

Clinical Accuracy of Static Computer-Assisted Implant Surgery (sCAIS) for Single Implant Placement: An In Vivo Study

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ABSTRACT

Objective: The objective of the present study is to evaluate the accuracy of static Computer-Assisted Implant Surgery (sCAIS) in single-tooth implant placement by using formula method.

Materials and Methods: Total of 10 patients with one missing posterior tooth (unilaterally or bilaterally) in maxilla or mandible were selected for guided implant surgery. After implant placement, measurements between planned implant, achieved implant and reference anatomical landmarks on radiographs and images of planning software were noted and evaluated the accuracy by using formula method.

Results: The results of present study showed that mean measurement deviation of 0.35 mm at the implant crest and 1.03 mm at the implant apex, and angular deviation of 1.3°. The results showed greater accuracy in terms of the mean values of positional deviations. The main difference was at the apex (p value = 0.03mm) and least difference in crestal position (p value = 0.21mm).

Conclusions: It was found that guided implant surgery by using sCAIS is as accurate as planned and therefore, within the limitations, present study recommends digital guided implant surgery for single implant placement with high accuracy.

Keywords: Digital Guided Implant Surgery, Prosthetically Driven Implant Placement, Accuracy of sCAIS

Introduction

The dental implant has become a widely accepted treatment modality in the field of dentistry to rehabilitate patients with single, multiple, and/or complete edentulous sites [1]. Successful dental implant placement depends not only on osseointegration, but also on the function and esthetics of the final prosthesis. Poor treatment planning and deficient surgical procedures may lead to compromised implant position and thus predispose to compromised outcomes and short- or long-term complications [2,3]. Proper implant position is considered today an essential prerequisite for ensuring successful treatment outcomes, as well as long-term maintenance of the prosthesis and the peri-implant tissue health.

Implant placement taking into consideration the appropriate angulation and position in relation to the adjacent teeth and underlying bone, or “prosthetically driven placement”, is quickly

gaining popularity. Implant placement in single tooth space is a straightforward clinical procedure in implant dentistry when not involving bone augmentation. And implant treatment for single missing tooth is the best option for patients than other restorative procedures [4].

Nowadays, digital technologies are gaining a predominant position in implant dentistry. CBCT scans provide clinicians with Digital Imaging and Communications In Medicine (DICOM) data which can be aligned with Standard Tessellation Language (STL) files obtained from intraoral scanners in Computer-Aided Design (CAD) software to plan implant treatment and design drill guides. However, the accuracy of these separate technologies, the drill guides as well as the patients' perception of the treatment when using these technologies are still subject of debate [5].

Digital-Guided Implant Surgery (DGIS) or Computer-Assisted Implant Surgery (CAIS) is a technique in which digital imaging is combined with CAD/CAM software and equipment to plan

the most accurate approach to implant surgery. This method enables the clinician to select the most appropriate implants for a case, based on the patient's anatomy and dimensions of their soft-tissue, available bone, and arch. Implant surgical guide facilitates proper positioning and angulation of implants using CBCT and assist in treatment planning [6]. Guided implant surgery solutions offer clinicians the predictability and confidence of optimal implant positioning. Implant dentistry has shifted from a "surgically driven approach" to a "prosthodontically driven approach", because appropriate implant positioning is crucial to achieve long-term functional and esthetic success. Digital technology is now commonly recommended because it can reduce inaccuracy in terms of implant positioning [7]. Studies on the accuracy of implant placement report greater accuracy with respect to the planned position of the implant when surgical guides were used compared to freehand implant surgery [8-10].

When using static Computer-Aided Implant Surgery (sCAIS) in partially edentulous cases, a higher level of accuracy can be achieved when compared to fully edentulous cases. The mean 3D deviation for sCAIS at the entry point was 1.2mm (1.04, 1.44, 95% CL), at the apical position was 1.5mm (1.29, 1.62mm, 95% CL), and for angular deviation was 3.5° (3.00, 3.96, 95% CL) [5]. For single implant placement, a tooth-supported surgical guide is generally considered the most accurate option. Tooth-supported surgical guide offers a high level of stability and precision during the implant placement procedure. Since they are attached to the patient's natural teeth, they provide a stable reference point for accurate implant positioning [11].

