimize the risk of bias.

Digital light processing DLP technique was used for manufacturing the casts, SLA printers were proved to be more accurate concerning deviations at the entry point and vertical implant position when compared to DLP printers. DLP printing was also considered 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.

The full arch-supported surgical guide is used as it is the gold standard for support to gain the most accurate implant placement position.

The digital light processing (DLP) technique is used for manufacturing casts and surgical guides. DLP printers proved to be more accurate concerning deviations at the entry point and vertical implant position when compared to SLA printers (9).

DLP printing is also considered 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 (10).

Discussion for results

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

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

Accuracy measurements were made by the superimposition of each postoperative scan body on the corresponding preoperative virtual planning using the same anatomical landmarks in each study model.

Standardization of all study elements as possible (cast material and dimensions, surgical guide design, sleeve height, implant size, and type and operator) allowed the results to focus on the type of surgical guide that was the main target of the study.

Buccolingual, depth, and angle deviation:

Comparison between both groups was performed by using an Independent t-test revealed significant differences between them as $P < 0.05$, (Group I was significantly higher than Group II), as presented.

The mean difference in the buccolingual direction in Group I between planned implants and placed implants was (0.37) compared to Group II which shows a deviation of (0.32).

The mean difference in depth in Group I between planned implants and placed implants was (0.89) compared to Group II which shows a deviation of (0.57).

The mean difference in angle in Group I between planned implants and placed implants was (3.91) compared to Group II which shows a deviation of (2.85).

Mesiodistal deviation:

Comparison between both groups was performed by using an Independent t-test which revealed the insignificant difference between them as P > 0.05, (Group I was insignificantly higher than Group II), as presented**.**

The mean difference in the mesiodistal direction in Group I between planned implants and placed implants was (0.36) compared to Group II that show a deviation of (0.34)

The mean difference in mesiodistal direction at the alveolar crest between planned implants and placed implants was 0.28 mm (range, 0.05 to 0.62 mm) and the difference in the buccolingual direction was 0.49 mm (range, 0.08 to 0.72 mm). The mean mesiodistal angulation deviation was 0.84° (range, 0.08° to 4.48°) and the mean buccolingual angulation deviation was 3.37° (range, 1.12° to 6.43°). (11).

Cost-effectiveness:

The use of DLP surgical guides was significantly cost effective as it is nearly half the price of SLA surgical guides which could be beneficial for minimizing the overall cost for the patient.

Conclusion

From the results of the study, it can be concluded that the SLA guides can be considered a satisfactory alternative for accurate implant placement and DLP guides were satisfactory and cost-effective.

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