

JCDD

Journal of Clinical & Digital Dentistry



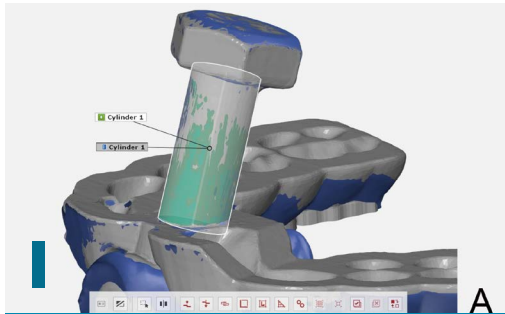


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About the Journal

The Journal of Clinical and Digital Dentistry are published four times (March, June, September, and December) annually since May 2019. The abbreviated title is "J Clin Digit Dent". In the journal, articles concerning any kind of clinical dentistry such as prosthodontics, orthodontics, periodontics, implant dentistry and digital dentistry are discussed and presented.

Aims and scope

This journal aims to convey scientific and clinical progress in the field of any kind of clinical and digital dentistry.

This journal publishes

- Original research data and high scientific merit in the field of clinical and digital dentistry.
- Review articles.
- Case reports in implant dentistry including GBR, digital dentistry, 3D printing, and prosthodontics.
- Short communications if they provide or document new technique and clinical tips.

About the Journal

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Editorial

Big progression of Implant treatment in Esthetic zone

With advancements in implant surgical and prosthetic techniques, dentists are striving to achieve implant restorations that closely resemble natural teeth. Initially, prosthodontic-driven implant treatment focused primarily on functional occlusal relationships, but it has since evolved to prioritize esthetic outcomes in addition to functional results.

Implant surgery and restorative treatment in the esthetic zone remain a constant challenge for clinicians. To ensure successful outcomes for both patients and dentists, a precise diagnosis, well-planned surgical treatment, the anatomy of the prosthesis, and healthy periodontal tissues for long-term stability are essential. These elements elevate the dentist's role, blending clinical precision with artistic skill.

The diagnostic process, evaluation of the edentulous area, surgical guide design and use, bone grafting during implant surgery, and the transition from provisional to definitive restorations all critically impact the final treatment outcome. This demands that dentists remain vigilant and meticulous throughout the entire procedure.

In this issue of JCDD, we feature valuable clinical insights on the classification of implant surgery based on edentulous space, the accuracy of surgical guides post-autoclave disinfection, and key processes in implant prosthetic treatment. I hope it serves as an excellent resource for readers around the world, and I look forward to enjoying the clear autumn sky together with the readers of JCDD.



A handwritten signature in black ink, appearing to read 'Wongun Chang' in a stylized, cursive script.

Wongun Chang, DDS MS PhD

ChecQ

QUICK CHECK FOR IMPLANT STABILITY

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Safe and accurate measurement that uses evidence-based RFA Technology

Accurate

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Economical

An internal replaceable battery ensures long-term usability.

Convenient

Use with wireless type and automatic measurement & power-saving mode

Technical

Implant stability measurement device developed by Dentis' technology



Dimensional stability of 3D printed tooth-supported implant surgical guides after autoclave sterilization

James D. Browning DDS,MSD

Seok-hwan Cho DDS, MSD

Abstract

Statement of problem.

3D printed surgical guides for dental implant placement must be sterilized prior to use for patient safety. It is of clinical interest to know if surgical guides suffer distortion during the sterilization process. However, there is limited data evaluating the distortion resulting from the manufacturer's recommended sterilization protocol.

Purpose.

The purpose of this in vitro study was to evaluate the effect of autoclave sterilization on the dimensional stability of 3D printed tooth-supported implant surgical guides.

Material and Methods.

Twenty surgical guides were made with 3D printing resin in an SLA printer, and were split into two groups (n=10). Group L consisted of long-span guides including the teeth from first molar to first molar of maxillary arch. Group S consisted of short-span guides including the teeth from canine to canine of maxillary arch. All the guides were designed for placing a single implant at the left central incisor position. No other teeth were missing. After 3D printing, the surgical guides were washed, cured, and the print supports were trimmed. A metal bolt was secured in the guide tube position.

James D. Browning



Dr. James Browning is a prosthodontist who is currently in private practice in Plano, Texas. Dr. Browning graduated from Texas A&M Baylor College of Dentistry with his Doctor of Dental Surgery degree. At graduation, he received recognition for excellence in removable prosthodontics with the Horace P. Beachum Denture Prosthesis Award. After dental school Dr. Browning completed a three-year residency in prosthodontics, and simultaneously completed a Master of Science in Oral Biology. Subsequently, he taught as an Adjunct Assistant Professor in the Graduate Prosthodontics residency program at his alma mater. Dr. Browning also had a professional career in software engineering prior to becoming a dentist. His background in software design has been a useful asset in adopting digital technologies in his dental practice. Dr. Browning regularly utilizes 3D imaging, digital scanning, computer aided design, 3D printing, and milling in his private practice.

Seok-hwan Cho



Dr. Seok Hwan (Aaron) Cho currently serves as the Department Chair of Prosthodontics and as an Associate Professor at the University of Iowa College of Dentistry and Dental Clinics. Prior to his current role, from 2017 to 2022, Dr. Cho held the position of Associate Professor and Program Director of Graduate Prosthodontics. He also directed the Post-Doctoral Implant Placement Program at Texas A&M University School of Dentistry (Texas A&M Dentistry). Dr. Cho is a board-certified prosthodontist and a certified master ceramist, demonstrating his exceptional expertise in prosthodontics and dental ceramics. He completed his Advanced Specialty Program in Prosthodontics at the Texas A&M Dentistry (formerly Baylor College of Dentistry). He received the Robert S. Staffanou Memorial Graduate Prosthodontic Award upon graduating, in 2010, from the prosthodontic program at Texas A&M Dentistry. In 2011, he won first place in the Stanley D. Tylman Research Awards from the American Academy of Fixed Prosthodontics. One of Dr. Cho's most notable accolades is the Claude R. Baker Faculty Award from the American Academy of Fixed Prosthodontics, which he won in 2017. The award recognizes his outstanding contributions as an exceptional junior faculty member in predoctoral fixed prosthodontic teaching.

After scanning the guides in a laboratory scanner as controls, the guides were sterilized by autoclave according to the resin manufacturer's recommendation (121°C, 104 kPa, 30 minutes). The post-sterilization scans were aligned either on the bolt or on the cusps to compare with the pre-sterilization scans. For statistical analysis, Mann-Whitney U tests were run on the independent samples ($\alpha = .05$).

Results.

There were consistent patterns of distortion typically observed in the apical direction of the teeth. In addition, greater deviations appeared on the distal extensions of group L. When aligning samples on the bolt, there were statistically significant differences of deviations between scans at the distal-most sites of group S and group L ($P < .001$), while there was no significant difference of deviations at the canine sites between two groups ($P = .631$). When aligning samples on the cusps, the group L exhibited significantly greater deviations in bolt angle ($P < .001$) and apical point position ($P < .001$) than those of the group S.

Introduction

3D printing technology known as rapid prototyping or additive manufacturing is being used more and more in dentistry, with a wide range of materials from plastics, to metals, to organic tissues.¹ Each method and material is unique and needs to be scientifically evaluated for clinical performance. Evidence-based dentistry aims to provide scientific rationale for using methods and materials in the treatment of patients.