Several methods for surgical guidance have been proven effective in increasing accuracy. However, guided surgery is not always the chosen option due to lack of facilities or the urgency of the case. Moreover, malpositioning of the drill guide by inaccurate software and hardware, could lead to a misplacement of implants. Given appropriate presurgical planning, including 3-dimensional radiographic imaging and proper case selection, 3D guided implant surgery may be an acceptable alternative. Therefore, it is critical to identify the accuracy of digital guide to achieve the accurate positioning of the implant fixture. The purpose of this study is to determine the accuracy of digital-guided surgical planning in single-tooth implant placement.

Materials and Methods

Patient Selection

This study proposal was approved by the Institutional Review Board of University of Dental Medicine, Mandalay with the approval number of IRB-02M-2023-UDMM. Surgical guide was produced using 3Shape implant studio software. All implant surgeries were conducted under local anesthesia by one experienced implantologist. The implantologist confirmed the virtual planning and drilling sequence prior to the surgeries. Fit and stability of the 3D surgical guides were verified prior to the surgery through tactile inspection and confirmed the fit through the respective window areas of the guide on cusps of the teeth.

Since the drill guides were only tooth-supported, flapless procedures were performed. All implants used in this study

were SQ bone-level Dentis implants (Korea) ranging from 4.0 - 5.0mm in diameter and 8 - 10 mm in length. All implants were placed following 1-stage protocol. After implant surgery, postoperative orthopantomogram (OPG) radiograph was taken. Paired preoperative CBCT images and postoperative OPG radiographs were chosen with reproducible landmarks. The primary clinical outcomes were (1) mesiodistal position of the center of the implant at the crest of bone, (2) mesiodistal position of the center of the implant at the apex and (3) the angulation of the implant in the mesiodistal plane.

Quantification of positioning accuracy (At crest of bone)

The distance between the two adjacent teeth at the crest of bone (1a) of the tooth-borne edentulous site was taken in planning software. The same distance (1b) was measured again by hand on the image to calculate the relationship between the image size and the actual anatomy. The distance between bone crest of mesial adjacent tooth and center of planned implant was measured (1c) by hand. Then same distances (2b, 2c) were measured again in postoperative OPG. This method was performed for each implant individually. True distance between bone crest of mesial adjacent tooth and center of implant was calculated by using the following formula for planned and achieved implant.

$$\text{For planned implant} = xi = \frac{(1a)(1c)}{1b}$$

$$\text{For achieved implant} = xa = \frac{(1a)(2c)}{2b}$$

Quantification of Positioning Accuracy (At apex)

The distance between the apexes of two adjacent teeth (3a) of the tooth-borne edentulous site was taken in planning software. The same distance (3b) was measured by hand on the image to calculate the relationship between the image size and the actual anatomy. The distance between apex of mesial adjacent tooth and center of planned implant apex was measure (3c) by hand. Then the same distances (4b, 4c) were measured again on the postoperative radiograph to calculate the distance between the center of the implant and the adjacent tooth at the apex in millimeters for both the planned and the achieved implant. This method was performed for each implant. True distance between apex of mesial adjacent tooth and center of implant was calculated by using the following formula for planned and achieved implant.

$$\text{For planned implant} = xp = \frac{(3a)(3c)}{3b}$$

$$\text{For achieved implant} = xq = \frac{(3a)(4c)}{4b}$$

Quantification of Angulation Accuracy

Mesiodistal angulations of the adjacent tooth (bi°) and the planned implant (ai°) position were recorded in planned software. Then the same angulations (ba° , aa°) were measured in postoperative OPG image. The difference between the two angulations were calculated. The discrepancy in angulation between the planned and achieved implants were calculated in degree. One investigator performed all measurements.

$$\text{For planned implant} = (ai^\circ - bi^\circ)$$

$$\text{For achieved implant} = (aa^\circ - ba^\circ)$$

Statistical Analysis

The collected data was coded, and entered by using MS excel 2006. Statistical analysis was performed by using Statistical Package for Social Sciences (SPSS) statistical software version 22. The normality of the collected data was checked first, the data was described by mean and standard deviation or median and IQR (interquartile range). Paired t-test was used for the comparison of the variables. P value < 0.05 was considered statistically significant.

