

“Retrospective Cohort Study on the Accuracy and Precision of Shaft-Guided Implant Drills: Clinical Research”

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Abstract:

Background: Guided implant surgery with immediate loading may improve placement accuracy and preserve crestal bone.

Aim: To evaluate shaft-guided implant placement accuracy and five-year crestal bone changes using BioHPP abutments.

Materials and Methods: This retrospective study included 58 patients receiving 60 implants through a digital workflow. Implant accuracy was assessed using CBCT, and crestal bone changes were evaluated over five years.

Results: Mean 3D deviation was 0.54 ± 0.41 mm at the platform and 0.73 ± 0.60 mm at the apex, with a mean angular deviation of $2.4 \pm 1.9^\circ$. Mean marginal bone loss at five years was 0.865 ± 0.26 mm.

Conclusion: Shaft-guided implant placement with immediate loading using BioHPP abutments demonstrated clinically acceptable accuracy and favourable long-term bone stability.

Key Word: shaft-guided implant drills, BioHPP abutment, CAD/CAM.

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I. Background

The Restoration of missing or failing teeth with implant-supported prosthesis is one of the most viable treatment options, and considering the higher success rates documented by long-term clinical trials over the decades and its subsequent wide acceptance rendering it as the first restorative option in many clinical situations[1-5]. Traditionally, dental implants require a healing period of 3 to 6 months before loading, but this may increase patient burden, especially when restoring in the esthetic zone. The development of computer-assisted guided surgery has helped realize prosthetic-driven implant placement. Contemporary guided implant surgery systems are generally based on cone-beam computed tomography (CBCT) and computer-aided design and computer-assisted manufacturing (CAD/CAM) technologies. CBCT visualizes anatomic structures without superimposition, which enables 3-dimensional (3D) diagnosis and treatment planning. CAD/CAM technologies improve the fabrication of surgical guides by reducing manual work and facilitating the transfer of the planned implant position to the guide template. Accurate placement of implants makes it possible to deliver restorations to the patient's mouth on the day of the surgery. Accordingly, these advancements have optimized implant treatment to be more predictable, less invasive, and faster from both a surgical and a prosthodontic point of view[6]. Various studies have clinically demonstrated high success rates of implants with immediate loading [7,8] with no changes in the osseointegration process or the level of bone loss [9,10]. Given these, a meta-analysis by Zhang et al. in 2017 compared clinical and radiographic outcomes of many recent randomized controlled trials evaluating loading protocols and supported the immediate loading protocol as a good selection in implant restoration, reducing the treatment time without influencing marginal bone loss or osseointegration [11,12].

Frequent removal and reinsertion of the abutment in a staged implant restoration play a critical factor in the onset of crestal bone loss due to the formation of micro-gaps where pathogenic bacteria can be trapped [13-15]. Thus, the success of implant therapy largely depends on precise implant planning and correct three-dimensional placement with shorter restorative phases using the one-time-abutment protocol which is best carried out through digital workflow. It often requires thorough communication between the surgeon, prosthodontist, and qualified dental technician as it is influenced by many factors such as anatomical variations, prosthetic materials, and superstructure designs.

Studies have shown that guided implant placements are highly accurate and predictable [16,17]. However, it's important to note that even with static-guided implant surgery, small errors can accumulate

throughout the process and cause deviations. These errors can happen during the acquisition and transfer of data, the virtual implant planning, the 3D printing of the stent, and the mechanical deviation from guided implant systems that can occur during the surgical procedure due to instrument tolerance and the operator's skills. This can lead to a challenging situation for clinicians when an immediate final prosthesis is planned and milled but can only be delivered after major chairside modifications. Therefore, it is crucial to have restorative materials available that have easy-handling properties and sufficient strength to compensate for these potential deviations.

The recent revolution in CAD/CAM technology for prosthetic dentistry has led to the innovation of newer chair-side milling materials, among which PEEK and Ceramic-reinforced PEEK (BioHPP) are gaining much attention [18]. PEEK is a thermoplastic polymer with high mechanical performance that has been used in general medicine since the 1980s, and its applications in dentistry has increased. However, the elastic modulus is very low compared to cortical bone and cannot be advised to be used as a final abutment [19]. On the other hand, Bio-HPP shows promising results regarding physical, mechanical, and bio-compatibility properties. The material's surface offers excellent conditions for healthy peri-implant tissue attachment and demonstrates bacteriostatic properties, lowering the prevalence of peri-implant mucositis. It has an ideal modulus of elasticity, allowing a progressive transmission of masticatory force and softer loading of dental implants, making it a good choice of material for final implant superstructures [20-23]. Considering its easy handling characteristic and esthetic compliance, integrating this biomaterial with a complete digital workflow allows clinicians to plan the implant position and fabricate the final custom implant abutment before the surgery with the added advantage of modifying the abutment in the mouth to compensate for any deviation that occurs [24]. Stereolithographic guides are primarily used to provide precise information for guiding the osteotomy in the orientation and location of implants based on pre-surgical planning. However, the rapid development of this technology has created unrealistic expectations for its effectiveness and ease of use. While the literature shows varying results due to deviations occurring at each step, the contribution of each step to the overall error remains unclear due to the plurality of equipments and softwares. Additionally, there is a lack of information on the transfer error of 3D guides to the surgical field and its effect on the prosthetic field.