Implantology has seen an increase in the use of 3D printing with the fabrication of surgical guides which were traditionally made by vacuum-formed thermoplastic splints.² Stereolithography (SLA) is a common 3D printing technology used to produce implant surgical guides.³ SLA builds the guides layer-by-layer with a scanning laser which projects into a tank of light-cured photopolymer resin.^{3,4} The workflow of designing, planning, manufacturing, preparing, and using guides involves many steps, which potentially can introduce inaccuracy of implant placement.⁵ In addition to the accuracy of surgical guides, the materials involved must be safe for patients. The substances used to fabricate guides must be biocompatible and suitable for sterilization.⁶

There have been numerous studies evaluating the accuracy of implant placement in guided surgeries, but there is limited literature investigating the dimensional stability of the guides themselves after they have been submitted to the stresses of sterilization.^{2,3,7-13} Shaheen et al produced a pilot study evaluating a small sample size of PolyJet 3D printed objects that were not surgical guides.

Conclusions.

There were significant differences of distortion at the distal-most sites between group L and group S. However, there was no significant difference of distortion up to the canine areas for both groups. Group L demonstrated significant angular distortion of the implant drill guide tube and significant apical location distortion in comparison with group S.

Clinical implications.

Unnecessary extension of 3D printed surgical guides should be avoided to prevent the potential degree of surgical guide distortion by autoclave sterilization process.

They printed a tooth replica, mandibular cutting guide, and an orthognathic splint. The U-shaped orthognathic splint was unique in their study in that it covered the full arch of teeth and was similar in shape and span to tooth-supported implant surgical guides. They sterilized the objects with gas plasma and steam heat (autoclave) and found that only the splint exhibited morphological distortion after sterilization. It was shown that the distal extensions of the splints exhibited the most distortion with deviations of 1.5-1.7mm, and that the splints were clinically unusable. They also found that steam heat autoclave sterilization caused more distortion than gas plasma.¹² Marei et al scanned and compared surgical guides while mounted on casts with an intraoral scanner before and after sterilization. They found no statistically significant deviations at the center points of the guide sleeves.⁹ More studies are needed to determine if guides can be significantly affected in ways that may compromise the accuracy of implant placement.

However, there were no studies comparing distortion due to sterilization between short-span guides and long-span guides. The aim of this study was to evaluate the dimensional stability of short-span (6 units) and long-span (12 units) SLA 3D printed tooth-supported implant surgical guides after autoclave sterilization. The null hypothesis was that no significant differences would be found between the two groups after autoclave sterilization.

Material and methods

A total of twenty surgical guides were designed in implant planning software (Blue Sky Plan version 4.3.10; Blue Sky Bio, LLC) and edited in 3D mesh editing software (Meshmixer version 3.5.474; Autodesk, Inc.). The guide tube parameters used were those used clinically for 5mm T-sleeve (Straumann Group). Short and long guides were made identical in the inter-canine region, with the long guides extending distally to the first molars. Twenty surgical guides were fabricated by SLA 3D printer (Form 2; Formlabs Inc.) in a 3D printing resin material (Surgical Guide Resin; Formlabs Inc.), which is different from the one Marei et al⁹ used in their study, because the resin material was introduced recently. The surgical guides were split into two groups of ten. One group (Group L) consisted of long-span guides which covered the maxillary arch from right first molar to left first molar. The other group (Group S) consisted of short-span guides that covered the maxillary arch from right canine to left canine. All the guides were designed for placing a single implant at the maxillary left central incisor position. No other teeth were missing. (Fig. 1.) illustrates the short and long guide designs.

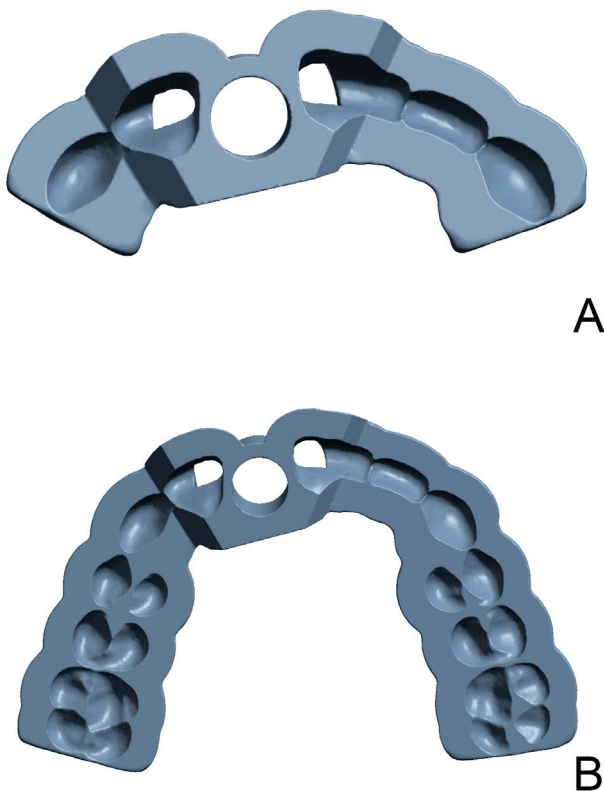


Fig. 1. Surgical guide designs.
(A) Short guides.
(B) Long guides

After printing, the guides were washed, cured, and the print supports were trimmed. For each guide, a stainless-steel bolt (6.35 mm diameter) was selected that fit securely in the guide tube. The bolt was secured in the guide tube with light-cured resin to serve as an immutable reference between before and after (sterilization) scans. (Fig. 2.) demonstrates how the bolts were inserted and fastened in the guide tubes.



Fig. 2. 3D printed surgical guide with stainless-steel bolt secured in guide tube.

After one week, the guides were coated with a thin layer of powder spray (Scanspray; Renfert Dental Corp) and scanned (control group) in a desktop scanner (D900; 3Shape). Next, the guides were sterilized by autoclave (M11; Midmark) according to the resin manufacturer's recommendation (121°C, 104 kPa, 30 minutes). After sterilization, the guides were scanned again (test group). The before and after scans were performed within 24 hours of each other.

The post-sterilization scans were aligned and compared with the pre-sterilization scans in CAD inspection software (GOM Inspect 2019; GOM GmbH), and the differences were evaluated qualitatively and quantitatively. For the inspection process, the before and after scans were aligned by two different methods. One method was to align the scans by local best fit on the bolt, which would reveal the distortion of the resin (Fig. 3A). The other method was to align the scans by local best fit on the resin only in the cusp regions of the teeth, which would reveal the effects on the position of the bolt (Fig. 3B).