Results

Measurement of Planned Implant Positions at Crest of Bone and Apex

The mean position of planned implant at crest of bone is 6.99mm with standard deviation of 5.04mm. The mean position of planned implant at apex is 9.44mm with standard deviation of 3.41mm. Descriptive statistics for planned implant position at crest of bone and at apex are shown in Table 1.

Table 1: Measurement of Planned Implant Positions at Crest of Bone and Apex

	Positions of planned implants (mm)			
	Mean	SD	Minimum	Maximum
At crest of bone (xi)	6.69	1.66	4.24	9.33
At apex (xp)	9.44	3.41	4.03	14.77

Measurement of Planned Implant Angulation

The mean difference in angulation of planned implant and adjacent tooth is 7.25° with standard deviation of 3.95°. Descriptive statistics for difference in angulation of planned implant and adjacent tooth is shown in Table 2.

Table 2: Measurement of Planned Implant Angulation

	Angulation of planned implant (degree)			
	Mean	SD	Minimum	Maximum
(ai° - bi°)	7.25	3.95	1.5	12.5

Measurement of Achieved Implant Positions at Crest of Bone and Apex

The mean position of achieved implant at crest of bone is 6.9mm with standard deviation of 1.71mm. The mean position of achieved implant at apex is 10.23mm with standard deviation of 3.38mm. Descriptive statistics for achieved implant position at crest of bone and at apex are shown in Table 3.

Table 3: Measurement of Achieved Implant Positions at Crest of Bone and Apex

	Positions of planned implants (mm)			
	Mean	SD	Minimum	Maximum
At crest of bone (xa)	6.9	1.71	4.33	10.38
At apex (xq)	10.23	3.38	5.23	14.28

Measurement of Achieved Implant Angulation

The mean difference in angulation of achieved implant and adjacent tooth is 7.55° with standard deviation of 3.72°. Descriptive statistics for difference in angulation of planned implant and adjacent tooth is shown in Table 4.

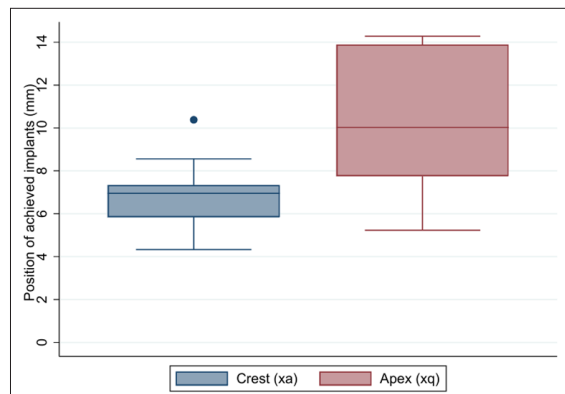


Figure 1: Measurement of Achieved Implant Positions at Crest of Bone and Apex

Table 4: Measurement of Achieved Implant Angulation

	Angulation of planned implant (degree)			
	Mean	SD	Minimum	Maximum
(aa° - ba°)	7.55	3.72	3	14

Comparison of Planned and Achieved Implant Positions at Crest of Bone

The result of Paired t- test indicated that there is no significant difference in position of planned and achieved implant at crest of bone (p value = 0.21mm).