Therefore, this study aims to evaluate the accuracy and precision of shaft-guided surgical drills (SKY pro guide, bredent medical, Germany) by implementing a complete digital workflow for guided implant placement and immediate restoration with a prefabricated prosthesis that connects to the planned implant position immediately post-surgery and assess the effect of immediate loading using BioHPP hybrid abutment on crestal bone [27-29].

It is hypothesized that minimizing the tolerance between the drills and guide sleeve would result in higher accuracy of implant placement, while immediate loading would limit crestal bone loss.

The Null hypothesis is that guided implant placement causes a significant deviation that could lead to failure in the immediate prosthetic phase and loss of bone at the crest. This emphasizes the importance of carefully evaluating the potential risks and benefits of these techniques in dental implant procedures.

II. Material And Methods

For this retrospective cohort study carried out at a private practice Opus dental speciality, India, 58 patients with either a missing or a failing tooth indicated for immediate or delayed implant placement were treated with 60 guided implants (blueSKY, bredent medical, Germany) integrated with definitive immediate loading using BioHPP (SKY elegance, bredent medical, Germany) one-time abutment and High Impact Polymer Composite (HIPC) crown.

Inclusion criteria : All patients were screened based on clinical and radiographic examination as per the inclusion criteria:

- (a) at least 18 years old partially edentulous adults with at least six teeth remaining,
- (b) expected sufficient bone volume to perform implant insertion with at least a 3.5 mm implant diameter without simultaneous bone augmentation
- (c) extractions performed at least 3 months earlier for type 3 & 4 implant placement (Chen & Buser, 2009)
- (d) External sinus lifts were performed at least 6 months before implant placement in patients indicated for the procedure,
- (e) Fulfill criteria for immediate loading i.e. implant insertion torque greater than 35Ncm and ISQ 68-75
- (f) follow-up for at least 1 year after final restoration and (g) no history of systemic bone disease or Bisphosphonate therapy and stable medical condition to undergo implant surgery, smokers were not excluded.

Exclusion criteria were as follows:

- (a) implant placements and simultaneous ridge augmentation,
- (b) physical or psychological disorders generally contraindicating implant therapy,
- (c) patient with long-span edentulous space with no distal support (3-4 teeth),

- (d) presence of periapical infection for immediate placement situation
- (e) less than one year of follow-up after definitive restoration.

After initial screening, all patients underwent a CBCT examination (CS 8200, Carestream Dental LLC, India) with a field of view of 120x 85 mm, voxel size 0.2mm at 90 kV, 6.3mA, an exposure time of 15 seconds, following standard guidelines ensuring the teeth are not in occlusion and oriented parallel to the floor by calibrating the interorbital plane with the marking on the machine. Additionally, an intraoral scan with interocclusal bite was acquired for both arches using an intraoral scanner (CS3600® Carestream Dental LLC, India). The resulting Digital Imaging and Communication in Medicine files (DICOM) and Standard Tessellation Language (STL) files were imported into implant planning software (coDiagnostiX, Dental Wings GmbH, Germany) and matched using a surface registration protocol.

The resulting alignment of the STL model and DICOM data was carefully examined, and a digital wax-up was performed considering the ideal prosthetic and anatomic conditions following which a virtual mock implant surgery (blueSKY, bredent medical) with required diameter and length was carried out and examined in 3-dimensional aspect, this implant position was locked once approved by the surgeon. The surgical guide was designed and exported in STL format for 3D printing (Asiga max UV, India) with 3 mm wall thickness and 0.08 mm of guide-teeth offset, and a rotation marker was incorporated, which aids in the correct placement of the implant in relation to planned abutment and crown, metal surgical guide sleeves (SKY pro guide, bredent medical) specific to the system. The sleeves (bredent pro guide) were incorporated into the printed surgical guide. An approved surgical plan was printed to provide instructions during implant surgery. All the surgical guides were tooth-supported and patients were treated by the same clinician between 2017 and 2018.

This study examines the use of shaft-guided drills that are composed of three parts (Fig 1): the stopper part, the guide part, and the drilling part. The stopper part of the drill corresponds to the stepped structure of the sleeve's internal surface and limits the drilling depth when the two structures are joined. The guide part of the drill fits closely with the metal portion of the guide and restricts unwanted motion during drilling.