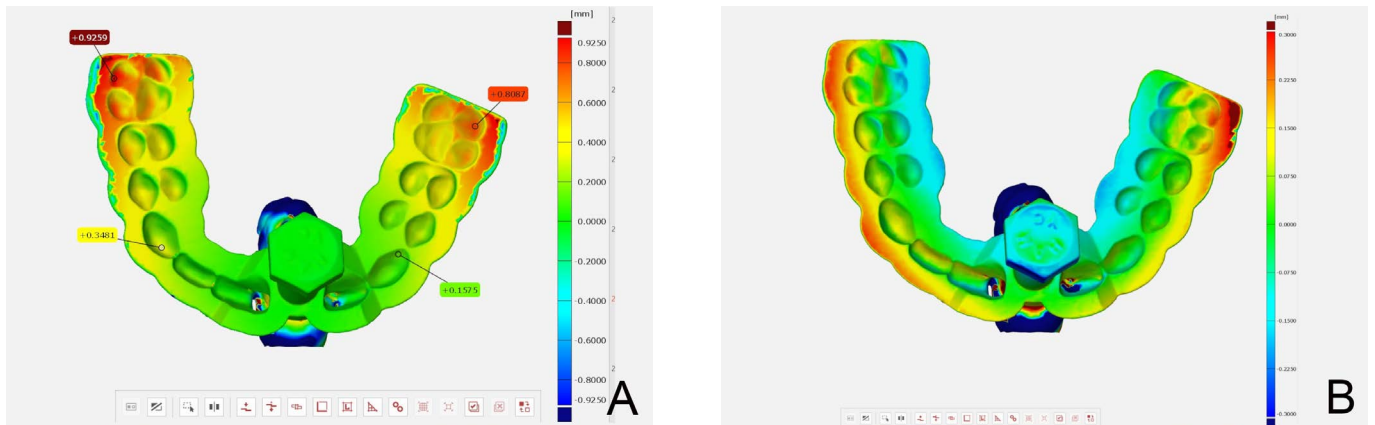


Fig. 3. (A) local best fit alignment based on bolt. Note green regions around bolt and anterior region of guide resin.
 (B) local best fit alignment based on cusp regions of resin. Note strip of green color along cusps

In both methods, deviations were measured at selected tooth positions and along the bolt. Color map analysis was evaluated to study the nature of the deviations between the before and after scans, and other software functions were used to measure surface and bolt deviations for statistical analysis (**Fig. 4**).

For the tooth positions in the long guides, measurements were taken at the points of greatest deviation in the distobuccal cusps of the right and left first molars as well as the points of greatest deviation in the cusps of the right and left canines (**Fig. 3A**). For the tooth positions in the short guides, measurements were taken at the points of greatest deviation in the cusps of the right and left canines. For all the guides, the difference in bolt angulation was recorded. Additionally, a point was placed at the apex of the bolt, and the difference in position was measured at this location (**Fig. 4**).

The measurement values were recorded in Microsoft Excel and then transferred to IBM SPSS Statistics version 25. Mann-Whitney U tests were run on the two independent groups ($\alpha = .05$). These nonparametric tests were used as the variables of interest were not normally distributed.

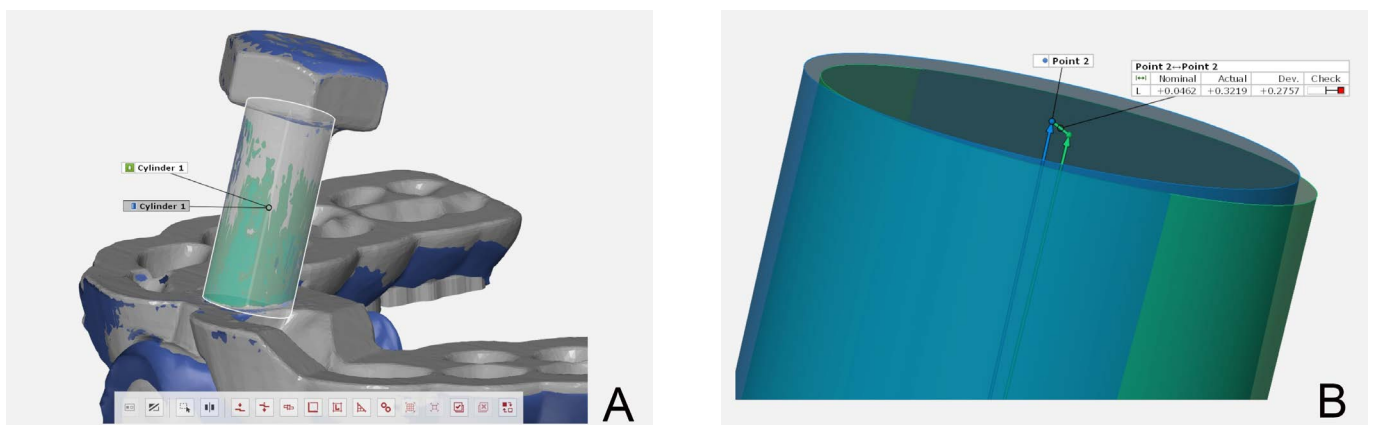


Fig. 4. (A) virtual cylinder constructed along surface of bolt. Cylinder consisted of long axis and end points.
 (B) blue and green arrows indicate long axes of cylinder in before (blue) and after (green) scans. Points at ends of arrows are indicated.

Results

[Table 1] presents the median, interquartile range, and minimum-maximum range of the deviations at the distal-most sites of the guides. The two distal-most sites were the maxillary right first molar (MxRFM) for the Group L and the maxillary right canine (MxRC) for the Group S. When aligned on the bolt, the median deviations (mm) at the distal-most sites for Group L and S were 0.889 and 0.283, respectively. Mann-Whitney U testing indicated a statistically significant difference between long and short groups ($P < .001$).

[Table 2] presents the median, interquartile range, and minimum-maximum range of the deviations at the maxillary right canine (MxRC) sites of the guides. When aligned on the bolt, the median deviations (mm) at the MxRC sites for long and short guides were 0.302 and 0.283, respectively. Mann-Whitney U testing indicated the values between long and short groups were not statistically different ($P = 0.631$).

[Table 1] Deviations (mm) at distal-most sites based on bolt alignment

Description	Median (mm)	Interquartile Range (Q1, Q3)	Range (Minimum, Maximum)
MxRFM of Group L	0.889	(0.696, 1.020)	(0.326, 1.350)
MxRC of Group S	0.283	(0.186, 0.327)	(0.159, 0.369)

Note. Absolute values were recorded for negative deviations

[Table 2] Deviations (mm) at MxRC based on bolt alignment

Description	Median (mm)	Interquartile Range (Q1, Q3)	Range (Minimum, Maximum)
MxRC of Group L	0.302	(0.218, 0.361)	(0.165, 0.512)
MxRC of Group S	0.283	(0.186, 0.327)	(0.159, 0.369)

[Table 3] presents the median, interquartile range, and minimum-maximum range of the deviations of bolt angle of the guides when aligned on the cusps. The median deviations (degrees) of the bolt angle for long and short guides were 1.086 and 0.415, respectively. Mann-Whitney U testing indicated a statistically significant difference between long and short groups ($P < .001$). Deviations of the bolt angle were toward the palatal direction.

[Table 4] presents the median, interquartile range, and minimum-maximum range of the deviations of the apical point of the bolt when aligned on the cusps. The median deviations (mm) of the apical point of the bolt for long and short guides were 0.201 and 0.089, respectively. Mann-Whitney U testing indicated a statistically significant difference between long and short groups ($P < .001$). Deviations of the apical point were toward the palatal direction.

[Table 3] Deviations of bolt angle (degrees) based on cusp alignment

Description	Median (degrees)	Interquartile Range (Q1, Q3)	Range (Minimum, Maximum)
Group L	1.086	(0.940, 1.284)	(0.539, 1.545)
Group S	0.415	(0.312, 0.627)	(0.219, 0.744)

[Table 4] Deviations of apical point distance (mm) based on cusp alignment

Description	Median (mm)	Interquartile Range (Q1, Q3)	Range (Minimum, Maximum)
Group L	0.201	(0.168, 0.293)	(0.118, 0.445)
Group S	0.089	(0.048, 0.130)	(0.037, 0.151)

Discussion

The effect of two different spans of 3D printed surgical guide on the distortion by autoclave sterilization was investigated. There were significant differences of dimensional stability of the distal-most sites between the two groups. In addition, the group L demonstrated significantly higher distortion values in terms of angle of bolt and apical direction evaluation. Therefore, the null hypothesis that no significant differences would be found between the two groups after autoclave sterilization was rejected.

