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ACCURACY OF TWO STEREOLITHOGRAPHIC SURGICAL GUIDE SOFTWARE FOR COMPUTER AIDED IMPLANT PLACEMENT. CONE BEAM COMPUTED TOMOGRAPHY BASED COMPARISON

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ABSTRACT

Implant surgery with surgical guide has been introduced with a concept of prosthetic driven implant. The surgery might be considered as easy even for inexperienced clinician because of step simplicity with high precision of implant and the final prosthesis. The aim of the present study was to evaluate the accuracy of implant placement in the jaw bones as related to two types of surgical guide's software blue sky bio and Digital Dental Service–Professional after preoperative CBCT. In total, 7 patients (4 men and 3 women; mean age range 50 ± 28 years) with missing teeth. All drillings and placements were performed using surgical guides. After postoperative CBCT a special image-processing software using the 3-matic software matching preoperative planning images with postoperative data was performed. Finally, the bone and teeth volume was removed, leaving the planned and placed implant volumes superimposed on the identical 3D spatial image. The parameters of accuracy were angular deviation (angle between the axis of the planned and placed implants) and linear deviation at the implant shoulder (distance between the coronal centers of the planned and placed implants) and implant tip (distance between the center tip of the planned and placed implants) will measure. Also, the final position of the implants in the software was recorded for postoperative comparison.

INTRODUCTION

As dental implants increased in popularity as tooth replacement therapy, the accurate assessment of patient anatomy and the collaboration between restorative clinicians and surgeons have become critical determinants of successful outcomes.(1) Prosthetically driven implant surgery has been a subject of fundamental interest to the dental profession. Precise implant positioning has obvious advantages, such as favorable esthetic and prosthetic outcomes, long-term stability of peri-implant hard and soft tissues as a result of simple oral hygiene and the potential to ensure optimal occlusion and implant loading.(2–4) As a rule, precise and accurate pre-operative prosthetic and surgical planning serves as a necessary pre-requisite for later clinical success in dental implantology.(5) Implementation of complex prosthetic planning in a three dimensional surgical field frequently represents a major surgical challenge.(6)

Conventional periapical and panoramic imaging techniques combined with visual inspection and clinical palpation may be insufficient to obtain the best pre-surgical planning in complex or compromised cases.(7) To optimize implant placement and to reduce surgical complications, the clinicians must have full knowledge of jaw bones so that any osseous topography and bone volume excesses or deficiencies can be corrected before implant therapy.(8–10) Implant surgery with surgical guide

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gains more and more importance in implant dentistry .[11] It is a key goal of the surgery with the guide to obtain a maximum accuracy by transferring the virtual implant position into the clinical situation. [12] In reality, the surgery requires several steps as follows; fabrication of a radiographic template, cone beam computed tomography acquisition with the template in position, computer-assisted planning of implant placement and ending in fabrication, and the use of surgical guide for drilling and implant placement. Thus, the accuracy depends on all cumulative and interactive errors involved from fabrication of a radiographic template to the placement with surgical guide. [13] Previous studies have proved a high accuracy for implant surgery with surgical guide. [14]

Computer guided surgery allows a reliable transfer of the surgical plan to the surgical field through guided drilling templates, helping the surgeon to achieve adequate dental implant placement in full prediction of the final prosthetic outcome, soft tissue management, emergence profile, and tooth morphology. [15] Using computer technology also aids in patient satisfaction because surgical times are shorter, less invasive treatment, shorter healing times, and there are less chances of clinical complications. [16,17] in certain cases, the implants and prosthesis can be placed at the same appointment using the “Immediate smile” or the “all-on-4” protocols. [18,19] there are several elements required for guided implant surgeries: the imaging data set (which may originate from CT or CBCT), surgical planning software, a radiographic guide to transfer the prosthetic planning design to the planning software, and the surgical guide itself. The characteristics of the latter two are going to depend largely on the chosen software program. Implant planning software allows one to virtually plan the implant surgery and to derive surgical guides from the information acquired. A good surgical guide planning is the one that allows the practitioner to accurately place the implant in the desired position with a predefined insertion path with minimal tolerance that is non-flexible and stable during the surgical procedure .[5]

Currently there are few software systems using the CT scans to aid in planning surgery and produce surgical drilling guides. These guides are manufactured in such a way that they match the location, trajectory, and depth of the planned implant with a high degree of precision. As the dental practitioner places the implants, the guides stabilize the drilling by restricting the degrees of freedom of the drill trajectory and depth. Earlier studies concluded that the implant placement based on computer guided surgery resulted in implant positioning with improved bio-mechanics and esthetics.[20,21]

Patients were be randomly divided into 2 equal groups:

1) Group 1: using (Blue Sky Plan* software in fabrication of surgical guide.