To plan the prosthesis, a virtual scan body is configured over the planned implant and exported to CAD software (exocad GmbH, Germany). The implant model is generated and the superstructure is designed using an appropriate abutment (SKY elegance Prefab BioHPP abutment, bredent medical). The design is then exported to CAM software for milling of the definitive abutment and HIPC crown. Finally, a digital model is printed for verification of the prosthesis in relation to the planned implant position.

Fig 1: Shaft guided drill



Pre-surgical antibiotics (Augmentin 625 mg) and anti-inflammatory medications (Enzoflam) were administered 2 hours before the procedure. Surgeries were performed by a single operator following standard operative protocols thereby eliminating intra-operator errors. A static surgical guide was verified intra-orally for

Fig 2 : Matching of the CBCT data Set with Virtual Implant

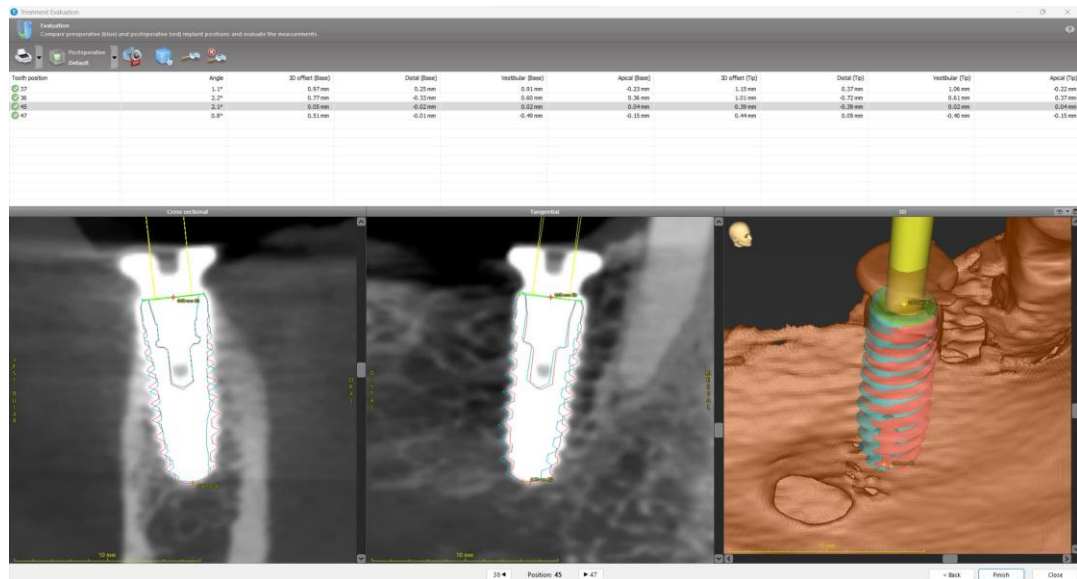
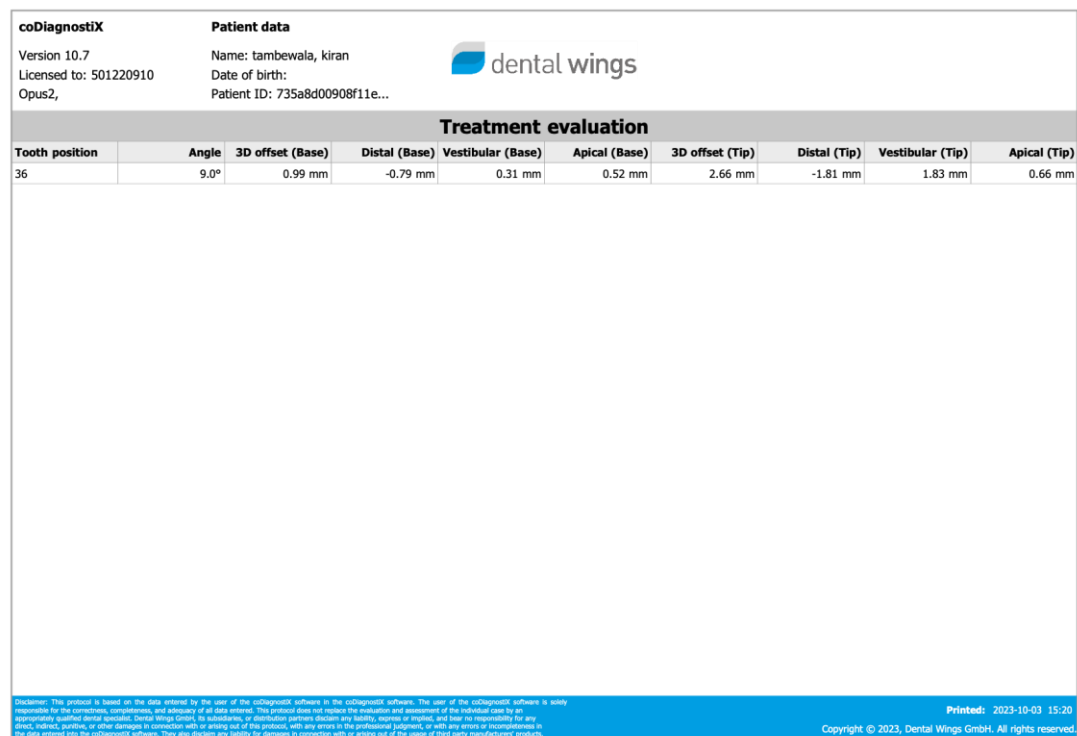