Two alignment methods were used in this study to compare samples' pre-sterilization and post-sterilization scans. The first method of alignment was by local best fit on the metal bolt. This is important because the bolt is assumed to be immutable (dimensionally stable) throughout the study. Therefore, making an alignment by selecting only the bolt should reveal the distortion of the resin. The image in the Figure 3A illustrates how the bolt and anterior aspect of the resin guide are well aligned with no deviations (green), and the distal extensions of the resin exhibit considerable deviations in the apical direction (red). The general pattern observed for both groups was that of increasing distortion as the length of the guides increased. Table 1 compares the extent of the distortion at the distal-most sites of the guides for both groups. The longer guides (Group L) suffered significantly greater deviations than the shorter guides (Group S). The maximum deviation recorded was 1.350 mm, which was similar in magnitude to deviations found by Shaheen et al, who recorded 1.5 - 1.7 mm differences at the distal-most aspects of their orthognathic splints.¹²

There are potential clinically relevant consequences for the pattern of distortion. Practitioners commonly evaluate surgical guides by placing them in the mouth and assessing how well they seat on the teeth and how stable they fit without rocking. With this pattern of distortion where the distal extensions are raised apically, the guide would fit like a tripod with contact at the two distal ends and at the center of the anterior. In this scenario, the guide would rest securely on the teeth but would have rotated due to the apical deviation at the distal ends. The distortion could go unnoticed due to the apparently stable fit. If the opposite were true, where the distal ends deviated toward the coronal direction, the guide would rock in the anteroposterior dimension. Consequently, it would be expected that the rotation of the guide due to its raised distal ends would cause the apex of the bolt to rotate toward the palatal. This is what was observed when the guides were aligned by the second method in the present study.

The second method of alignment in the present study was by local best fit on the cuspal regions of the resin. This alignment reveals how the distortion in the resin affects the orientation of the bolt and can be observed in the image to the (Fig. 3B). The band of green along the cuspal regions demonstrate how the scans were aligned. In this alignment, the bolt is no longer green. The facial aspect of the bolt is blue which indicates a negative deviation, and the palatal aspect of the bolt is red which indicates a positive deviation. Therefore, the apex of the bolt has rotated toward the palatal direction. This can also be seen in Figure 4 with the difference in orientation of the virtual cylinders that were constructed on the before (blue) and after (green) scans of the bolt. The median bolt angle deviations (degrees) were significantly different between Group L and Group S. This is to be expected given that the distal extensions of Group L exhibit greater deviations and therefore cause more rotation of the body of the guides.

It is worth noting that no significant differences were found between the groups at the canine sites when the guides were aligned on the bolt. This indicates that most of the distortion took place primarily distal to the canines, as is illustrated in the Figure 3A. The results in this study consistently found that shorter surgical guides exhibited less distortion than longer ones. This is logical given that small deviations can accumulate over greater distances. Currently, there is no consensus in literature regarding design elements of surgical guides. More studies would be needed to further investigate the nature of guide resin distortion. Then perhaps better guidelines could be established. Many design factors could potentially affect the stability of the guide during post-processing and sterilization, such as thickness, height, width, length, number of implant sites, and the presence or absence of cross bracing. Other factors such as resin type, printer type, print orientation, and print resolution could also have effects on the properties of the guides.^{1,3,5,8,10} Additionally, further investigation would be required to determine what degrees of distortion should be considered clinically relevant.

There were some limitations that could have affected the outcomes of the present study. The surgical guide resin and the metal bolt have surfaces that are not well suited for scanning. The guide resin is translucent and the metal bolt is shiny and reflective.

Conclusions

The scanner could not achieve a successful scan without the use of Scanspray. Additionally, the bolts used in this study had a similar diameter as clinically used guide sleeves; however, the bolts had more mass and could have acted as cantilevers, which was not clinically accurate. The bolt could potentially transfer heat or weight into the guides to contribute their own distorting effects. The software inspections did not indicate any distortion around the base of the bolt where it joined the resin guide. The guides could have been placed in a different orientation during sterilization to help identify if the bolts were contributing to the observed distortion pattern. Clinicians should consider these findings on a case-by-case basis. The tolerable degrees of inaccuracy depend on numerous factors such as tooth position, available bone, adjacent structures, and operator experience. If placing multiple implants in the same arch, the clinician could consider whether using multiple shorter guides would improve accuracy over one longer guide.

Within the limitations of this study, the following conclusions were made:

1. There were significant differences of distortion at the distal-most sites between group L and group S. However, there was no significant difference of distortion up to canine area for both groups. Increasing distortion can be expected as the length of the guide increases.
2. Group L demonstrated significant angular distortion of the implant drill guide tube and significant apical location distortion in comparison with group S.

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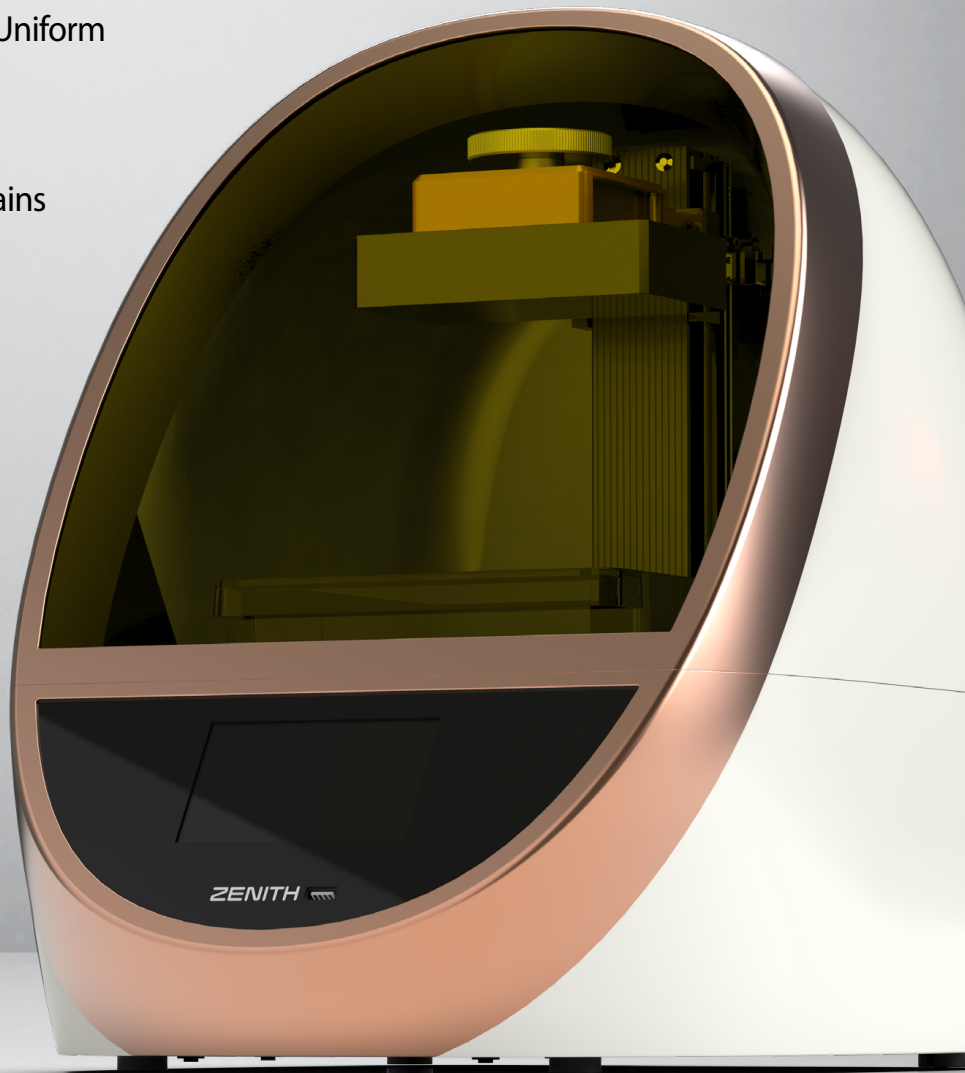
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COMING SOON

