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DIGITAL SCANNING VS. DESKTOP SCANNING EFFECT ON ACCURACY OF GUIDED IMPLANT SURGERY IN PARTIALLY EDENTULOUS PATIENTS (RANDOMIZED CLINICAL TRIAL)

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ABSTRACT

Objective: To compare accuracy of surgical guided implant produced by intraoral scanner and desktop scanner in partially edentulous patients.

Material and methods: Ten individuals with partial dentures were chosen for implant insertion. Eight bilateral instances and two unliteral cases totaling 42 implants were implanted in 4 men and 6 females, with a mean age of 47 years (42-55 years) included. Patients were split into two equal groups at random (n = 21 each): group one Surgical guide manufactured using intra oral digital impression. while group two Surgical guide manufactured using model cast scanning by desktop scanner. a pre cone beam CT scan was done and post CBCT was done after implant placement with the same parameters of pre CBCT. Superimposition of CBCT scans was made. The linear and angular deviations of placed implants were measured.

Results: The mean 3D angle, platform, apical, and vertical deviations in the intraoral scan group were 2.5°, 0.7 mm, 1.1 mm, and 0.6 mm, respectively. While the average 3D angular, platform, apical, and vertical deviations for the desktop scanner group were, respectively, 2.6°, 0.1mm, 1.1mm, and 1.1mm.

Conclusion: both scanning protocols have comparable effect on apical , coronal , vertical and angular deviations of placed implants, although intraoral scanner shows less vertical deviation.

KEYWORDS: Intraoral scanner, partially edentulous patients, desktop scanner, linear deviations , angular deviations, surgical guide .

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INTRODUCTION

Surgical guide systems can be conventional or computer-guided systems. In addition, the computer-guided system can be subdivided into static and dynamic computer-assisted guideways. Computer aided surgery is more accurate than conventional free hand surgery. However, the static approach is more commonly used than the dynamic approach due to its easy handling and reduced costs [(1)].

The difference between the two systems is that the static systems in computer-guided surgery apply a static surgical guide or template made through a laboratory process, whereas the dynamic or computer-navigated systems use the mechanical or optical system to display the process on a real-time monitor [(2)].

Currently, the static surgical guide can be subdivided into three different systems: metal sleeve with drilling key handle type, metal sleeve without drilling key handle type, and non-sleeve without drilling key handle type. Different opinions exist on the classification of various types of surgical guides. For example, Balshi and Garver consider the state of the patient's teeth as the primary parameter and introduce three basic surgical stent guides for implant placement .Completely edentulous, Slightly edentulous/removable partial denture design or Slightly edentulous tooth-supported design [(1)].

Taking impression is a significant step in the dental diagnostic and treatment procedure within all dental fields. Dental impression-taking techniques have steadily developed into two separate types since the advent of digital technology in the 1980s: those that rely on conventional impression materials, such as alginate, polyether, silicone, plaster, and polysulfide; and those that utilise intraoral scanners (IOSs) and desktop scanners to create digital optical impressions [(3)].

As a result of developments in impression materials, technology of conventional impression has been extensively utilised for several years. Technology of digital impression has become more prevalent as digital dentistry has become more mainstream [(3-5)].

In terms of acquiring digital impressions, there are two widespread methods existing at the moment. One involves scanning a plaster cast using desktop scanner, meanwhile the other method includes scanning the patient's natural dentition by direct using of IOS [(3-5)].

In terms of reduced anxiety and nausea response, comfort, and better communication with the patient as they feel more involved in their treatment, this emotional involvement can be beneficial, the method that uses iOSs to obtain digital impressions appears superior to the method that uses desktop scanners to acquire digital impressions, which still requires the use of traditional impression technique to acquire physical impressions or casts.Patients have a tendency to prefer optical impressions reported in the literature [(3-5)].

According to Gallardo et al systematic .'s review, the advantage of a scan over a traditional approach is not necessarily that it is faster (a full arch scan may take 3-5 minutes, similar to the time needed for traditional impressions), but rather that it does not necessitate the extra steps of pouring and obtaining a physical plaster model. You can email virtual 3D models (proprietary or STL files) directly to the patient [(4)].