Fig 3 : Deviations calculated by Treatment Evaluation Tools



correct seating and stability; a flapless approach was performed after nerve block or infiltration anesthesia using 2% lignocaine and epinephrine 1:100,000 (Lignospan, SEPTODONT, Louisville). Osteotomy was performed following the manufacturer protocols (SKY pro guide, bredent medical). Implant stability was assessed with

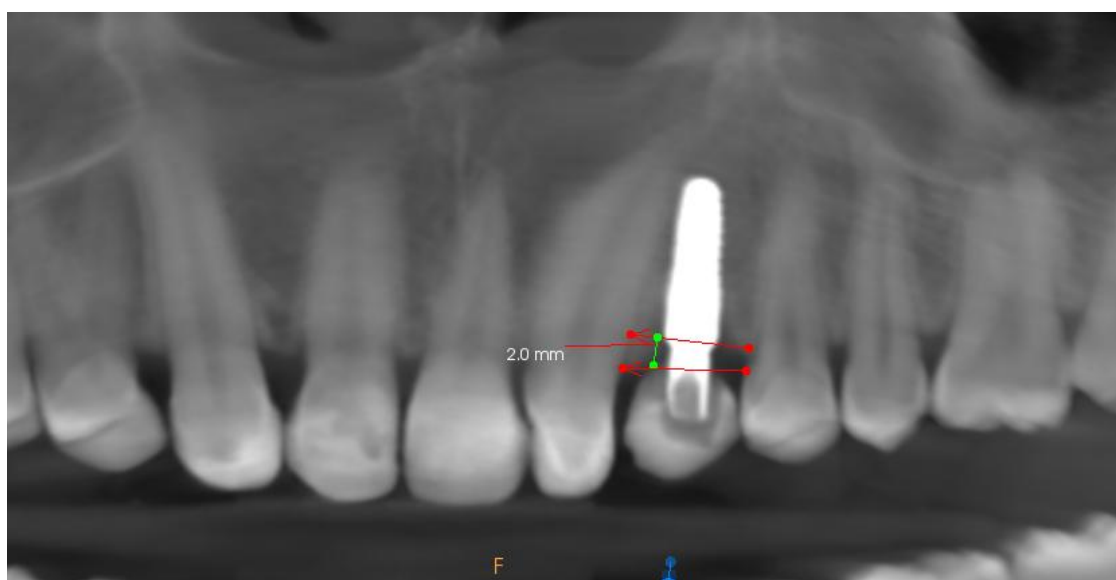
radio frequency analysis using Penguin RFA (Integration Diagnostics Sweden AB, Gothenburg, Sweden). Implant stability quotient (ISQ) values ranging between 68-75 and insertion torque of >35 Ncm were indicated for immediate loading of the implant [11, 12, 19].

Following this, the ceramic-reinforced BioHPP Final abutment was inserted, and the prosthetic position was verified. The crown was luted to the abutment extra-orally using visio.link primer (brendent) and combo.lign luting cement (brendent). The excess cement was removed and light-cured; the surface was polished using Diamond polishing wheels (3M™ Sof-Lex™, India). The abutment was torqued to 25 Ncm (final torque) as per the manufacturer's protocol. Access holes were plugged with Teflon, layered with composite and a post-operative CBCT scan was acquired.

A treatment evaluation software was made available by Dental Wings to assess the accuracy of the final implant positioning. The software allowed each post-operative data set to be compared to the planned implant positioning, which provided the following deviations: angle, 3D offset, distal, vestibular, and apical errors in positioning (for both the implant platform and apex). The CBCT post-operative file was imported into coDiagnostiX using the same method described above for the pre-operative scan. The scan was then segmented, adjusting the gray value to most clearly visualize dental elements. The same parameters were then used to segment the pre-operative scan. This facilitated the seamless overlapping of the images for the post-operative comparison. The “planned implant” outline was then manually moved within the radiopaque implant position, as viewed in the sagittal, axial, and coronal planes (Fig 2). The software then calculated the deviation in the distal, vestibular, and apical directions (Fig 3). The distal value denoted a distal discrepancy when positive, and a mesial discrepancy when negative. The vestibular value indicated a buccal deviation when positive, and a lingual deviation when negative similarly the apical value showed the implant was positioned beyond the planned depth when positive, and short of the intended depth when negative. The total 3D offset was also listed, which was the calculated hypotenuse of the three points created by the distal, vestibular, and apical data. The total angular discrepancy was listed in degrees. All the data was entered into a Microsoft Excel spreadsheet and overall averages were calculated [28,29].