Implant Selection and Placement with Adequate Spacing ①

Jonghuyn Park DDS, MSD

Introduction

Natural teeth have individual spaces in the dental arch. This article discusses the minimum and maximum space required for implant placement, thereby reproducing natural teeth. Usually, space restoration for existing individual teeth can be achieved by a one-to-one replacement of a natural tooth with an implant without major difficulties. However, in cases where a long period of time has passed since the loss of a tooth, during which the adjacent teeth have been displaced, or where there is lack of space due to crowding of the natural teeth, there will likely be difficulties in performing the dental implant procedure with adequate placement. On the other hand, if the space is relatively wide, a dentist may believe that the placement of a single implant is an insufficient utilization of the space, and at the same time, feel that the space is insufficient for the placement of two implants.

This article presents some useful figures based on objective evidence that can be applied in clinical practice. The investigation begins with the following question: what is the minimum space needed to accommodate a single implant?

Case report

Space required after a single tooth loss

1) A distance of 6 mm between the heights of the contours of adjacent teeth is considered the minimum space required for an internal conical connection implant.

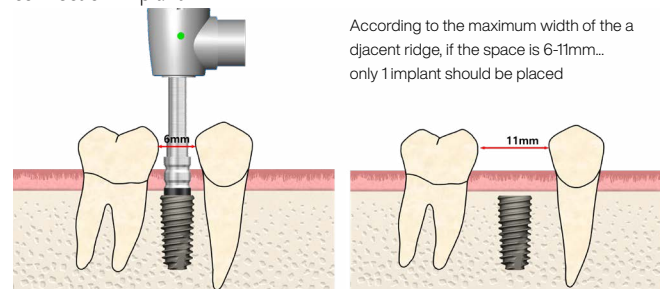
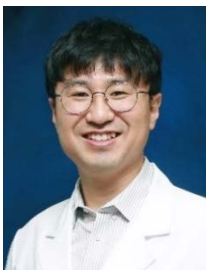


Fig. 1. Distance is measured between the heights of the contours. If the distance is in the range of 6–11 mm, restoration through the placement of a single implant is recommended.



Jonghuyn Park

Dr. park completed his residency at the Department of Prosthodontics at Gangneung-Wonju National University, earning an MSC in Prosthodontics. He is currently the Prosthodontics Specialist and Director of Seosan Doori Dental Clinic. Additionally, he serves as a Director of the Korean Academy of Esthetic Dentistry and is part of the writing staff for the Korean Journal of Clinical Dentistry. He is also the Director of the OIC Master Course.

The adequacy of the space is determined by measuring the distance between the heights of the contours of the teeth adjacent to the lost tooth. Further, subsequent prosthetic restoration must also be taken into account. In order to secure a minimum space of 6 mm, the teeth might be profiled to decrease the heights of the contours to the available range, or if sufficient space cannot be secured, orthodontic treatment preparatory to the placement of an implant may be required. If the distance is in the range of 6–11 mm, the placement of a single implant is recommended.

The interproximal distance between the roots at the alveolar crest levels, and the distance from the alveola crest to the cementoenamel junction (CEJ) of an adjacent tooth, also need to be measured prior to dental implant surgery. However, even though adjacent teeth can easily tip when a tooth is lost, the extent of root movement tends to be small. In other words, during the same duration of time, the decrease in the distance between the heights of the contours of adjacent teeth exceeds the decrease in the distance to the CEJ. The space between the heights of the contours of adjacent teeth easily decreases, and this space also determines the shape of the tooth utilized during prosthetic restoration. At the height of the contour, interproximal contact with the prosthesis can easily occur, and with a spacing of 6 mm or less, it is difficult to properly form the shape of the tooth. In this article, we revisit the discussion on the space between the heights of the contours of adjacent teeth.

There was no major difficulty in performing the implant procedure for the case shown in Figure 2 because space was secured around the CEJs of the adjacent teeth. However, because the distance between the heights of the contours of the adjacent teeth was less than 6 mm, despite interproximal adjustment, it can be observed that the implant crown is small. If the space had been any smaller, it would not have been possible to load the prosthesis. As can be seen from this case, 6 mm is recommended as the minimum required spacing. A space smaller than 6 mm between the heights of the contours of adjacent teeth would pose a challenge for both the implant placement and prosthesis.



Fig. 2. October 1, 2022

A 5.7-mm space was secured through interproximal adjustment of the teeth adjacent to #35. The implant prosthesis of #35 appears to be slightly smaller than the premolar (#34).

In the case shown in Fig. 3-4, the interproximal space between the heights of the contours was relatively ample at 7.5 mm, but even after orthodontic treatment, the space near the root apex was very limited at only 2 mm. As it was determined that implant restoration would be difficult, a 3-unit zirconia bridge was chosen instead. To avoid root canal treatment, the margin was planned supragingivally, and radiographs were taken intermittently during the preparation of the abutment to preserve pulp vitality.

In cases like the one shown in Fig. 3-4, where orthodontic treatment has not been performed, there are few cases where space near the root apex is insufficient as long as a minimum of 6 mm is secured between the heights of the contours. Therefore, I will focus on discussing the space between the heights of the contours.

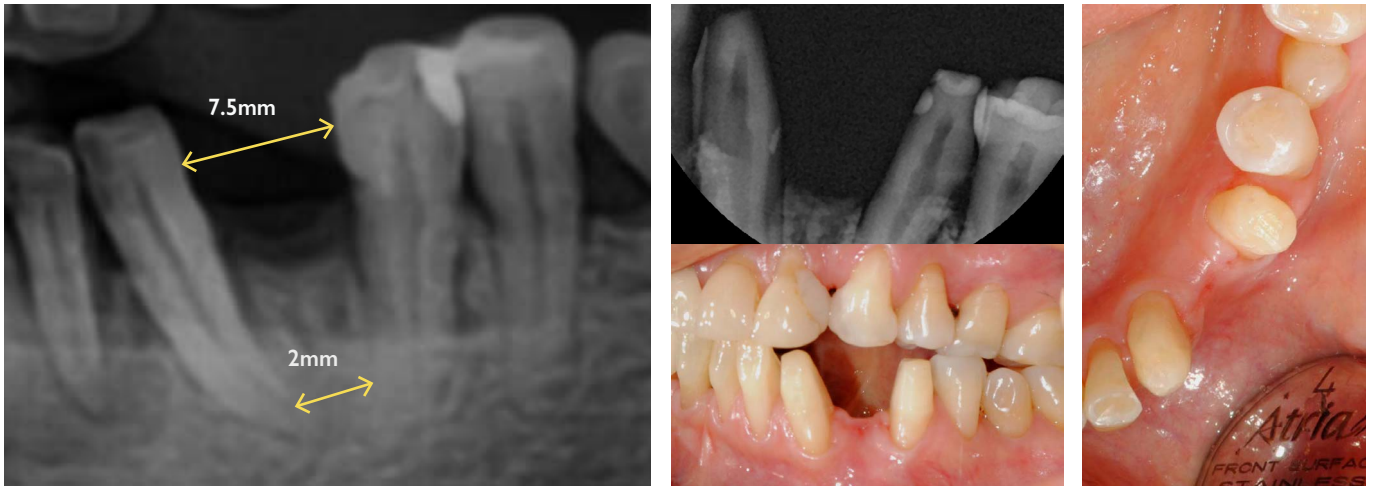


Fig. 3. July 7, 2014
After orthodontic treatment at the university hospital, restoration was attempted with a Maryland Bridge, but it repeatedly failed.



