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ACCURACY OF CUSTOM TWO-PIECE SURGICAL GUIDE FOR ALL-ON-FOUR DENTAL IMPLANT PLACEMENT IN PROSTHODONTIC DENTAL TREATMENT

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Abstract
The purpose of this research was to assess the usability of an implant navigation system among dental students and dentists with different degrees of expertise in prosthodontics. The success of any endosseous dental implant depends on the presence of healthy, functioning peri-implant hard and soft tissues. Participants were dental students and dentists from the same dental school and hospital, but with varying degrees of implant experience. At the outset of the trial, all participants received instruction in using the AqNavi system. We came up with a novel implant that uses computed tomography (CT) or Cone beam CT (CBCT) scanning to arrange its multi-vector endosseous attachment around each patient's unique underlying bone. Error deviations (total, longitudinal, and angular) were measured by each of the five dentists, and the differences between them were analyzed using one-way repeated-measures ANOVA. The results proved that the participants' prior implant expertise had no impact on the navigation system's operating accuracy for dental implants. The implant navigation system helps the dentist place the dental implant in the ideal location, regardless of the dentist's prior expertise with similar procedures. Our "individual patient solutions dental" protocol is based on the principle of a fully functional and rigid osteosynthesis technology and provides a rapid solution for implant-borne dental rehabilitation in challenging conditions of soft and hard tissues, setting it apart from any previous or current dental implant protocol.

Keywords: Prosthodontic, Dental, Surgical, implant, teeth

INTRODUCTION

By using a surgical guide, a dentist may ensure that an implant is placed at the precise, predetermined site that will provide the best depth, angle, and size for the given area. For stability, it rests over the neighboring teeth like a hard acrylic mouthguard. Each implant drill is guided through the aperture by one or more metal cylinders inserted in the acrylic, ensuring that the drill can travel just one area and to only one depth. Surgeons used to have to open patients' gums and measure the breadth of their jawbones during implant placement before the development of implant surgical guides. Together with a 2D x-ray, this data would be used to estimate how far away from the implant site critical anatomical components like nerves, the nasal floor, and the sinuses need to be in order to ensure adequate retention. After a few months of recovery have passed and it is time to install a crown on top of the implant, the dentist may discover that the implant isn't in the best possible site to do so. This may make it difficult to restore a tooth to its normal form, and it can cause problems such as poor oral hygiene (due to food being trapped) and an unattractive look (due to the crown's protruding from the gums in an unnatural way). The digitally created crown of the tooth is then used as a surgical guide to ensure the tooth is placed in the optimal spot in relation to neighboring teeth, the tongue, and the lips. Before beginning surgery, the best possible implant width and length may be chosen and digitally inserted into the best possible spot in the bone by integrating digital tooth information with a 3D x-ray (called a CBCT). By preparing with the final objective in mind, the operation may be completed more quickly and with a better outcome, and any problems can be more easily identified and addressed before the procedure even begins.

Endosseous implants (dental implants) are prostheses that are placed into bone in order to serve as anchors for orthodontic braces or to support dental prostheses like crowns, bridges, dentures, or facial prostheses. Osseointegration is the biological process by which materials like titanium or zirconia create an intimate attachment to the bone and become contemporary dental implants. After surgical placement of an implant fixture that has been preconditioned for osseointegration, a prosthetic tooth is attached. Osseointegration, the biological process whereby an implant bonds with bone to become permanent, takes a varied period of time to complete before either the dental prosthesis (a tooth, bridge, or denture) is connected to the implant or an abutment is put, the latter of which will support a dental prosthetic/crown. Over the last three decades, dental implants have been the treatment of choice for patients who are missing one or more teeth. A thorough clinical evaluation of the patient is required before dental implant placement can occur, allowing for the selection of the most suitable procedures. In cases when a distal abutment is missing, a fixed bridge or crown supported by implants may be the most effective restoration. However, it might be challenging to precisely transfer the location of the implant abutments for the intended prosthesis(es) to the laboratory. Furthermore, the pressure from the prosthesis on the abutments might be affected by the angulation of the mandibular free-end saddles, leading to significant stress concentration in particular places, which can easily lead to implant failure. Surgical implant placement in the jaw is a common surgery, however there is little information available on the issue of guided implant placement. Computer tomography (CT) and traditional radiography tomography may be used to design the angulation and depth of implants. There have been several suggestions for surgical templates to aid in determining proper implant placement prior to surgery. Wax-ups, in which the patient's current denture is duplicated, may be used to create such molds. They may be designed by hand, based on a study cast, or with the use of a computer. Despite the widespread agreement on the value of using templates, the writers were unable to locate any research detailing their reliability.