CBCT Scans were taken annually and studied in CS 3D imaging software (Carestream Dental LLC,

Fig 4: crestal bone loss assessment



India) for crestal bone loss by reconstructing Panoramic images by drawing the panoramic curve on the axial image, and then cross-sectional images were created parallel to the implant's long axis. On the axial image, the coronal section was adjusted to pass through the implant, and then bone levels from the implant neck to the mesial and distal bone were measured in millimeters (Fig 4) [34]

III. Result and Discussion

Result:

In this study, 58 patients received 60 guided implant placement and immediate loading using ceramic-reinforced BioHPP one-time abutment and HIPC crown between March 2017 and December 2018. A follow-up period of 5 years was observed, during which no implant loss or associated pathology was observed. Eight patients did not attend the follow-up and were therefore excluded from the study.

The accuracy of implant placement was evaluated with dataset matching protocol with the treatment evaluation tool. The statistical analysis showed a mean 3D offset deviation of 0.54 ± 0.41 mm at the implant platform and 0.73 ± 0.6 mm at the base of the implant (i.e., the apex). The mean angular deviation was 2.4 ± 1.9 , and the mean deviations at the implant platform and apex were as follow: 0.38 ± 0.2 mm, 0.44 ± 0.3 mm, and 0.36 ± 0.25 for the distal, vestibular, and apical directions, respectively, at the implant platform (Table 1); and 0.4 ± 0.2 mm, 0.5 ± 0.5 mm, and 0.7 ± 0.6 mm for the distal, vestibular, and apical directions, respectively, at the apex. (Table 2)

Table 1) Distribution of mean deviation of Static guided implant surgery (Bredent Sky pro-guide surgical kit) [Measurements at the base (implant platform)].

	Mesio-distal deviation		Bucco-lingual-deviation		Corono-apical deviation		3D offset deviation	
Deviation (mm)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
At Base	0.3898	0.2675	0.4400	0.3593	0.3692	0.2528	0.5400	0.4110
Reference	0.0000	--	0.0000	--	0.0000	--	0.0000	--
P-value								
Base vs Reference	0.001***		0.001***		0.001***		0.001***	
P-value by one sample t test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.								

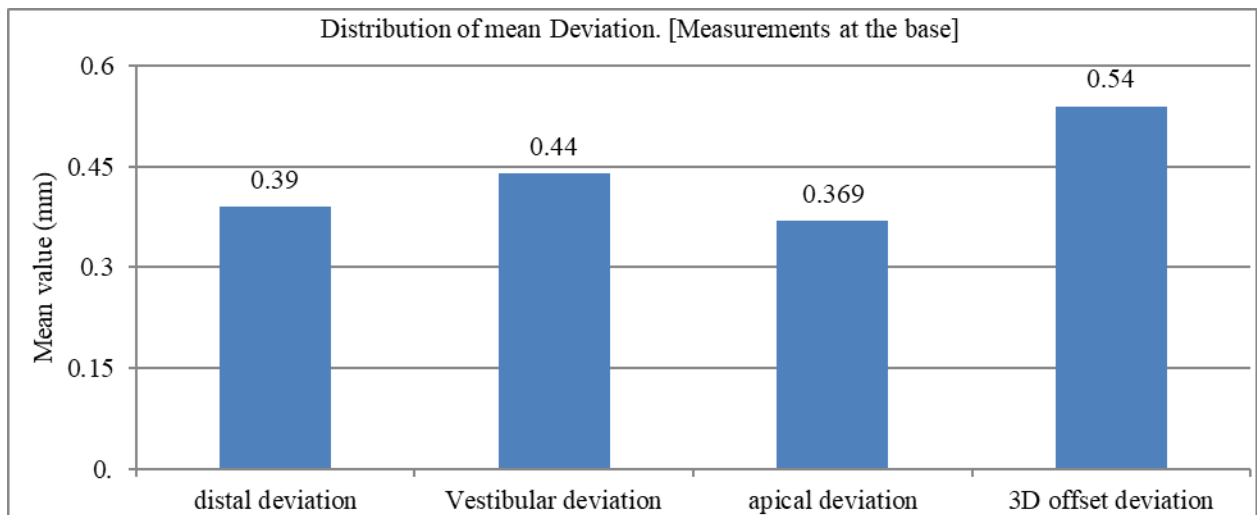


Table 2) Distribution of mean deviation of Static guided implant surgery (Bredent Sky pro-guide surgical kit) [Measurements at the apex].

	Mesio-distal deviation		Bucco-lingual-deviation		Corono-apical deviation		3D offset deviation		Global angular deviation	
Deviation (mm)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
At Apex	0.4012	0.2907	0.5216	0.5051	0.3806	0.3274	0.7320	0.6262	2.4720	1.9890
Reference	0.0000	--	0.0000	--	0.0000	--	0.0000	--	0.0000	--
P-value										
Apex vs Reference	0.001***		0.001***		0.001***		0.001***		0.001***	

P-value by one sample t test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.

