ACCURACY OF IMPLANT PLACEMENT USING TWO GUIDED DRILLING TECHNIQUES

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ABSTRACT:

Objectives: This study aimed to evaluate the accuracy of pilot drill guided implant placement surgery in comparison with full sequence guided implant placement surgery.

Material and methods: A total of 120 implants were placed in 15 completely edentulous patients following CBCT diagnostics. In a split mouth design, 60 implants were inserted using the full sequence guided approach, whereas another 60 implants were inserted using the pilot drill guide approach. Postoperative cone beam computer tomography (CBCT) was performed. Based on the superimposition process, linear and angular deviations between virtually planned and actually placed implants were measured at implant shoulder and apex.

Results: there was no statistically significant difference between pilot and full sequence implants in all deviation parameters except the angular deviation in the bucco-lingual direction, where pilot implants showed slightly greater deviation (1.8º)

Conclusions: Based on the results, guided pilot drilling is as accurate as full sequence drilling protocols

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INTRODUCTION

The primary objective of implant placement is to support prosthetic restorations that rehabilitate the patients to proper oral form, function, and aesthetics[1]. Since correct implant placement is a technique-sensitive process, it is conjugated with various diagnostic and guidance procedures[2].

The introduction of computer-based guided implant surgery has been an important development in implant dentistry[3]. Guided implant surgery makes it possible to transfer the planned three-dimensional position of the implant from the computer software to the surgical site. As such, the restoration can be fabricated prior to surgery and even placed into the patient's mouth immediately after surgery[4–7]Besides an improved prosthetic planning, it as well allows safe and precise implant positioning in relation to the vital anatomical structures such as the maxillary sinus, the mandibular canal and the mental foramen. The surgical intervention became fast, minimally invasive and more predictable[8–12].

The computer guided surgery can be limited to the pilot drilling or partial sections of the osteotomy or to the final implant placement. Especially in situations with limited mouth opening or restricted interocclusal distance, surgical guides may interfere with effective use of the drills in the posterior jaws segments and therefore, the templates may be used only for the initial steps of osteotomy preparation. However, this can adversely affect the accuracy[13].

Very limited studies[13] reporting the accuracy of pilot drill guided implant placement protocol in comparison with full guided implant placement protocol. The purpose of this study was to evaluate the linear and angular deviation between the virtual and the actual implant positions for implants inserted using single drill versus full sequence surgical guide.

MATERIAL AND METHODS

Patients selection:

In this split mouth randomized controlled clinical trial, fifteen completely edentulous patients were randomly selected from the outpatient clinic of the Prosthodontics Department, Faculty of Oral and Dental Medicine, Cairo University. Completely edentulous patients with adequate zone of attached gingiva and adequate bone volume for placing four implants in the maxillary arch and four implants in the mandibular arch were included in the study.

Every patient received pilot drill computer guided implants in the test side and full sequence computer guided implant (totally guided) in the control side. The test and control sides were randomly assigned according to a computerized random allocation program (Tripod random allocation software, Version 1.0, May 2004).

Virtual implant planning and surgical guide fabrication.

Scan appliance Preparation

At first complete denture was constructed with optimal tissue fitness and ideal teeth setting to allow for prosthetic driven implant placement. Maxillary and mandibular radiopaque scan appliances were prepared by duplicating the maxillary and mandibular dentures using autopolymerizing acrylic resin (Acrostone dental company, Egypt) mixed with barium sulfate (Elnasr pharmaceutical chemicals co, Egypt) at a ratio of 4:1. For preoperative and postoperative cone beam computed tomography (CBCT) registration process, three radiographic markers (Amalgam tablets,YINYA, Zhengzhou Linker Trading Co., Ltd-Henan China) were connected to the polished surface of the scan appliance in a tripoding pattern, one tablet was placed in the anterior region and the other two tablets were placed in the right and left posterior region. A vinyl polysiloxane (VPS) (Zetaplus. C-silicone putty. Zhermack Company – Italy) bite index was taken in the patient‘s centric relation and at a slightly high vertical dimension to separate the mandibular and maxillary arches and ensure an optimal fit of the scan prosthesis during the scanning process.

A preoperative CBCT scan (I-CAT 17-19, Imaging Sciences International, Hatfield, PA, USA.) was taken for the patient's maxillary and mandibular arches with the scan appliance and interocclusal bite index in their position in patient's mouth.

Virtual implant planning

After CBCT scan, the DICOM images were then imported in Mimics10.01® software (Materialize incorporation, Belgium.) to be reformatted into axial, panoramic, cross sectional and three dimensional images. Virtual implant models 3.7×10mm and 3.7×12mm were used for posterior and anterior implants respectively. The virtual implants were evenly planned in the dental arch for better stress distribution where two implants were planned in the lateral incisor area and the other two implants were planned in the second premolar area. After accepting the implants positions, the positions of the three fixation screws were planned to be equally distributed anteriorly and posteriorly in the dental arch. According to the position of the planned implants, the 3D virtual surgical stent was segmented (Figure 1) and exported as STL file to be processed by rapid prototyping unit where selective laser sintering was used to build the stent from poly-amide material. Metallic sleeves with the same diameter of the final drill (3.7) were then fitted into the planned holes of the fabricated stent which was ready for the surgical procedures.