Fig. 4. February 2, 2022
Follow-up of the 3-unit zirconia bridge after 8 years.

2) If the available space is less than adequate, more space is secured through orthodontic treatment.

3) A single implant is selected when the spacing is 6–11 mm.



Fig. 5a-c. A case with lack of space due to mesial tipping of the adjacent teeth after the loss of #36 and #46 is presented. More space was secured through orthodontic treatment prior to the implant restoration. A 3-year clinical follow-up image is presented.

(a) September 2, 2019

(b) June 21, 2024 implant placement 3Y F/U

(c) June 26, 2024 3Y F/U

As observed from the preoperative panoramic photograph in Fig. 5a-c, because a long time has passed since the tooth loss, there was a loss of space for #36 and #46, along with a decrease in spacing between the mandibular teeth (#33, #34, #35, #43, and #44). This was not a case where the problem could be resolved with interproximal reduction. In such cases, orthodontic treatment can serve as an excellent approach. After securing adequate space, the procedure for the implant prosthesis was also completed.

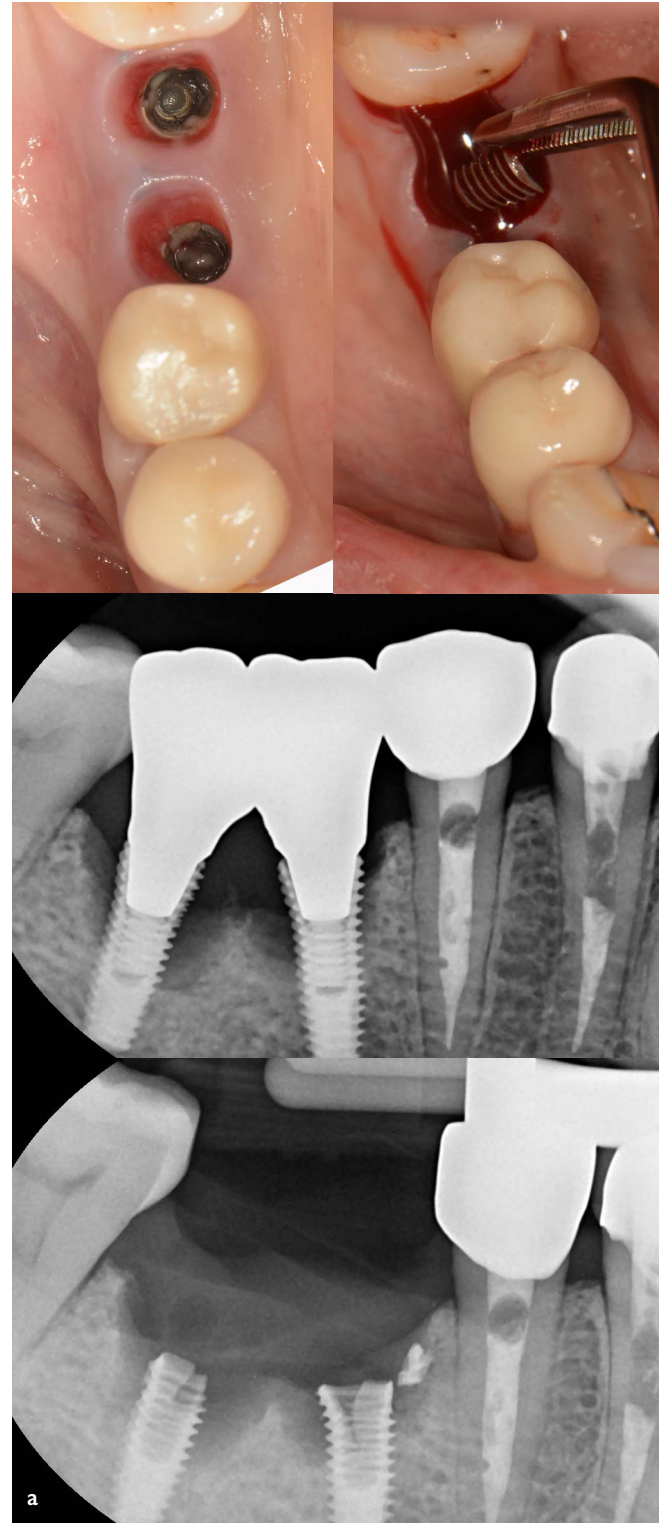


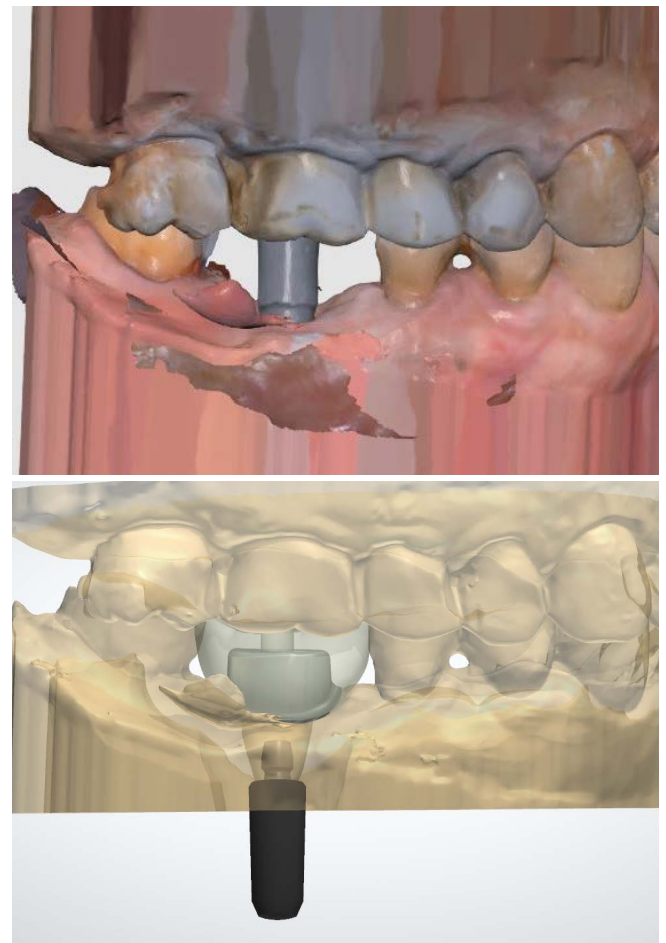


Fig. 6a-c. After removing the two implants that were placed in another dental clinic 9 years ago, a restoration was performed with a single implant. A comparison of the crowns of #46 and #47 shows that the space was not too wide for the use of a single implant
 (a) September 4, 2019 The patient underwent a procedure at another dental clinic 9 years ago
 (b) March, 2020
 (c) January 2, 2024 4Y R/C

In the case introduced in Fig. 6a-c, two internal conical connection implants were placed mesial and distal to the space of #46 9 years ago at another dental clinic. Peri-implant bone loss was observed on a standard radiograph, and a fracture of the implant was revealed when the prosthesis was removed. This fracture may have been the result of a complex interplay between multiple factors, but one of the reasons was the difficulty in obtaining a passive fit between the abutment and internal connection of the implant as a result of the screw-retained splinting of the internal conical connection implant. The existing, fractured implant was removed. It was then replaced with a wide neck implant with a tissue level diameter of 4.5, and a definitive prosthesis was fabricated. The photograph shows that the restoration was possible with a single implant without problems. A stable outcome was confirmed even after 4 years.