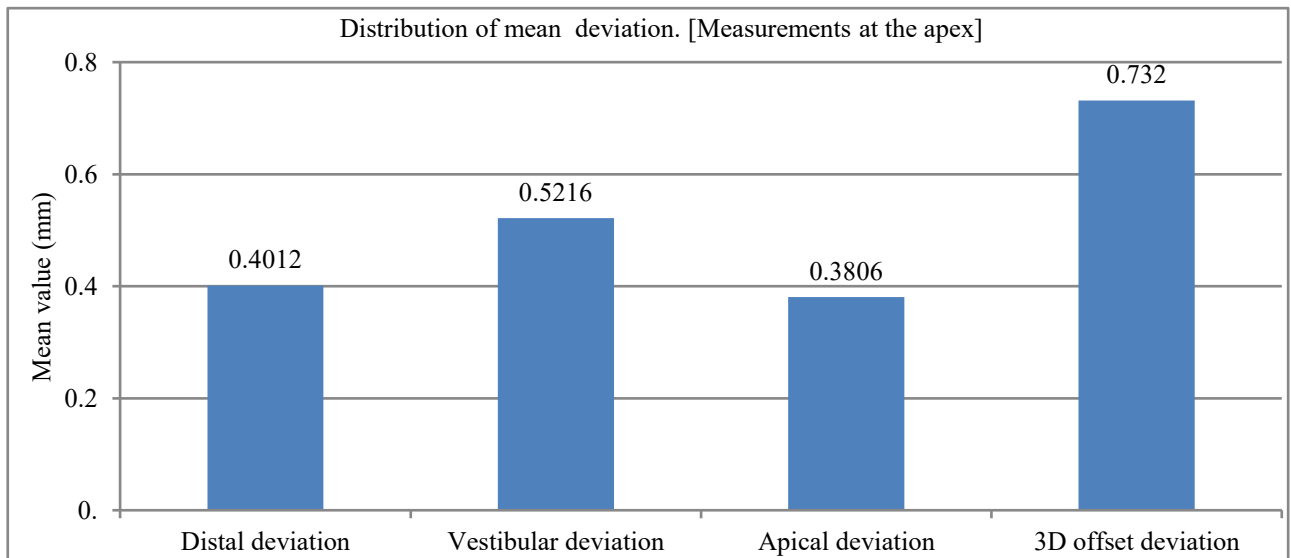
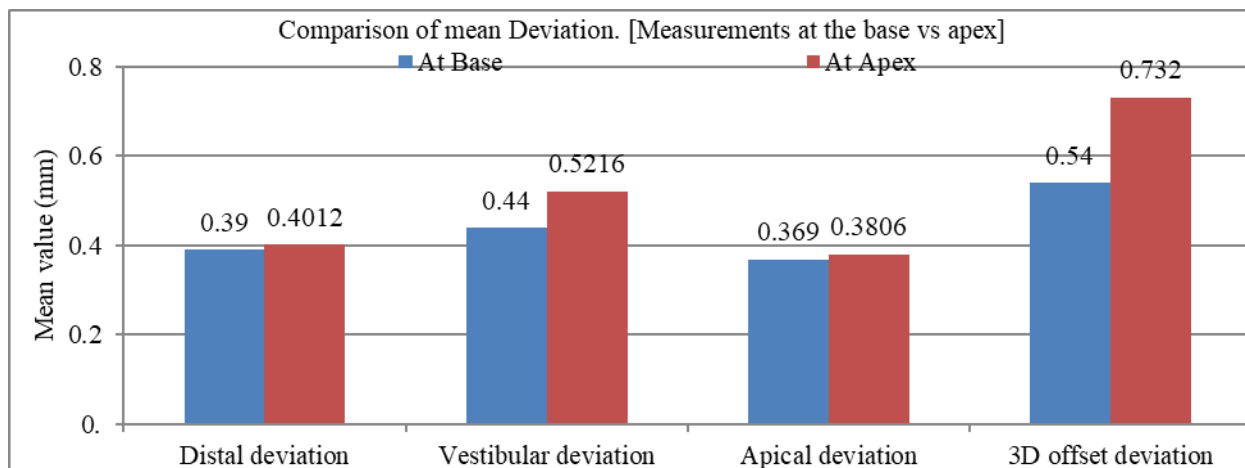


Table 3) Comparison of mean deviations of Static Guided surgery [measurements at the base and the measurement at the apex]

	Mesio-distal deviation		Bucco-lingual-deviation		Corono-apical deviation		3D offset deviation	
Deviation (mm)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
At Base	0.3898	0.2675	0.4400	0.3593	0.3692	0.2528	0.5400	0.4110
At Apex	0.4012	0.2907	0.5216	0.5051	0.3806	0.3274	0.7320	0.6262
P-value								
Base vs Apex	0.840 ^{NS}		0.359 ^{NS}		0.847 ^{NS}		0.075 ^{NS}	

P-value by independent sample t test. P-value<0.05 is considered to be statistically significant. NS – Statistically non-significant.