Table 5: Comparison of Planned and Achieved Implant Positions at Crest of Bone

	Positions of planned and achieved implants at crest of bone (mm) Mean (SD)	95% CI of the difference		P value
		Lower	Upper	
Planned (xi)	6.69(1.66)	5.5	7.88	0.21
Achieved (xa)	6.9(1.71)	5.68	8.12	

*Paired t-test p value < 0.05

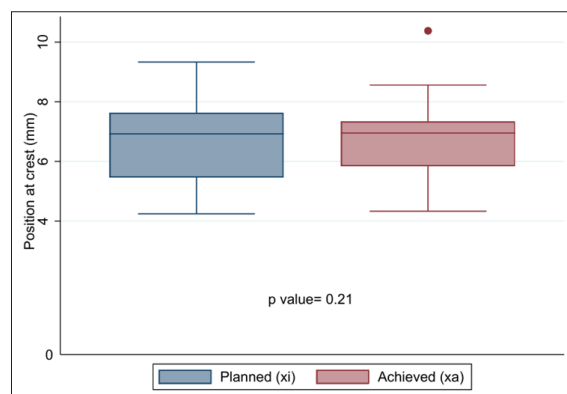


Figure 2: Comparison of Planned and Achieved Implant Positions at Crest of Bone

Comparison of Planned and Achieved Implant Positions at Apex The result of Paired t- test indicated that there is significant difference in position of planned and achieved implant at apex (p value = 0.03mm).

Table 6: Comparison of Planned and Achieved Implant Positions at Apex

	Positions of planned and achieved implants at apex (mm) Mean (SD)	95% CI of the difference		P value
		Lower	Upper	
Planned (xp)	9.44(3.41)	7.01	11.88	0.03
Achieved (xq)	10.23(3.38)	7.82	12.65	

*Paired t-test p value < 0.05

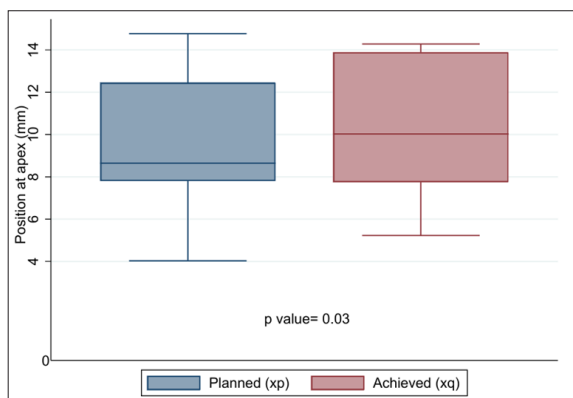


Figure 4: Comparison of planned and achieved implant positions at apex

Comparison of Planned and Achieved Implant Angulations

The result of Paired t- test indicated that there is no significant difference in angulations of planned and achieved implant (p value = 0.54mm).

Table 7: Comparison of Planned and Achieved Implant Angulations

	Angulations of planned and achieved implants (degree) Mean (SD)	95% CI of the difference		P value
		Lower	Upper	
Planned (ai° - bi°)	7.25(3.95)	4.43	10.07	0.54
Achieved (aa° - ba°)	7.55(3.72)	4.89	10.21	

*Paired t-test p value < 0.05

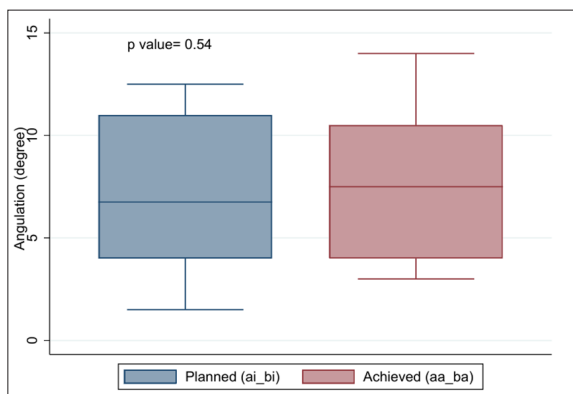


Figure 5: Comparison of Planned and Achieved Implant Angulations

Discussion

The implementation of digital technology has influenced the dentistry at a great place. With the rapid development of CAD/CAM systems, the digital workflow is continually growing in dentistry and is considered essential role in modern dentistry. This study performed to evaluate the accuracy of digital-guided implant surgical planning in single-tooth implant placement.

Positional Deviation Measurements of Accuracy of sCAIS

The results of our study showed that mean measurement deviation of 0.35mm at the implant crest and 1.03mm at the implant apex, and angular deviation of 1.3°. The results of the present study showed greater accuracy in terms of the mean values of positional deviations.