If the distance between the heights of the contours of the adjacent teeth is 11 mm or less, the placement of a single implant would be a natural choice without hesitation. In fact, placing two implants in a space smaller than 11 mm is considered to be highly likely to cause biological and mechanical complications.

4) Making a decision when the spacing is 11.1–11.9 mm requires multiple considerations.



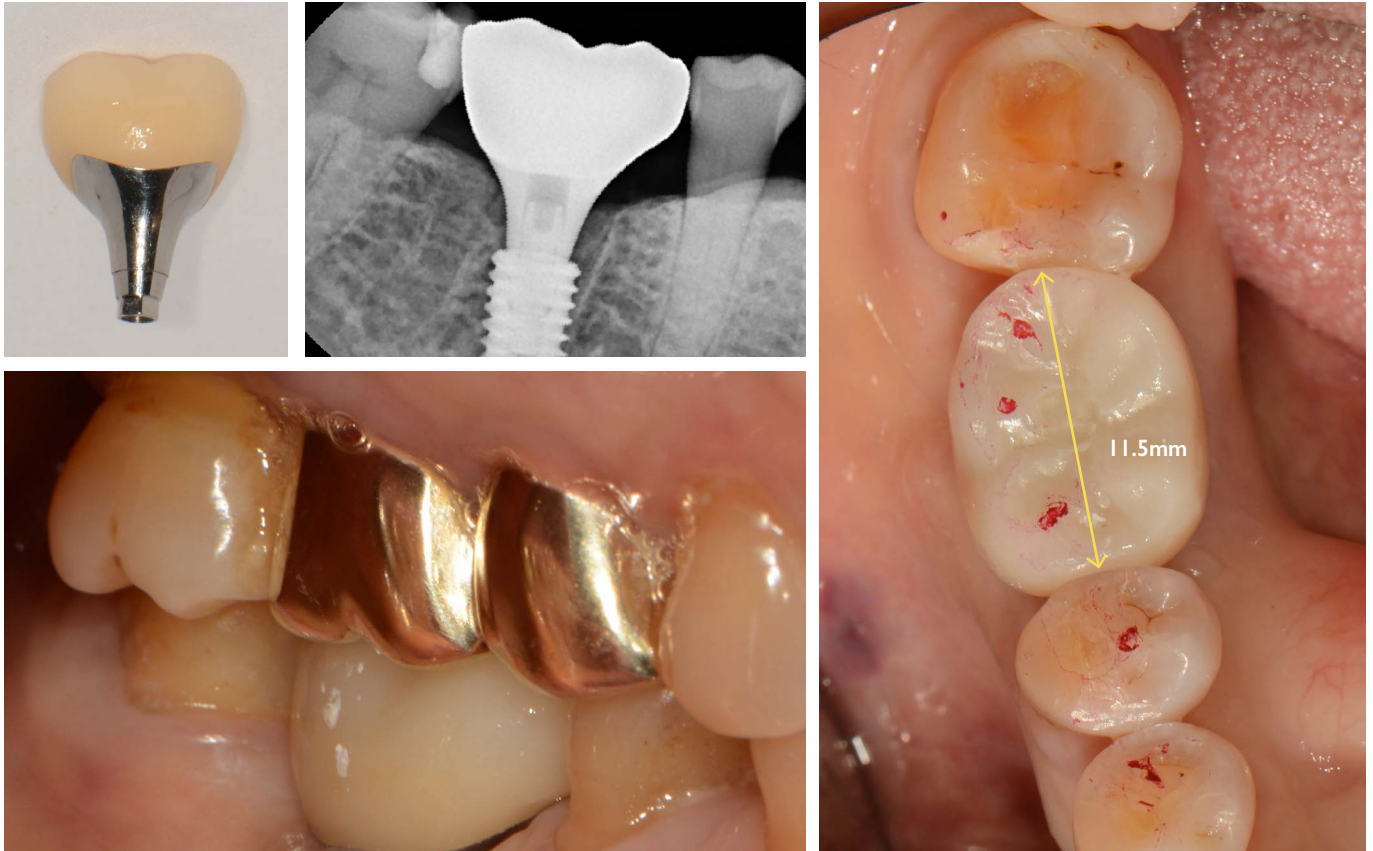


Fig. 7. Restoration of #46 when the spacing was 11.5 mm using a single implant. A comparison of the crowns of #46 and #47 confirms the wider space and wider space for # 46.

A case that requires greater consideration involves a spacing in the range of 11.1–11.9 mm. In this case, multiple options are compared to determine the best solution. Fig. 7 shows the placement of a single implant for a spacing of 11.5 mm. The first molar space of 11.5 mm appears somewhat large for restoration with a single implant. Excessive masticatory force could be applied to the implant. Without placement in the right position and direction, the embrasure may be widened. However, the space seems somewhat small for the use of two implants. Thus, restoration was performed by placing a single implant at an accurate position and depth, and in order to prevent the excessive widening of the embrasure, efforts were made to ensure a natural shape using a custom abutment.

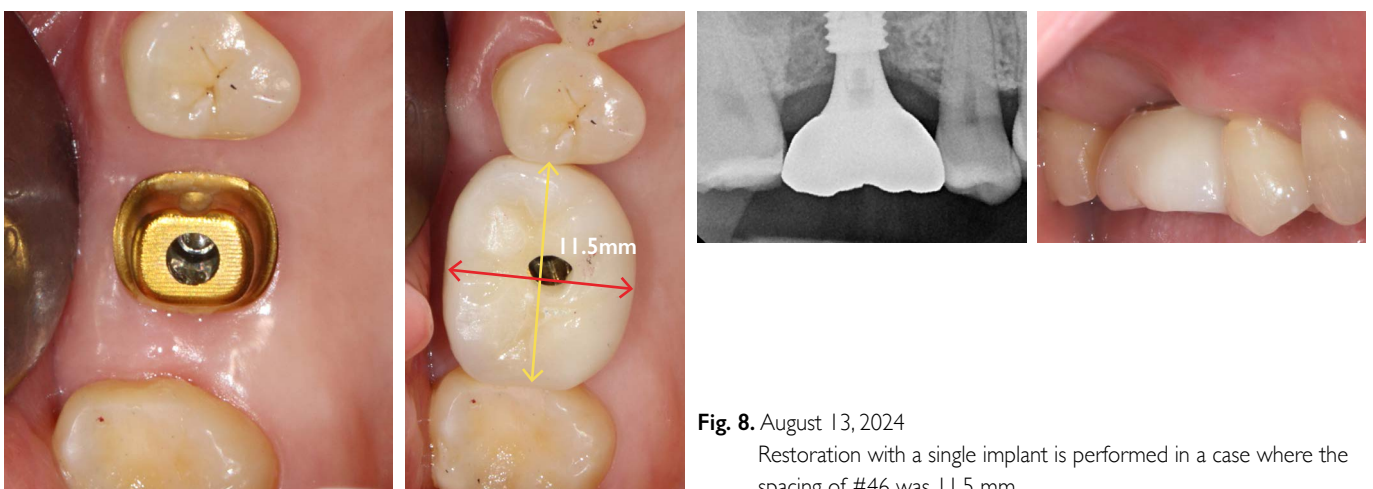


Fig. 8. August 13, 2024
Restoration with a single implant is performed in a case where the spacing of #46 was 11.5 mm.