Additionally, if the intraoral scan is inaccurate or the clinician is dissatisfied with some of the features of the recorded optical impression, the problem may be quickly fixed by erasing the mistake and rescanning the area rather than having to go through the full process again. The traditional impression would have to be recreated. [(3)]

The aim of this study was to compare accuracy of guided implant placement produced by intraoral scanner and desktop scanner.

MATERIALS AND METHODS

Sample size calculation

The main consequence of this power study was lateral deviation at implant apex. Based on the findings of Lin CC et al (2020), the impact sizes with the value of (0.73) were calculated. Using an alpha () level of 5% and a beta () level of 20%, which results in a power of 80%, the minimum predicted sample size was 63 implants (21 implants per group). G*Power Version 3.1.9.2 was used to calculate sample size [(6)]

Participants

Eligibility criteria

- Patient seeking implant.

Partially edentulous patient.

- Placing flapless implants is possible for patients whose bucco-lingual bone thickness is more than 6 mm.
- Both sexes were involved.

Exclusion criteria:

- Completely edentulous patient.
- Patients who need sinus lifting or grafting in order to insert implants.
- Individuals with fine ridges.
- Patients with systemic conditions such uncontrolled diabetes mellitus that may have an influence on bone quality and Osseo integration.
- Patients with periodontal disease that is aggressive and inadequate dental hygiene.
- Patients getting chemotherapy or radiation treatment.
- Patients with restricted mouth opening.

Randomization:

- Patients were randomly divided to two groups .
- The whole sample size were divided into equal 2 groups.
- All patients who give consent for participation .

Implantation:

- Main supervisor generated the allocation sequence.
- Implantologist enrolled participants.
- Co-supervisor assigned participants to interventions.

Masking/blinding:

- The researcher and the observers, who were blind to the group to which this case belongs, gave each patient a code.
- Evaluators and statistician were blinded.

Patient history and clinical examination

Ten subjects—four men and six females—with a mean age of 47 years (42–55 years) had a careful history gathering process, clinical examination, and extra- and intra-oral comprehensive exams for each patient. There were eight bilateral cases and two unliteral instances.

Cone beam computed tomography and impression taking

To gather bone data inside the edentulous region where the implants were put, all patients had CBCT scans (Planmeca Promax 3D Mid - Asentajankatu, Helsinki, Finland). After acquisition, the pictures were exported as digital imaging and communication in medicine (DICOM). In group I, a full arch digital imprint was obtained using an intraoral scanner (Medit i700 Seol, South Korea) to create a surface tessellation language (STL) file for the patient's digital cast. In group II, a conventional imprint was made, followed by pouring to create a plaster cast, which was then scanned using a desktop scanner (Medit T, Seol, South Korea) to create a digital cast in the STL file format.

Implant planning and guide fabrication

In the virtual implant planning step, the implants position and angulation were virtually designed **(Figure 1)**. The width (diameter) and length of each implant were measured at the proposed sites. The type and size were chosen from the implant library supplied by the software depending on the implant system used(dentaurum,Ispringen ,Germany).

For multiple implants, a parallelism tool was used .

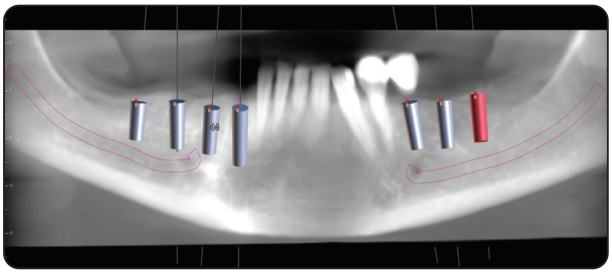

Fig. (1) Virtually planned implants of upper and lower jaw and nerve tracing

The STL image was overlay with the DICOM data from each patient's CBCT scan using Blue Sky Bio Implant Planning Software (Langenhagener, Mdi Europa GmbH) (Figure 2). A 3D printer (laser printer T310 ,Seol, South Korea) is used to produce the guides in the process of "guide printing" **(Figure 3).**