2) Group 2: using (DDS-Pro** software in fabrication of surgical guide.

Pre-surgical procedures included the following steps:

Double scanning procedures*:*

For the patient analysis, Cast Scanning with CBCT, the two data sets were loaded to the implant planning software for superimposition stage. Implants& crown planning, simulation & superimposition stage (prosthetic driven implant). After implant planning on the software & implant verification in different views surgical guide fabrication. It’s drawn on the cast. It is also possible to edit the borders extension of the surgical guide. Export the plan as STL file for printing by the 3D printer.

* Blue Sky Bio, LLC, Grayslake, IL, USA (version 3.29.28)
** Digital Dental Service-Professional England (version 1.4.36)

The surgical drilling protocol is printed as (pdf.) file format from each software after complete fabrication of the guide. Which provide detailed information about the drill length, implant length & diameter. Guide verification after printing on the cast.

Surgical procedure:

Before the administration of local anesthesia, we make sure that the surgical guide is properly fit into the patient mouth Tooth-supported guides will seat and stabilize with the help of natural teeth (teeth supported surgical guide). Osteotomy was completed according to the drill sequence of the implant system, which are used with a special mucotome followed by 2-mm pilot and final. Then other drill till the final one followed by implant installation then the cover screws or gingival formers were fastened implants were left to osseointegrate for 4 to 6 months, depending on the anatomical location.

Post-surgical procedures:

After the implant placement, all patients were again scanned with CBCT using the same image acquisition parameters and the same device as for the preoperative examination. After surgery the data is loaded into the software for accuracy evaluation.

RESULTS

1. Comparison between the two studied groups according to lateral deviation (mm)

Lateral deviation at Implant Shoulder was 0.50 ± 0.28 mm in BSB Software while in DDS Software it was 0.69 ± 0.22 mm, although blue sky plan Software was less than DDS Software in Lateral deviation at Implant Shoulder, there was no statistically significant difference between BSB Software and DDS Software.

Lateral deviation at Implant Apex was 1.32 ± 0.21 mm in blue sky plan Software while in DDS-pro Software it was 1.34 ± 0.26 mm, although BSB Software was less than DDS-pro Software in Lateral deviation at Implant Apex, there was no statistically significant difference between BSB Software and DDS-pro Software (Table1 and figure 1).

TABLE (1): Comparison between the two studied groups according to lateral deviation (mm)

Lateral Deviation (mm)	Blue sky plan Software (n= 10)	DDS Software (n= 10)	U	p
Implant Shoulder				
Min. – Max.	0.25 – 0.97	0.29 – 1.0	32.0	0.173
Mean ± SD.	0.50 ± 0.28	0.69 ± 0.22		
Median	0.37	0.70		
Implant Apex				
Min. – Max.	1.11 – 1.66	0.71 – 1.67	43.0	0.596
Mean ± SD.	1.32 ± 0.21	1.34 ± 0.26		
Median	1.25	1.42		

2-Comparison between the two studied groups according to angular deviation

Angular deviation was 3.18 ± 0.33 degree in BSB Software while in DDS-pro Software it was 3.28 ± 0.34 degree, although BSB Software was less than DDS-pro Software in angular deviation, there was no statistically significant difference between BSB Software and DDS-pro Software Table 2 and figure 2).