LITERATURE REVIEW

Elnashoukaty HM, ElDakkak S, Abdelhakim A. (2023) The absence of external irrigation during osteotomy creation and the need for specialized drills and equipment have been cited as drawbacks to completely guided dental implant surgery, despite claims that it provides a high degree of precision. The precision of a tailored 2-piece surgical guide is debatable. The goals of this in vitro study were to (1) design and fabricate a novel surgical guide concept for guiding the placement of implants to the desired position and angulation without affecting the external irrigation during osteotomy preparation; (2) determine the guide's accuracy; and (3) eliminate the need for a specialized armamentarium. A two-part surgical guide was created using 3D modeling and printing. The newly constructed surgical guide was used to successfully position implants in laboratory casts according to all-on-4 principles. After surgery, a cone beam computed tomography image was layered on top of the intended implant placements to establish how far off from the original design they really were. A total of 88 implants were put using the all-on-4 method in 22 mandibular laboratory casts, using an alpha error of 5% and 80% research power. Both the freshly produced surgical guide and the standard fully guided technique were used on them. From the layered scans, we were able to calculate the deviations from the suggested design at the entrance point, the horizontal apex, the vertical apical depth, and the angles. The Mann-Whitney U test (α=.05) was used to evaluate the significance of differences in angular deviation, while the independent t test was used to analyze differences in apical depth, horizontal deviation at the apex, and horizontal deviation in the hexagon measurements. The apical depth deviation did not change significantly between the new and old guides ($P>.05$), but there were significant variations in the apex ($P=.002$), hexagon ($P<.001$), and angular deviation ($P<.001$). When compared to the fully guided sleeveless surgical guide, the new guide showed promise for more precise implant placement. In addition, it allowed for continuous circulation of irrigation around the drill during the drilling process without the need for any specialized equipment.

Taruna, M & Chittaranjan, Samuel & Sudheer, N & Tella, Suchita & Abusaad, Md. (2014) Endosteal dental implants used as load bearing abutments are heavily influenced by the mechanical environment in which they are placed. The treatment strategy determines the kind, quantity, and placement of implants. Increasing the anteroposterior spread of implants, placing longer implants, and maximizing the number of implants may alleviate pressure on the crestal bone in biomechanically impaired environments like poor-quality bone. One such treatment procedure that enlightens us for its use in completely edentulous patients and which also leaves behind the routine treatment alternative of conventional dentures with successful short-term, long-term, and retrospective studies is the All-on-4® concept. The success of the prosthesis and the prosthodontic approach based on the principles of occlusion are the primary areas of concern for any treatment option. This article examines the prosthodontic features of the All-on-4® concept.

Thimmegowda, Umapathy& Bs, Anila & Ashwini, CP &Jayam, Cheranjeevi (2015) Aesthetics, function, and most importantly the ability to maintain excellent oral hygiene are all guaranteed with a prosthetically powered implant prosthesis. This success relies heavily on the precision of both the treatment planning process and the actual delivery of care. Surgical implementation of planned therapies is projected to improve in tandem with developments in treatment planning (virtual software) for implant prosthesis. With the use of surgical templates, doctors can provide more reliable surgical and prosthetic rehabilitation. The cosmetic and functional benefits of a prosthodontically driven implant have increased as surgical guides have minimized the likelihood of iatrogenic injury to essential anatomic structures. The authors provide a high-level overview of surgical guide usage in clinical settings within the scope of this paper. A surgical guide may be compared to a pilot's copilot.