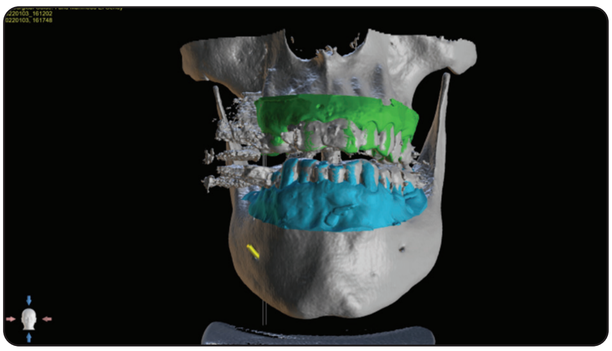

Fig. (2) Superimposition of CBCT with STL to fabricate the guide.

Fig. (3) 3D printed lower guide .

The 3D printed guide was autoclaved for 15 minutes at 121°C and a pressure of + 1 bar in order to sanitize it since the guide's accuracy was unaffected by the sterilization process. The guide was then checked to make sure it was adjusted and steady throughout surgery in the patient's mouth [7].

Surgical procedure

The implant placement was carried out under local anesthesia. After checkingthe anesthesia, the surgical guide was inserted inside patient's mouth.

The completely guided implant kit was used to execute drilling in the fully guided protocol up to the final drill. The osteotomies were produced in line with the manufacturer's instructions for fully guided protocols. The osteotomy sites required to be drilled in line with the drill sequence after completing the drilling technique. We were able to manage the drilling depth using a drill stopper **(Figure 4).** After the right depth had been prepared, the implant was placed [8].

Using insertion torque data, the main implant stability was evaluated at the moment of implant placement [9].

Evaluation methods:

Patients were recalled for another post CBCT scan with the same parameters of pre CBCT scan.

Then superimposition was done. Linear deviations were measured in mm and angular deviations in degrees by using blue ski bio software. **(Figure 5)**

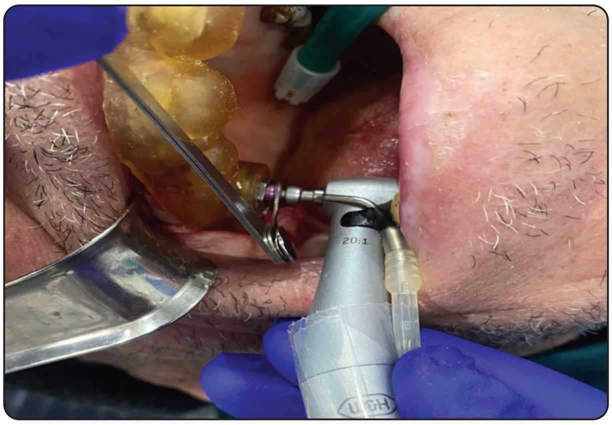

Fig. (4) Fully guided implant placement protocol.

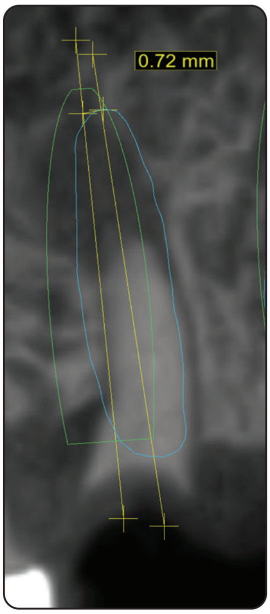

Fig. (5) Apex deviation at mesiodistal axis.