TABLE (2): Comparison between the two studied groups according to angular deviation

Angular deviation	Blue sky plan Software (n= 10)	DDS Software (n= 10)	t	p
Min. – Max.	2.60 – 3.80	2.80 – 3.80	0.669	0.512
Mean ± SD.	3.18 ± 0.33	3.28 ± 0.34		
Median	3.25	3.30		

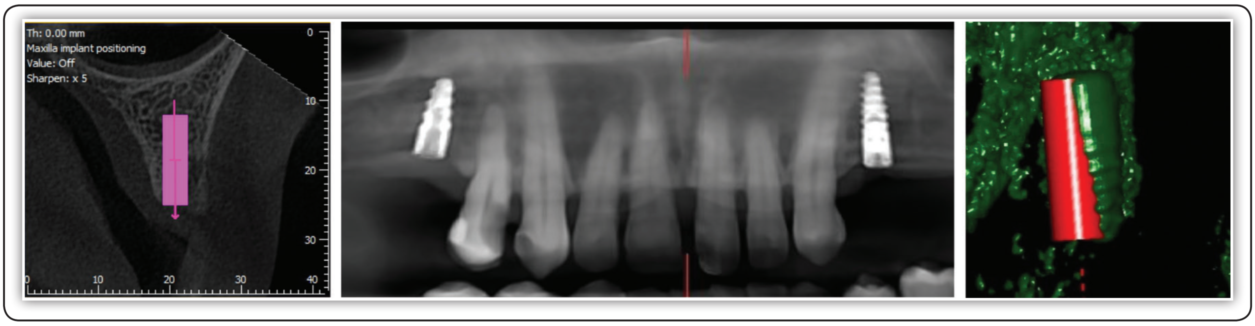

Fig (1): (A) Implant simulation indifferent views, (B) Postoperative CBCT for matching and comparison, (C) Image fusion (superimposition) and measure of the deviations.

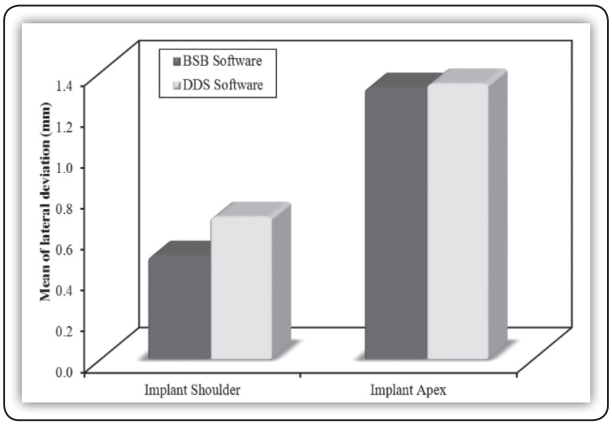

Fig. (2) A graph showing the two studied groups according to lateral deviation (mm)

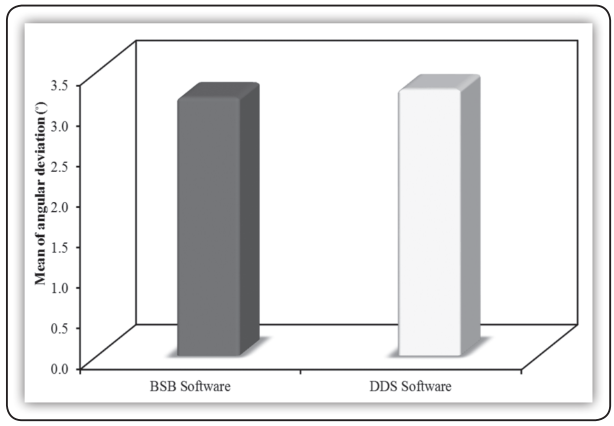

Fig. (2) : A graph showing the two studied groups according to angular deviation

DISCUSSION

The success of dental implant treatment depends much on the three-dimensional position of implant in the jaw bone and its relation with adjacent teeth, vital structures, and the occlusion[22]. A malposition or misaligned implant often poses problems at the time of surgery or during fabrication of the prostheses. It may jeopardize the aesthetic outcome and may have more biological and technical complications in the long term. [23,24] Over the years, the precision of implant placement had relied solely on the skill and experience of the surgeons. [40]Today, with the advancement of digital technology and imaging techniques, clinicians can evaluate the bone anatomy in greater details and determine the best position for implant placement. Many commercial software are now available for transferring the planned implant to the surgical site.