To date, many authors have reported on the clinical accuracy of Computer-Assisted Implant Surgery (CAIS). The early studies showed wide range of measurements as the imaging technologies (CBCT) and intraoral scanners had not reached the most accurate levels of nowadays. However, many comparative studies on the accuracy of implant position performed by sCAIS and freehand techniques were conducted in vitro. Sarment et al. and Nokar et al. reported that the deviation achieved with a CAD/CAM surgical guide was less than that of conventional stents in all dimensions [12,13]. These results were in agreement with the combined in vivo/in vitro study from Nickenig et al. [14]. It was found that the 3D surgical guide template produced significantly smaller variation between the planned and actual implant positions at the implant shoulder (0.9mm) and apex (0.6–0.9mm) compared with the free-hand implantation (2.4–3.5mm and 2.0–2.5mm). In a meta-analysis, Schneider et al. reported a mean angle deviation of 5.3° (95% CI: 4.0-6.6°) and a mean deviation at the implant shoulder and apex of 1.1mm (95% CI: 0.9-1.4mm) and 1.6mm (95% CI: 1.3-2.0mm) respectively. Another meta-analysis reported a mean angle deviation of 3.8° (0-24.9°) and a mean deviation at the implant shoulder and the implant apex of 1.0mm (ranging from 0-6.5mm) and 1.2mm (ranging from 0-6.9mm) respectively [15,12]. Nevertheless, both of these reviews included in vivo and in vitro studies, addressing single and multiple missing teeth, thus affecting the ability to directly extrapolate to more specific clinical settings.

In a systematic review of Tahmaseb et al., it revealed mean total errors of 1.12mm at the implant platform and 1.39mm at the implant apex, and a mean angular deviation of 3.89° [16]. Cassetta and his colleagues observed the accuracy of a computer-designed surgical guide comparing three dimensional positions of planned and placed implants. They observed quite high deviation values between the postoperative position and the preoperative plan at the coronal and apical portions of implants, as well as in the angulation of implants. And the influence of some clinical factors in determining the precision of the surgical guide were also studied [17,18].

Studies on technical accuracy of surgical guides reported possible drilling access deviation of 0.16 to 0.6mm horizontally and 0.5mm vertically, and angle deviation in the range of 0.4 to 3.3degrees [19-21]. Derksen et al. stated that the mean angular deviation was 2.72° ± 1.42, the mean three-dimensional deviation at the implant's entry point was 0.75mm ± 0.34 and at implant's apex, the mean was 1.06mm ± 0.44 [22]. The number of

unrestored teeth, the implant's location, the implant's length, and cortical interference had a significant influence on the accuracy of placement. Skjerven et al. examined the in vivo accuracy of 27 implants in 21 patients using a fully digital planning modality and SLA surgical guides [23]. The mean lateral deviation at the implant platform/apex, depth deviation, and angular deviation were 1.05mm/1.63mm, +0.48mm, and 3.85°, respectively.

Regarding the in vivo accuracy of sCAIS using conventional planning workflow, a meta-analysis of 14 clinical studies by Zhou et al. reported a mean global deviation of 1.25mm at the implant platform, 1.57mm at the implant apex, and a mean angular deviation of 4.1° [24]. Lin reported a mean global deviation of 0.78mm at the implant platform/crest and 1.28mm at the implant apex; the mean angular deviation $4.30 \pm 2.87^\circ$ [7].

In the systematic review conducted by Abad-Coronel in 2024, ten studies reported coronal deviations ranging from 0.44 to 0.56 mm, apical deviations from 0.64 to 1.03 mm, angular deviations between 2.03° and 2.42°, and vertical deviations from 0.19 to 0.45 mm. Overall, static guided techniques demonstrated superior accuracy, while bilateral guides provided greater stability, and 3D-printed guides were found to be more cost-effective.

Currently, Huth conducted a randomized controlled clinical trial comparing dynamic (dCAIS) and static (sCAIS) implant surgery in 45 patients (70 implants) [25]. No significant differences in accuracy were found ($p > 0.05$). Mean deviations (dynamic vs. static) were 4.89° vs. 5.01° (angular), 1.81 mm vs. 1.55 mm (base), and 2.01 mm vs. 1.78 mm (tip) indicating that dCAIS provides comparable accuracy to sCAIS for implant placement.