Shewale, Akhilesh &Bhasin, Meenu & Bhasin, Prashant & Gambhir, Natasha (2018) Recently, many patients have shown interest in the All-on-4TM procedure for dental implant implantation due to its reputation as a highly functional, aesthetically pleasing, and economically viable treatment option. Patients who want permanent, natural-looking dentition but don't want to undergo sinus grafting or substantial bone augmentation may benefit from this method. Implant dentistry has been completely transformed by computer guidance. The technology is safer since it is more precise and accurate than manual methods. When using the All-on-4 technique in conjunction with guided surgery, a surgeon's skill level is not crucial. The implant may then be put on the strongest bone with little stress to the patient. This method also has a lower risk of problems in the post-operative period. Using a fixed prosthesis and the guided, All-on-4 approach, we recaptured the maxillary and mandibular teeth of a totally edentulous patient, who was then monitored for 18 months.

Chatzistavrianou, Despoina& Wilson, Paul & Taylor, Philip (2019) Replacement of missing teeth with implants is a viable therapeutic option, but it requires meticulous planning, restoratively-driven implant placement, and tailored management to avoid technical and biologic issues. The course began with an introduction to evaluating and preparing for surgery on new patients. The second installment of this series will focus on the prosthodontic and surgical factors involved in maintaining implant-supported restorations. CPD/Clinical Significance: The goal of this article is to provide the dental practitioner an overview of the evidence-based planning, surgical, prosthodontic, and maintenance procedures for implant-supported restorations.

RESEARCH METHODOLOGY

We use a second right maxillary example (Fig. 1) to explain the technical details. The structure is laid out as follows: Prosthodontic backward planning is used to determine the ideal placement of implant posts first. The thickness of the underlying bone and the intended vector of insertion of the subsequent supra structure inform the design of the skeleton. Finally, undercuts, which should be avoided to prevent gaps vs. no-contact between framework and bone, are tested for in the final implant design, and the transition zone between the posts and the framework is strengthened. Since the posts serve as abutments for standard dental implants, no supplementary hardware is required for subsequent prosthodontic work. As a result, our non-submerged approach leaves the implant posts mostly visible in the mouth cavity.

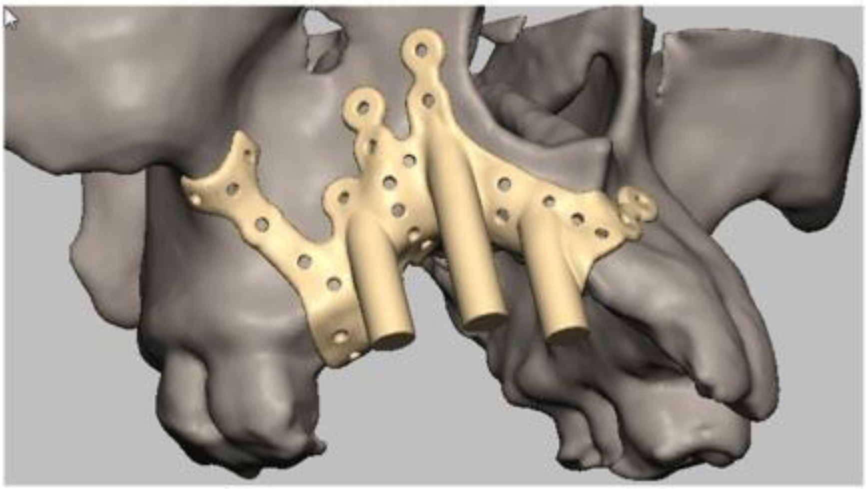

Figure 1: Multiple screw holes provide multi vector stiff fixation in this posttraumatic right maxillary reconstruction using an IPSdental, which is intended to anchor in the midfacial buttresses and subnasal region. You may change the shape of the posts to suit your needs

The metal framework is 1.2 mm thick; the screw holes are 2.0 mm in diameter, and the screw head is flush with the surface of the metal thanks to a countersink design. Openings in the framework may be constructed, for instance, to avoid interference with the mental nerve, which is just one example of how the complicated anatomy of the recipient site can be handled and represented in the design of the particular patient solution. A functionally robust load-bearing implant with high stability given by multi vector mini-screw retention is made possible by strategically placing several screw holes in the skeletonized steel framework. A minimum of 15 screws and a maximum of 30 screws may be needed, depending on the size of the implant.

Statistical methods

One-way analysis of variance (ANOVA) was used to determine the means and standard deviations of the three types of errors (total, longitudinal, and angular) across the five dental experience levels and six geographic locations. Error deviations (total, longitudinal, and angular) were measured by each of the five dentists, and the differences between them were analyzed using one-way repeated-measures ANOVA. In addition, the intraclass correlation coefficient (ICC) was determined to ensure that the superimposition could be reliably reproduced across different experimental error rates. JMP (JMP, SAS Institute, Inc. 2003) was used for the analyses. Statistical software (Stata Statistical Software; College Station, TX; Stata Corp LP) was used to determine the level of significance.