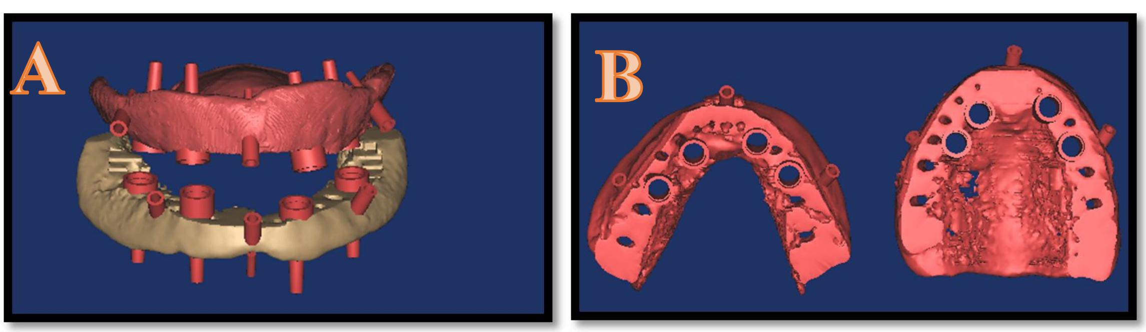

Figure 1: The virtual surgical guide (A) the virtual surgical guide with dental implants and fixation screws in place (B) the final virtual surgical guide before exporting as STL file

Surgical implant placement procedures.

After local anesthesia injection, Implant installation was performed according to DENTIS Guide procedures (DENTIS Guide, dentis-korea). The surgical guide was fixed in place on the supporting mucosa by PVS bite index in patient‘s centric relation with the opposing denture and it was fixed to the underlying bone by three equally distributed anchor pins (Figure 2). For the full sequence guided surgical side (control side), osteotomy preparation and implant installation were guided with the surgical guide. For the single drill guided surgical side (test side), only pilot drilling performed with the surgical guide, while the rest of the drilling and implant installation were performed free hand.

With the surgical guide in place, implants were inserted in the control side to a specific depth due to the vertical stop on the fixture mount. To complete the osteotomy for the intervention side, the surgical stent was removed, free hand manual drilling and implant placement was completed as in the conventional manner. Because the surgery was flapless, the required depth was estimated visually by the measured mucosal thickness on preoperative CBCT. The patients were allowed to wear their dentures at the day of the surgery as the surgery was flapless. After 4 months second stage surgery was scheduled for implants exposure and finally the patients were supplied by screw retained prosthesis.

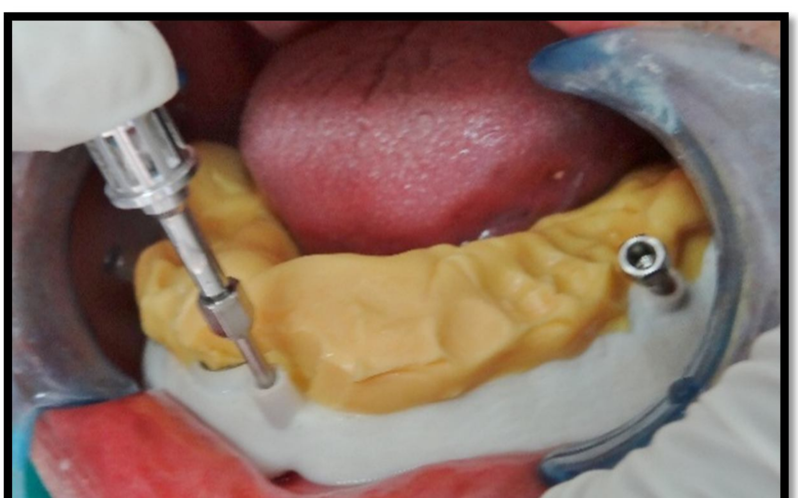

Figure 2: bite index and Screw fixation of the surgical guide.

Accuracy assessment

In this study, two observers separately reported the measurements regarding the accuracy of the dental implants to overcome the inter-examiner variability. Within one week after implant placement, postoperative CBCT scan was taken for the patients with the same preoperative scan prosthesis and interocclusal bite index. STL registration and superimposition of the pre and postoperative CBCT scans were performed by the help of the same radiopaque markers (Amalgam tablets) of the two scans.

Accuracy was assessed by measuring the deviation between the planned and placed implants in the mesio-distal plane and bucco-lingual plane. Four deviation parameters were defined on each plane (global linear, lateral, vertical, and angular). The four diameters were measured for the coronal and apical center except for the angular deviation. On the mesio-distal plane, coronal, apical and angular deviations were measured on the panoramic view. Deviation measurements for bucco-lingual plane were performed on the axial view (to detect global linear, and lateral deviation) and the cross sectional view (to detect angular deviation and depth deviation).