The study found that the mean deviation of Distal, Vestibular, Apical direction, and 3D offset measurement showed no significant difference between the base and apex measurements (Table 3). These findings suggest that the variations in measurements were not substantial enough to cause deviation for the planned implant prosthesis (P-value>0.05 for all)

Statistical analysis shows that there are higher deviations in global angular measurement, followed by 3D offset measurement, and then distal, vestibular, and apical measurements when compared to the reference value of zero. However, these deviations are not clinically significant and do not have any impact on immediate implant restorations.

The study's results after 5 years of follow-up show a mean crestal bone loss of 0.86 ± 0.26 , (Table 3) compared to the baseline value of zero. This provides strong evidence that not removing abutments placed during surgery significantly reduces horizontal bone remodeling around immediately restored teeth. The minimal invasive nature of digital workflows, material and shape of the abutment also contribute to this effect.

Discussion:

Advancements in digital technology have brought about significant changes in the field of dentistry. The emergence of new intraoral scanners has effectively reduced patient discomfort, surgical complications, and potential treatment costs. This has led to more efficient and accurate treatment outcomes, resulting in predictable, precise, and time-saving procedures. With the help of guided implant dentistry and artificial intelligence, CAD/CAM systems can be used to create custom abutments and fabricate the final prostheses before surgery. This allows for same-day delivery and helps preserve the anatomical architecture of the patient's mouth especially when physiologic restorative biomaterials can be used to reduce the direct transmission of masticatory forces to the implant during healing phase. Therefore, the choice of restorative or superstructure biomaterials also plays a significant role in the success of these treatment modalities.

Recent studies conducted by Mostafa, El-Shabrawy et al. have suggested a higher level of satisfaction with PEEK abutment compared to zirconia abutment, based on assessments of modified gingival index and visual analog scores. In 2017, Skirbutis et al. [41, 18, 19] reported that PEEK has low plaque affinity properties, which results in minimal tissue remodeling and better healing of peri-implant tissue. This makes PEEK and ceramic-modified PEEK (BioHPP) the materials of choice for immediate implant restoration.

The present retrospective study assesses the accuracy and precision of static guided implant surgery with shaft-guided drills and marginal bone loss over 5 years using CBCT analysis. The precision of the system was evaluated by implementing a complete digital workflow, which included guided implant placement and immediate loading with one-time-abutment BioHPP abutment and definitive high-impact polymer crown (HIPC) crown. Computer-guided implant surgery has been developed over decades and the accuracy of static-guided implant surgeries (sGIS) has been widely investigated. A meta-analysis by Zhou et al. proclaimed a mean global deviation of 1.25 mm at the implant platform, 1.57 mm at the implant apex, and a mean angular deviation of 4.1° . Furthermore, a systematic review by Tahmaseb et al. reported mean total errors of 1.12 mm at the implant platform and 1.39 mm at the implant apex and a mean angular deviation of 3.89° for sGIS.

The results of the present study demonstrated a mean angular deviation of 2.4 ± 1.9 degrees and a mean horizontal deviation of 0.38 ± 0.26 mm in mesiodistal direction, 0.44 ± 0.35 mm in buccolingual direction, 0.36 ± 0.25 mm in apical direction at implant platform and 0.4 ± 0.2 mm (mesiodistal), 0.52 ± 0.5 mm (Bucco-lingual), 0.38 ± 0.32 (apical) at implant apex Respectively. The angular deviation of the Shaft

guided drills in this study was less than the general value of angular deviation reported in the systematic review. The findings presented here are consistent with those of Cassetta et al. who studied the effects of reducing the tolerance between the drill and guide sleeve on the total error of implant placement. In order to reduce tolerance, two tubes were used - a guide tube was attached to the head of the surgical handpiece, and a master tube was embedded in the surgical guide. The diameter of the guide tube was only 0.05 mm smaller than that of the master tube, which allowed for a close fit during the drilling procedure imitating the benefits of double sleeve guided surgery without its inconveniences. This prevented lateral movement of the drill and allowed only in-and-out motion. As a result, the accuracy of the system with the guide sleeve was superior to that of the system without it. The shaft drills used in this study have a similar mechanism for reducing tolerance. Therefore, it can be concluded that the direct guiding components play a crucial role in limiting lateral drill movement and that tolerance control is essential for improving the accuracy of the guided surgery system.