DATA ANALYSIS

We provide individualized IPS-dental planning and engineering, with the goal of streamlining the planning process by eliminating the need to laser-scan the wax-up in favor of employing digitally modifiable and deformed STL-models for the dental arch. Additionally, STL-models are created to be digitally projected on top of the specific maxillary and mandibular anatomy, which is similar to our method in manufacturing bespoke orbital implants for one- to four-wall-orbital defect restorations. Currently, a medical engineer will spend anywhere from four to six hours on the planning process; six days will pass during SLM-manufacturing and shipping of the implant; and the implant will be delivered alongside a polyamide-printed-out 3D-model of the recipient site. The last step before autoclaving the dental solution for a single patient is to polish the posts, which begins with the framework. The sterilizing staff uses an autoclave to ensure the safety of the implant. The recipient site is exposed by making a lateral incision and then perforating the overlaying mucosa or soft tissues with the implant post. The goal is to prevent damage to the soft tissues around the alloplastic implant. Postoperatively, a panoramic radiograph is obtained after a single intraoperative injection of penicillin-G. Six weeks are given to the soft tissues to settle before the prosthodontic suprastructure is made.

Previous subperiosteal implants that were not tightly fastened result in bone loss and deterioration of the anatomical position owing to bone atrophy and framework displacement. Rigid fixation, which has been used successfully in traumatology and reconstructive surgery since the 1950s, is included into our innovative IPS-dental. Long-term (5-10 year) investigations of IPS dentistry are needed to prove this, although in general, atrophy of the craniomaxillofacial skeleton below the underlying bone of tightly fastened plates is unusual. As long as the implant-framework is rigidly fixed, atrophy itself would not be a cause for the failure of this implant. In contrast to the standard reconstruction protocols used for larger jaw-defects, our method does not result in additional comorbidities due to a second operation site, and the bone does not need to be placed in an appropriate position to allow for a later favorable dental implant positioning and prosthodontic rehabilitation.

Comparison of the angular, longitudinal, and total errors made by dentists

Reproducibility was achieved in terms of total error, longitudinal error, and angular error. Separately, the ICCs for the five dentists were 0.58 (95% CI 0.206, 0.949), 0.86 (95% CI 0.598, 0.983), and 0.79 (95% CI 0.402, 0.974). Variations in five dentists' measurements of truthfulness were analyzed using a one-way repeated-measures ANOVA. There were statistically significant variations in both the longitudinal and angular error ($P < 0.0000$ and $P < 0.0453$, respectively).

Results from those who tried out the implant navigation system

Table 1 demonstrates that the VS took much less time to operate than other expertise levels. Total, longitudinal, and angular errors for boreholes drilled using the AqNavi System were 2.00 ±1.24 mm, 1.65± 0.98 mm, and 5.38 ±2.45°, on average. These figures were 1.92 ±0.90 mm, 1.24 ±0.99 mm, and 5.12 ±2.48°, respectively, in the CR evaluation. The equivalent measurements and angles obtained from the R3 test were 1.66±0.89 mm, 0.98±0.53 mm, and 3.48±1.76°. These figures were as follows: 2.40 ±0.87 mm, 0.92 ±0.76 mm, and 5.53 ±1.81° in the DI test. As an indicator of implantation precision, the DC test revealed average deviation values of 2.10 ±0.85 mm, 0.64 ±0.46 mm, and 4.31 ±2.13°. Both the longitudinal and angular errors were significantly different across dentists' tests ($P < .0001$) and between dentists' own results ($P = .001$). When the results of these tests were compared among 5 different dentists, no statistically significant changes in total error were found. One-way analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) tests revealed statistically significant variations in both longitudinal and angular errors across the various assessments. A dental navigation system may help bridge the gap that comes from lack of expertise. In particular, the margin of total error was not significantly different from zero.