The results of present study supported Skjerven et al., Derksen et al., Lin, Cristial Abad-Coronel and others who concluded that the least difference in crestal position but not coincided in the main difference, which was in apex while others stated was angular deviation [233,22,7,26]. The differences in the results of the studies are different, but reasonable, considering that in vitro studies, which are conducted in a well-controlled environment, normally have a higher accuracy compared to in vivo studies. And accuracy measurement methods would also influence the different data.

Özden Yüce et al. concluded that tooth-supported surgical templates had no particular effect on the accuracy of single implant placement [27]. Nevertheless, this procedure allows flapless surgery with minimal invasive approach, reduce operation time and post-operative pain levels. Guides supported by posterior teeth were more accurate than guides supported by anterior teeth because of the geometry and increased surface area of the posterior teeth [28]. Bilateral tooth-supported guides exhibited highest in vitro accuracy and similar in vivo accuracy to unilateral tooth-supported guides; mucosa-supported guides exhibit lowest in vivo accuracy [29]. The guides used in the present study were mostly partial and showed less deviation in all assess points. It could be due to the location of implant placement and because of single edentulous site.

However, it was concluded that the deviation of implant position was not affected by implant location, diameter or length for

both static CAIS and freehand implant surgery [30,31]. Choi et al. reported that practitioner's experience and width of the edentulous space significantly influenced implant position in both guided and freehand implant surgery [30]. As one experienced implantologist performed all surgeries in this study and addressed only a single edentulous space with the presence of mesial and distal neighboring teeth, such factors could not influence the present results.

Some researchers concluded that the accuracy was better for tooth-supported guides than bone and mucosa-supported guides [8,9,7]. Derksen et al. concluded that guided surgery with tooth-supported drill guides made in a digital workflow is a feasible treatment option [22]. All implants installed in this study were tooth-supported sCAIS because of single missing tooth and showed high accuracy results. In maxilla, because of greater supporting surface, and with the fixation of the surgical guide, accuracy of the guides was improved [17,18]. There were no obvious findings which showed different accuracy of surgical guides whether in maxilla or mandible in present study. And there was no screw fixation necessary as guides were well fitted in positions.

Zhou et al. stated that the position of guide, guide fixation, type of guide and flap approach could influence the accuracy of computer-aided implant surgery [24]. A totally guided system using fixation screws with a flapless protocol demonstrated the greatest accuracy. Implant's length, location, cortical interference and the number of unrestored teeth have a significant influence on the accuracy [22].

Derksen et al. showed significantly higher deviations at the implants apices and entry points in cases with unrestored teeth, moreover, longer implants (12mm) and implants which did not had cortical interference showed less angular deviations [22]. Implants that were lacking a directly neighboring tooth or implant to support the drill guide showed larger deviations at the implant apices and entry points. In this study, only 10mm length implants were used to clearly recognize the other effects. The crowding did not influence the accuracy; however, in moderate and severe crowding cases, seating of the drill guides sometimes consumed more time. Due to the described inaccuracies, caution needs to be taken in cases with limited bone or challenging anatomical circumstances.

The distance between sleeve to crestal bone (height of sleeve relative to bone) is also affect the accuracy of guided implant surgery [32]. The static computer-assisted implant surgery showed high trueness and precision. The closer the sleeve to the bone, the more accurate and precise the method. Freehand implant placement was less accurate and precise than partially or fully computer-assisted implant surgery [33]. In our study, no clear solution has been drawn how sleeve to bone distance effect the accuracy because of small sample size.

Methods to Evaluate the Accuracy of sCAIS

To date, the most commonly used method to assess the accuracy of sCAIS was the pre- and postoperative CT overlapping [34,4]. Although commonly applied to the accuracy studies, the major problem of CT matching is that, because of the streaking metal artifacts of the titanium implant, the geometry of the post-

operative implant was ambiguous, which could lead to an incorrect estimation of the implant position [4]. Another issue of the CT matching method was that the use of postoperative CBCT might be considered ethically questionable because the patient was exposed to extra radiation dose.