Statistical analysis

By examining the distribution of the data and using normality tests, numerical data were examined for normalcy (Kolmogorov-Smirnov and Shapiro-Wilk tests). The distribution of all the data was non-normal (non-parametric). The median, range, mean, and standard deviation (SD) values were used to show the data. For comparison between the two groups, the Kruskal-Wallis test was used. For pair-wise comparisons where the Kruskal-Wallis test is significant, Dunn's test was used. Comparisons within each group were made using the Wilcoxon signed-rank test. The cutoff for significance was chosen at P 0.05. With IBM SPSS Statistics for Windows, Version 23.0, statistical analysis was carried out. IBM Corp., Armonk, New York

RESULTS

3D (global)Angular deviation

Comparison between groups

Preoperatively, the two groups showed a statistically significant difference (P-value 0.001, Effect size = 0.725). IOS scan had statistically considerably smaller angular deviation than desktop scan, according to pair-wise comparisons across groups.

Post-operatively, there was no statistically significant difference between Desktop scanner and IOS scan (Table 1).

TABLE (1) Descriptive statistics and results of Kruskal-Wallis test for comparison between angular deviation (°) in the two groups

Time	IOS scan (n = 21)		Desktop scanner (n = 21)		*P*-value	*Effect size (Eta squared)*
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Pre-operative	0.6 (0.1-2.2) [C]	0.9 (0.6)	5 (2.1-10) [B]	4.6 (2.1)	<0.001*	0.725
Post-operative	7.2 (3.1-20.7) [B]	2.5 (4.2)	8.4 (3.9-12.3) [B]	2.6 (2.4)	0.019	0.108

: Significant at P ≤ 0.05, Different superscripts in the same row indicate statistically significant difference between groups

Global Horizontal deviation

No statistically significant difference existed between the two groups at the coronal level (P-value = 0.054, Effect size = 0.140).

There was no statistically significant difference between the apical level of IOS scan and desktop scanner (Table 2).

Vertical deviation

Between the two groups, there was a statistically significant difference (P-value = 0.029, Effect size = 0.254). Desktop scanner demonstrated statistically considerably larger vertical deviation than IOS scan, according to pair-wise comparisons across the groups (Table 3).

TABLE (2) Descriptive statistics and results of Kruskal-Wallis test for comparison between horizontal deviation (mm) in the three groups

Level	IOS scan (n = 21)		Desktop scanner (n = 21)		*P*-value	*Effect size (Eta squared)*
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Coronal	0.7 (0.25-1.4)	0.71 (0.34)	0.88 (0.25-2.6)	0.99 (0.69)	0.054	0.140
Apical	0.95 (0.5-2.9) ^{B}	1.17 (0.73)	0.95 (0.35-3.45) ^{B}	1.15 (0.92)	0.025	0.066

***: Significant at P ≤ 0.05, Different superscripts in the same row indicate statistically significant difference between groups**

TABLE (3) Descriptive statistics and results of Kruskal-Wallis test for comparison between vertical deviation (mm) in the three groups

IOS scan (n = 21)		Desktop scanner (n = 21)		*P*-value	*Effect size (Eta squared)*
Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
0.6 (0.1-1) ^{B}	0.68 (0.29)	1.2 (0.1-1.8) ^{A}	1.16 (0.67)	0.029*	0.254

***: Significant at P ≤ 0.05, Different superscripts in the same row indicate statistically significant difference between groups**

DISCUSSION

This an invivo study as invitro study could be an overestimate of accuracy and underestimate of error owing to absence of limitations, which subsequently leads to confounding factors, including mouth opening limitations, bleeding, saliva, bone density and mucosal resilience. Clinical factors including intraoral condition of patients, is also capable of affecting the deviation of implant [2].

With the computed tomography data, the transfer of intraoral conditions are conducted into the implant planning software. Surface scans of an item without artifacts are produced using optic scanners. A 3D picture cannot be created without doing many scans at various angles. Optical scanning was generally done to obtain STL data for the morphology of soft tissue and remaining teeth. Obtaining of STL data can be performed using the casting model's extraoral scan (EOS) through an optical (desktop) scanner or CBCT or digital intraoral scan (IOS) [2,10].