The use of Stereolithographic guides for the placement of dental implants is designed to provide greater control and eliminate the risks that are involved in standard implant surgery. Since the concept of prosthetic driven implant is clinically applied through the software which enable the clinician through the crown simulation icon of the software to move the implant body via crown movement & the final position of implant is determined according to the desired crown position. However, the risk for deviation (transfer error from the software-planning stage to the surgical field) remains substantial[25,26]. The surgical guide was evaluated intraoral, and the guided surgery was performed using a flapless approach. A flapless approach was chosen because of the availability of adequate keratinized tissue and bone volume that would require no contouring or other grafting procedures. Lack of flap elevation and subsequent interruption of blood flow can decrease postoperative discomfort, reduce surgical time, reduce healing time, and reduce bone loss[27].

In the present study, Lateral deviation at Implant Shoulder was 0.50 ± 0.28 mm in blue sky pro Software while in DDS-pro Software it was 0.69 ± 0.22 mm, although BSB Software was less than DDS-pro Software in Lateral deviation at Implant Shoulder, there was no statistically significant difference between BSB Software and DDS-pro Software. Lateral deviation at Implant Apex was 1.32 ± 0.21 mm in BSB Software while in DDS-pro Software it was 1.34 ± 0.26 mm, although blue sky pro Software was less than DDS-pro Software in Lateral deviation at Implant Apex, there was no statistically significant difference between BSB Software and DDS-pro Software. Angular deviation was 3.18 ± 0.33 degree in blue sky pro Software while in DDS-pro Software it was 3.28 ± 0.34 degree, although blue sky pro Software was less than DDS-pro Software in angular deviation, there was no statistically significant difference between blue sky pro Software and DDS-pro Software.Although there is no statistically significant difference between blue sky plan and DDS-pro software, blue sky plan software was less than DDS-pro Software in Lateral deviation at Implant Shoulder and was less than DDS-pro Software in Lateral deviation at Implant Apex and was less than DDS-pro Software in angular deviation.

Ozan et al.,[28] evaluated 110 implants placed using SLA surgical guides generated from computed tomography (CT). The mean angular deviation of all placed implants was 4.1° ± 2.3°, whereas mean linear deviation was 1.11 ± 0.7 mm at the implant neck and 1.41 ± 0.9 mm at the implant apex compared with the planned implants. The angular deviations of the placed implants compared with the planned implants were 2.91° ± 1.3° for the tooth-supported SLA surgical guide.

Di Giacomo et al.,[29] evaluated the match between the positions and axes of the planned and inserted implants when an SLA surgical guide was used. They inserted 21 implants in 4 patients using 6 SLA surgical guides using CT data, measuring the deviation between planned and inserted implants. They noted an average angular deviation of 7.25° ± 2.67° between the planned and the inserted implant axes. The deviations in distance between planned and inserted positions at the implant shoulder were 1.45 ± 1.42 mm and 2.99 ± 1.77 mm at the implant apex. Also, they observed large angular deviations of 10° and 12.2°, and linear deviations at the apex 2.6 mm and 3 mm in 1 patient because of poor fit of the surgical guide as the distal portion of a tooth hindered seating of the surgical guide.

Ahmet et al.,[30] Compared to the planned implants, the placed implants showed angular deviation of 4.9° ± 2.36°, whereas the mean linear deviation was 1.22 ± 0.85 mm at the implant neck and 1.51 ± 1 mm at the implant apex.

The deviations that were investigated in this study are generated from the cumulative sum of all errors throughout the ‘‘computer-aided implant placement’’ cascade; they include CBCT imaging (acquisition and reliability); software planning (conversion, segmentation, volume rendering, and manual removal of artifacts); guide manufacturing (simulation software or method before production, precision of the Stereolithographic machine, production and quality control, rigidity and physical properties of the material used, placement method and precision of the guide cylinders, metal tubes, and verification of the guide); proper guide positioning in the mouth[5,31].

Although there is no statistically significant difference between blue sky plan and DDS-pro software, blue sky plan software was less than DDS-pro Software in Lateral deviation at Implant Shoulder and was less than DDS-pro Software in

Lateral deviation at Implant Apex and was less than DDS-pro Software in angular deviation. Data suggested that computer-aided SLA surgical guides made by Blue Sky Plan software might be accurate tools for transferring ideal implant position from computer planning to the actual implant surgical phase of treatment.

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