A different method using the digital impression technique and implant scan body to identify the implant position has been proposed [4]. This CAD/CAM-based method could reduce the radiation exposure of the patient; it was also reported to be more accurate than the CT matching [35]. The accuracy of these measurement methods should be further investigated. In the study of Derksen, post-operative intraoral scanning was used instead of a post-operative CBCT scan. This non-invasive treatment evaluation tool eliminates the need for a post-operative CBCT scan, thereby reducing the total patient radiation exposure. However, this method cannot specifically validate whether an implant is placed within the bone; it only demonstrates the difference between the planned and the actual position [22].

Choi et al. proposed the formula method that calculate the discrepancy in position between ideal and achieved implants at crest, apex and angular deviation [30]. It can reduce the unnecessary radiation dose to the patient who has no specific indication for postoperative CBCT. In the present study, we adopted this formula method to measure the accuracy of sCAIS. As Choi et al., stated that limitations which prevented accuracy assessment in the buccolingual plane were encountered [30]. In the present study, formula method showed many inaccuracies especially while measuring distances between planned implant and neighboring anatomical landmarks in images.

Smits et al. evaluated the accuracy of sCAIS by using postoperative CBCT [31]. It provided accurate measurements which reliable and validate results. However, there is an ethical consideration that should postoperative CBCT be taken for investigation purpose. In 6th ITI consensus, with regard to implant treatment planning, CBCT provides cross-sectional images that demonstrate high accuracy and reliability for linear bone measurements with a relatively low radiation dose according to As Low As Diagnostically Acceptable (ALADA) guidelines [5]. If there is the reason for taking postoperative CBCT, it would be good opportunity to assess the accuracy of implant installed by sCAIS.

Similarly, in the study of Lin, pre- and post-operative CBCT images were superimposed, and the positional and angular deviations between placed and planned implants were measured with metrology software [7]. It concluded that the sCAIS planned by a fully digital workflow is with satisfactory accuracy so that it may be reliable for partially edentulous patients. The advantage of pre- and postoperative CBCT method is that it can confirm the position of the implant immediately after the placement. However, the artifacts created from the material of the implant (titanium) can cause ambiguity of the radiographic outline of the implant. This ambiguity generates the overall enlargement of the implant contour, which results in a confirmation of the precise position only through estimation. Problems in the image precision and sharpness can be improved if the newly developing metal artifact reduction method (MAR) is introduced [36].

Another method to evaluate the accuracy of sCAIS is superimposition of the planned and the placed implant positions in 3D pre- and postoperative CBCT [4]. In other words, two pieces of three-dimensional information need to be superimposed on a single identical plane. Superimposing two planes requires three or more different reference points that are not in a straight line. Moreover, the accuracy of the superimposition is determined by the resolution of the CT, which consists of a DICOM file. It is better to use both the direct and indirect methods to define the position of the placed implants. However, it is expected that an optimization algorithm that can automatically recognize and exactly extract the border of the implant from the CT image will be developed in near future. This algorithm requires the help of artificial intelligence, because the experience using the direct method and indirect method must continuously be accumulated.

Limitations of the Study and Further Recommendations

Major limitation relies on the method to evaluate the accuracy of sCAIS. In the present study, formula method showed many inaccuracies especially while measuring distances between planned implant and neighboring anatomical landmarks in images. Although ethical issue and metal artifacts are the main concerns, the most commonly used method to assess the accuracy of sCAIS is the pre- and postoperative CBCT overlapping. Further studies should be emphasized on optimization algorithm that can automatically recognize and exactly extract the border of the implant from the CBCT image using artificial intelligence. And developing consensus statement on taking post-operative CBCT following the ALARA principle.

Conclusion

Within the limitations of this study, the results show digital guided implant surgery has greater accuracy in terms of the mean values of positional deviations. The main difference was at the apex (p value = 0.03mm) and least difference in crestal position (p value = 0.21mm). Guided implant surgery by using digital surgical guide is as accurate as planned positions and angulations. Therefore, present in vivo study concluded that computer assisted implant surgery provides high accuracy of implant positions and recommended treatment option for single implant placement.