IOS has recently been used in multiple trials to demonstrate the performance of a totally digital surgical workflow, notably in patients who are partly edentulous. Two RCTs that examined the accuracy of implant placement using the IOS and EOS techniques in individuals with partial dentition who had at least five healthy teeth left and had only lost one tooth. Between the EOS and IOS techniques, both RCTs produced outcomes that were equally accurate. Therefore, both methods may be utilized to design computer-guided implant surgery for individuals who have some remaining teeth. This fits in with the findings of our investigation [(2)].

The definition of accuracy is stated as the deviation between the position of dental implant in the postoperative position and planning. Virtual three-dimensional implant planning transfer to the field of surgery without deviations is impractical as well as it is fundamental to figure out the accuracy level in addition to the method utilised and the conditions that may impact the accuracy degree[(11,12)].

Global accuracy may be impacted by errors. The alignment of the CBCT and the obtained digital scan, mistakes made during the collection of the CBCT picture, an erroneous tolerance, or improper installation of the guide sleeve are examples of such errors [(2)].

An essential aspect of implant dentistry is evaluating the precision of guided implant surgery, which mainly entails contrasting an implant's actual location with its anticipated position. Digital definitive casts or cone beam computed tomography are used in the two major methods [(12)].

The mean angular deviation, platform 3D deviation, apical 3D deviation, and vertical deviation in this study's intraoral scan group were 2.5°, 0.7 mm, 1.1 mm, and 0.6 mm, respectively. While the mean angular deviation, platform 3D deviation, apical 3D deviation, and vertical deviation for the desktop scanner group were, respectively, 2.6°, 0.1mm, 1.1mm, and 1.1mm.

Recent evaluations have emphasized the precision of the implant's location when it is put utilizing a surgical guide. According to data from a recent systematic study, there was a maximum variation of 4.5 mm and an overall mean deviation at the entrance site of 0.9 mm (95 percent confidence interval (CI) 0.7-1.1 mm). With a maximum of 7.1 mm, the comparable apex values were 1.3 mm (95 percent CI 0.05 to 1.5 mm). The largest angular deviation was 21.2°, with a mean deviation of 3.5° (95 percent confidence interval: 3.0-4.1). They came to the conclusion that CAIS increases implant placement accuracy [(10)].

An accuracy meta-analysis showed an average inaccuracy of 1.3mm at the apex and 1mm at the entering point. Additionally, Kiatkroekkrai et alfinding's revealed that the average angle deviation, platform 3D deviation, and apical 3D deviation in the intraoral scan group were 2.41°, 1.47°, and 0.87mm, respectively. The average angular deviation, platform 3D deviation, and apical 3D deviation for the extraoral scan group were 3.23 2.09°, 1.01 0.56 mm, and 1.38 0.68 mm, respectively. They solely compare the intraoral group with the lab in this research. Scanner group, while the sample size was the same as this research[(10)], the greater mean of angular deviation in this study compared to our meta-analysis may be caused by various IOS and lab scanner types and single edentulous sites [(13)]**.**

To evaluate the precision of implant placement, two separate radiographic and non-radiographic techniques may be utilized. The gold standard for assessing sGIS accuracy was pre-and post-operative CT overlapping until recently. The main problem with CT matching is that the post-operative implant geometry is unclear because of the titanium implant's streaking metal artefacts, which might lead to an incorrect estimate of the implant's location [(6)].

The accuracy of implant placement has often been evaluated using radiographic techniques by comparing pre- and post-operative CT scans using specialized software in related investigations.

With the patient's agreement and the ethical committee's clearance, the CBCT matching technique was used in the current investigation to measure the deviations of both planned and installed implants. After manually estimating the implant's location, we utilized a metrology software best-fit technique to replace the unclear implant's post-operative CBCT picture with an STL file of the implant. By reducing the risk of mistakes induced by manually defining the implant image, this computational processing assisted to get a more reliable implant location post-operatively.

CONCLUSION

Although the intraoral scanner exhibits less vertical deviation, the effects of both scanning techniques on the apical, coronal, vertical, and angular deviations of implanted implants are similar.

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