Table 1:Variation in the five drilling tests' total error, longitudinal error, and angular error

Grade	VS Mean ± SD	CR Mean ± SD	R3 Mean ± SD	DI Mean ± SD	DC Mean ± SD	*P*-value[a]	Multiple comparison[b]
Total error (mm)	2.00 ± 1.24	1.92 ± 0.90	1.66 ± 0.89	2.40 ± 0.87	2.10 ± 0.85	0.054	
Longitudinal error (mm)	1.65 ± 0.98	1.24 ± 0.99	0.98 ± 0.53	0.92 ± 0.76	0.64 ± 0.46	< 0.0001	VS > DC VS > DI VS > R3 CR > DC
Angular error (degrees)	5.38 ± 2.45	5.12 ± 2.48	3.48 ± 1.76	5.53 ± 1.81	4.31 ± 2.13	0.0011	DI > R3 VS > R3 CR > R3
Elapsed time (secs per drill)	112 ± 13.13	136 ± 17.47	144 ± 5.29	170 ± 5.59	180 ± 4.49	0.0029	

a One-way ANOVA (P < .05); b Tukey-Kramer HSD; CR: Chief resident; DC: Dental clerk; DI: Dental intern; R3: Third year resident; VS: Visiting staff

Total, lateral, and angular deviations of the maxilla and mandible

There was no statistically significant difference in the total error of drilling tests between the maxilla and the mandible (P =.32, Table 2). Mandibular total error variance was greater in the DI test compared to the CR test (P =.035). When comparing VS and CR results for maxillary longitudinal error, a statistically significant difference (P =.03) was observed. There were statistically significant variations (P<0.05) in the dentists' mean longitudinal mandibular error. There was no statistically significant difference in the amount of angular error in the maxilla between the two groups (P =.30), although CR had higher deviations in the mandible than DC did (P =.001).

Table 2: The discrepancy between the maxilla and mandible as measured by total error, longitudinal error, and angular error

	Maxilla (Mean ± SD)					*P*-value[b]	Mandible (Mean ± SD)					*P*-value[b]
	VS	CR	R3	DI	DC	MC[c]	VS	CR	R3	DI	DC	MC[c]
Total Error (mm)	2.15 ± 1.44	2.48 ± 0.77	2.26 ± 0.95	2.52 ± 0.87	1.82 ± 0.82	0.3193	1.85 ± 1.02	1.36 ± 0.64	1.95 ± 0.74	2.28 ± 0.87	1.52 ± 0.92	0.0351 DI > CR[a]
Longitudinal Error (mm)	1.31 ± 0.91	0.77 ± 0.52	0.54 ± 0.39	0.83 ± 0.83	0.98 ± 0.46	0.0309 VS > CR[a]	2.00 ± 0.96	1.70 ± 1.14	0.75 ± 0.52	1.01 ± 0.69	0.97 ± 0.61	0.0002 VS > R3[a] VS > DC[a] VS > DI[a] CR > R3[a]
Angular Error (degrees)	6.47 ± 3.37	4.96 ± 1.98	5.79 ± 2.26	6.36 ± 2.86	4.99 ± 1.56	0.2978	6.34 ± 3.28	8.12 ± 6.25	5.00 ± 3.76	7.03 ± 2.39	3.15 ± 2.23	0.0088 CR > DC[a]

aOne-way ANOVA (P < .05); bTukey-Kramer HSD; cMC: Multiple comparison CR: Chief resident; DC: Dental clerk; DI: Dental intern; R3: Third year resident; VS: Visiting staff.

Recent years have seen the use of learning theories to test the hypothesis that more experienced surgeons lead to better surgical results and less waste of medical resources. Successful dental implant surgery relies heavily on the surgeon's level of expertise. Dental implant navigation systems aim to improve surgical precision and reduce medical malpractice suits and claims of incompetence on the part of surgeons.

CONCLUSION

This paper concludes that the use of Individual Patient Solution-dental (IPS-dental) for dental rehabilitation in individuals with severe atrophy may be one way to circumvent the established limitations of traditional implantology. The findings showed that dentists with varying levels of expertise produced similar levels of total error deviation. Dental implant surgery may be taught to students much sooner than in the past with the use of the dental navigation system. The implant navigation system helps the dentist place the dental implant in the ideal location, regardless of the dentist's prior expertise with similar procedures. Instead of relying on years of clinical surgical experience for knowledge, we can access a lot of resources and speed up the learning process with the help of technology.

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