Statistical analysis

All accuracy measurements of each group of implants were described in terms of mean and standard deviation (SD). Wilcoxon Signed-Rank test was used to assess the difference in means of accuracy measurements in comparing between pilot and full sequence implants. The significance level was verified at $P \leq 0.05$. The results were considered to be statistically significant if p-value was less than 0.05. Also 95% confidence intervals were reported.

RESULTS

A total of 120 implants were analyzed by comparing the preoperatively planned and actually placed implants. The mean values for the linear and angular deviation changes in the buccolingual and mesiodistal direction are listed in table (1).

By using a Wilcoxon Rank Sum test, there was no statistically significant difference between pilot and full sequence implants in all parameters except the angular deviation in the bucco-lingual direction, where pilot implants showed slightly greater deviation (1.8º).

Table (1): Accuracy measurements of both Pilot and Full sequence implants

Measurement			Pilot		Full sequence		Wilcoxon Rank Sum test		Interpretation***
			Mean	SD	Mean	SD	W coefficient *	p-value**	
Mesio-distal	Coronal	Global linear	1.27	0.64	1.40	0.58	1387.5	0.2323	No difference
		Lateral deviation	0.66	0.56	0.70	0.51	1474	0.4853	No difference
		Vertical deviation	0.79	0.61	0.96	0.65	1354	0.1655	No difference
	Apical	Global linear	1.69	0.98	1.43	0.62	1763	0.339	No difference
		Lateral deviation	0.95	0.85	0.91	0.60	1474	0.4853	No difference
		Vertical deviation	0.67	0.55	0.79	0.57	1380.5	0.2169	No difference
	Angular		5.28	3.57	3.86	2.15	1898	0.08338	No difference
Bucco-lingual	Coronal	Global linear	1.16	0.54	1.09	0.55	1709.5	0.5164	No difference
		Lateral deviation	0.60	0.41	0.58	0.48	1716	0.4925	No difference
		Vertical deviation	0.82	0.60	0.95	0.71	1467.5	0.4617	No difference
	Apical	Global linear	1.55	0.92	1.21	0.57	1902.5	0.07887	No difference
		Lateral deviation	0.68	0.55	0.63	0.49	1670.5	0.6709	No difference
		Vertical deviation	0.69	0.55	0.76	0.69	1581	0.9336	No difference
	Angular		4.95	3.13	3.08	1.87	2212.5	0.000404	Difference exists

DISCUSSION

In this study the present results showed that the mean values at the implant shoulder for the freehand final drilling, and full guided implant insertion groups were 1.27 and 1.40 mm, respectively. At the implant apex, they were1.69 and 1.43 mm, respectively. For the angular deviation they were5.28 and 3.86, respectively. These value are comparable to the values reported in a systematic review[14] investigating the accuracy and clinical performance of static computer-assisted implant surgery. It was found that the overall average deviation at the implant entry point was 1.12 mm, and 1.39 mm at the apex. The average angular deviation was 3.89 degrees.

In this study, it was found that there was no statistically significant difference in the linear deviation between implants inserted using the pilot drill guided surgical protocol and that inserted using the full sequence guided surgical protocol. Only there was a statistically significant difference in the angular deviation in the bucco-lingual direction, showing slight more deviation for implants inserted using the pilot drill guided surgical protocol, where the mean of the differences was 1.8º which is considered clinically irrelevant.

Behneke et al[15] found that free hand final drilling, results in significantly less accuracy than full sequence drilling. Compared with the freehand final drilling site preparation, a reduction of maximum deviation of 0.3 and 0.6 mm was achieved with the fully guided technique for the implant shoulder and the apex reference points, respectively. The contradiction between their results and the results reported in the present study might be attributed to the study design, sample size and type of guide support. The present study investigated tissue supported guides compared to tooth supported guides for *Behneke et al*. The deformation that might occurred with tissue supported guides might have masked the difference between the two groups. The present study was a split mouth design for 120 implants with true allocation and blinding during measurements while *Behneke et al* reported retrosoective data for only 46 implants with no true randomization and blinding.

Based on these results, it seems that pilot drill guided surgical protocol can be replaced by full sequence guided surgical protocol especially in cases with limited mouth opening as it provide more accessibility with lower cost. However, in cases with a close relationship to the vital structures or low bony quality, fully guided system is advisable to avoid slight movements of the hand during drilling and implant insertion[16].

CONCLUSION

Computer aided tissue supported surgical guide allows for accurate placement of implants designed by virtual planning. There was no statistical significant difference between implants placed using guided pilot drilling and full sequence guided drilling in the linear deviation. There was a statistical significant difference between implants placed using guided pilot drilling and full sequence guided drilling in the angular deviation in the bucco-lingual plane. However, the difference was not clinically relevant. Further investigations could be done to investigate other technical and procedure related factors that may affect the transfer accuracy of the preoperative virtual plan to the surgical field.

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