Even when the sleeve of the guide template limits the blade part of the drill, a certain amount of gap is inevitable to allow the rotation of the drill within the sleeve which leads to deviation. To increase the positional concordance of the planned and placed implants, it is important to use the drill in a centric position and parallel to the internal wall of the sleeve, which can be challenging in the narrow intraoral space. Meanwhile, the use of longer sleeves has been suggested as a mechanical approach to reduce the tolerance of surgical instruments. Although the above-mentioned parallel drilling and the use of longer sleeves help increase the accuracy of implant placement, the sleeve should still have some amount of tolerance to prevent friction when the drill is rotating. In other words, the gap between the drill and the guide sleeve is unavoidable, which leads to errors in implant placement. Perhaps, other materials such as ceramic or PEEK can be used for the drill and guides that prevent heating so that the tolerance can be further reduced.

The depth control of instruments is an essential element of a guide system with a completely limiting design. The addition of a stopper physically restricts the depth of the osteotomy by allowing drill advancement only to the level of the stopper. This depth control enhances safety by preventing drills from intruding on vital anatomic structures such as the maxillary sinus and inferior alveolar nerve. The stopper is also useful for placing the implant at the planned depth, which not only improves treatment convenience but also enables immediate placement of the planned prosthesis.

The accuracy of guided implant surgery is influenced by procedures that transfer the digital virtual plan to the surgical site. Possible individual errors originate from intrinsic sources, which include issues with radiography quality, file conversion, CAD software, and the tolerance between mechanical components; and extrinsic sources, which relate to the fit of the surgical guide, the mucosal thickness at the surgical site, the position of the edentulous area, and the surgeon's experience. The accumulation of individual errors produces the total deviation between planned and postoperative outcomes.[37] Further studies have also reported that short-span optical intraoral scans by surface registration protocol for treatment planning are more precise as compared to model scans resulting in higher stability of surgical guides and thereby presenting higher accuracy of the workflow.

This study revealed the error in the accuracy of the newly developed guided implant surgery system. Since the data were obtained from clinical cases related to the immediate restoration of single crowns, the outcome values are clinically valid and meaningful. However, this study did not specifically assess the effects of individual error sources. Thus, controlled in vitro experiments or large-size clinical prospective trials will be needed in the future to analyze these effects.

Dental implants lack the periodontal ligament, restoring implants with an extremely rigid prosthetic superstructure, causing stress concentration in the apical region of the implant. If these forces are at an unfavorable angle, they can negatively affect implant osseointegration or result in bone atrophy [21]. BioHPP, a ceramic-reinforced PEEK material offers more clinical advantages than PEEK and has a modulus of elasticity comparable to cortical crestal bone, aiding in the more diffused transmission of masticatory occlusal forces both in vertical and lateral planes thus providing softer loading of implants. This property positively affects soft and hard tissue remodeling, particularly during the healing phase for immediate loading situations [20,21]. In 1997 Abrahamsson [38] published a split mouth experiment in beagle dogs in which histology samples were obtained from a test implant group, wherein he connected and disconnected the abutments monthly for 6 months, and a control implant group which he kept the abutment intact (One-time-abutment). The authors reported significant bone loss and recession of the peri-implant mucosa in the test group compared to the one-time-abutment group resulting in more apically positioned zone of connective tissue.

The mean marginal bone loss reported in the present study, 0.3 ± 0.2 mm at 12 months and 0.865 ± 0.26 at the 5-year interval, was not statistically significant. These findings are in agreement with the results reported by Marco Degidi et al. and Grandi, T. et al. [39,40] which concluded that the non-removal of an abutment placed at the time of surgery results in a statistically significant reduction of the horizontal bone remodeling around immediately restored implants. However, José Vicente Ríos-Santos reported no statistically significant difference in crestal bone loss between the one-time abutment concept and the staged approach. The

difference in the findings between both studies could be attributed to the better tissue biocompatibility and bacteriostatic properties of BioHPP material compared to titanium and zirconia [5, 20, 21,23], suggesting more reliable results for the described treatment protocol.

IV. Conclusion

The present study confirms that the use of shaft-modified drills and metal sleeve-incorporated stereolithographic templates i.e. shaft-guided sGIS is an effective way to improve the accuracy of implant placement. The achieved precision in the clinical use has been sufficient to restore all implants in the study with a prefabricated single tooth restoration with only minor modifications. This is achieved by minimizing the mechanical tolerance of the instruments. Ensuring the centric position of the drill parallel to the cylinder further aids in improving the accuracy, therefore the operator is advised to move the drill several times in and out to feel the smoothest drill position.

The present study reports on a five-year follow-up of crestal bone changes in immediate loading scenarios involving ceramic-reinforced PEEK (BioHPP) abutments. Radiographic evidence, obtained through CBCT imaging, revealed an absence of significant bone loss, corroborating the effectiveness of BioHPP abutments in preserving bone level. Furthermore, the study demonstrated superior soft tissue stability, a result that may be attributed to the one-time abutment application of BioHPP abutments. These findings suggest that BioHPP abutments may hold promise as a viable treatment option for immediate loading scenarios and warrant further investigation.

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