Figure 6: Single missing tooth for sCAIS

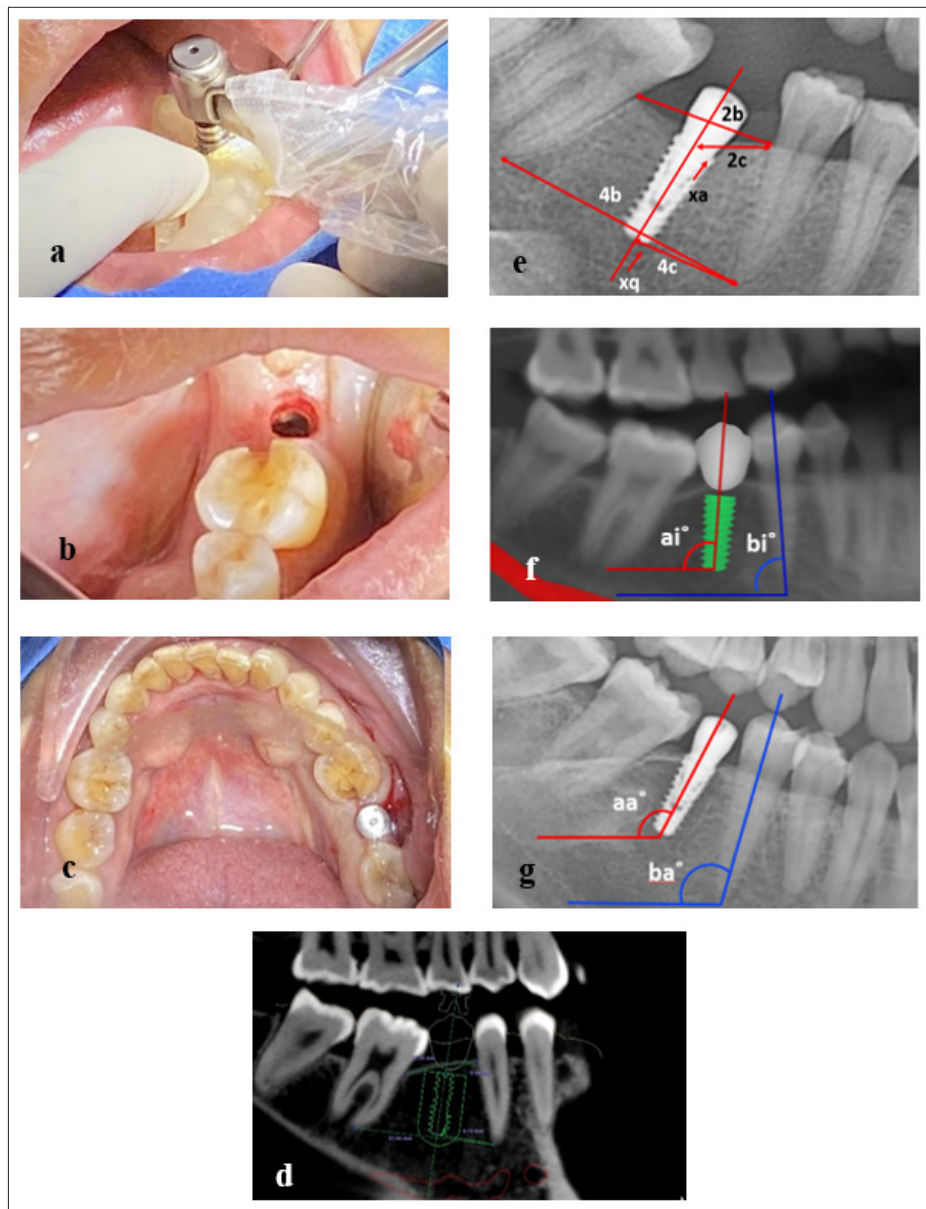


Figure 7: a to c: Clinical steps of sCAIS; d to g: Measurements of the accuracy of sCAIS

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