If there is sufficient space, the implant should be placed in as central a position as possible. This will minimize the number of cantilever units. In the case shown in Figure 6, the implant is placed closer to the mesial side, but it was positioned almost at the center.

5) Minimum space required for anterior teeth restoration

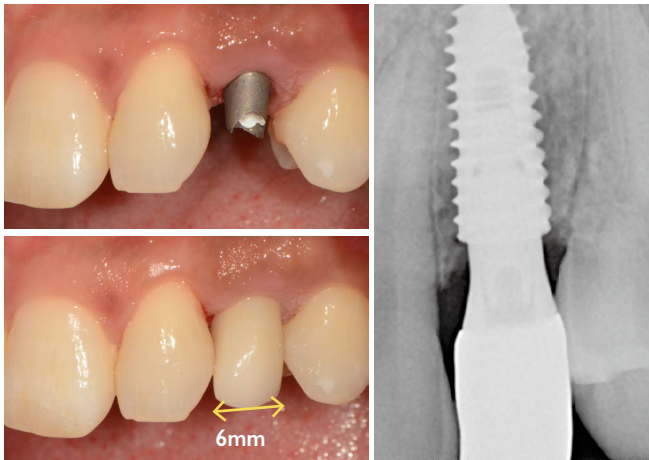


Fig. 9. Restoration is performed using an internal conical connection implant in a case with a small space for a canine tooth.

In the case shown in Fig. 9, it seems that there could be difficulties even with the recommended minimum distance of 6 mm based on the heights of the contours of the adjacent teeth. The available space at CEJ is not particularly large. Thus, caution is required to ensure adequate spacing and prevent any contact between the implant body and adjacent roots. Even a slight intrusion on the space by mistake is unacceptable in the space of a prosthetic restoration with an implant-abutment connection and crown insertion.

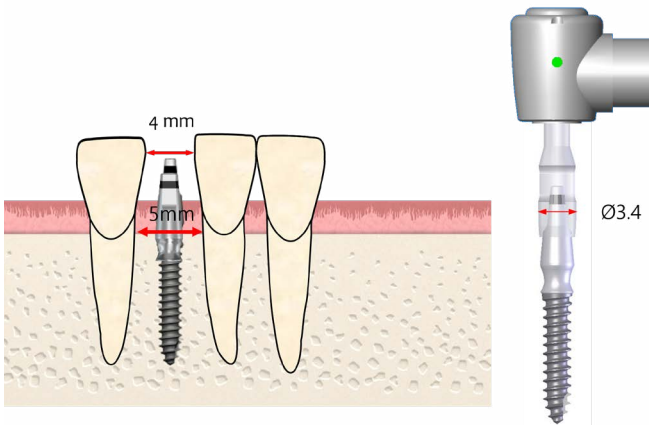


Fig. 10. In theory, the minimum spacing required for restoration with a one-body implant is 4 mm.

As seen in Fig. 10, a one-body implant is generally used for replacing a mandibular anterior tooth. Mandibular anterior teeth tend to be smaller than other teeth, with a relatively smaller loading of the masticatory force. The smallest diameter of an internal conical connection implant is 3.0. In the case of a one-body implant, the smallest diameter available is 2.0, depending on the manufacturer. Most frequently, a one-body implant with a 2.5 diameter is used for mandibular anterior teeth.

Referring to the above figure, a one-body implant could be placed when the distance between the heights of the contours of the adjacent teeth is 4 mm or greater. However, considering the possibility of human error in clinical practice, the author considers a distance of 5 mm between the heights of the contours of adjacent teeth to be the required minimum spacing.

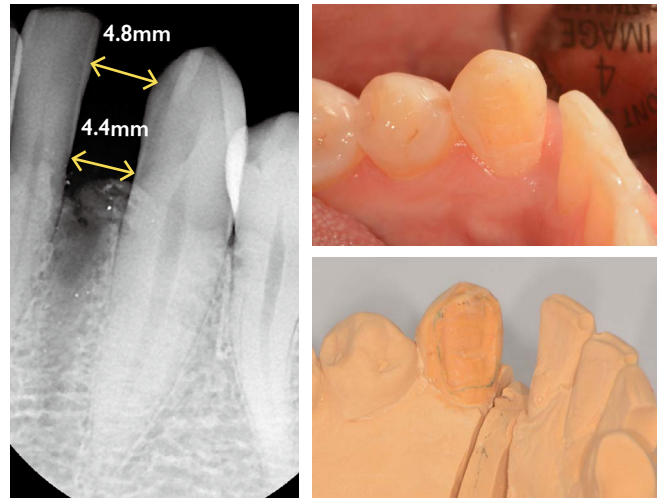


Fig. 11. The distance between the heights of the contours of adjacent teeth was 4.8 mm. The restoration was performed using a Maryland bridge.

If the distance between the heights of the contours of adjacent teeth is 4.9 mm or less even after trimming the adjacent teeth as much as possible, selecting the best option would be difficult considering the spacing at the CEJ. As shown in Fig. 11, in a case with a spacing of 4.8 mm based on the heights of the contours of the adjacent teeth, there was not much available space at the CEJ. Prosthetic restoration was performed using a Maryland bridge. The author believes that there is no reason to insist on an implant procedure considering all of the risks involved.



Fig. 12. One-body implant restoration for #41.

As seen from the case in Fig.12, a one-body implant can be used when the spacing is 5.0 mm. A spacing of 5.0 mm does not allow sufficient space in practice , contrary to expectations. However, this spacing allows restoration with a one-body implant.

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Improved Technique for Soft Tissue Transfer in Implant: From Provisional to Definitive Prosthesis

Donghyun Kim DMD
Kwantae Noh DMD, MSD, PhD

Introduction

The natural harmony between a fixed implant prosthesis and the surrounding soft tissue is crucial for an aesthetic outcome of implant treatment. Healthy peri-implant tissues, a well-defined emergence profile, and compatibility with neighboring teeth are essential for successful treatment, particularly in areas with high aesthetic demands, such as the anterior maxilla. Achieving a natural-looking implant with an appropriate emergence profile and restoring the pontic region can be accomplished by modifying the soft tissue with a temporary prosthesis.

Once the contour of the soft tissue has stabilized and the ideal shape of the temporary prosthesis has been established, it is vital to accurately convey this information to the dental technician. Over the past 30 years, several methods have been proposed for the precise transfer of soft tissue contours created by temporary prostheses. The most recognized method, using custom impression copings, was introduced by Hinds¹ in 1997 and continues to be widely utilized today, as it allows for accurate transfer of soft tissue to the final model.

However, this method has limitations, including the requirement for the final model to be fabricated after taking the pick-up impression, which may necessitate fabricating the model twice if a model was previously made for the temporary prosthesis. To address this limitation, various digital methods have recently been developed to transfer the contour of the temporary prosthesis to the final prosthesis.^{2,3} However, digital techniques often restrict the choice of materials for the final prosthesis. This case report presents a method that may address the limitations of conventional techniques used to accurately transfer the soft tissue contour formed by temporary prostheses.



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Case report

Case : A five-unit implant restoration case in a patient with a traumatic anterior maxilla

A 53-year-old male was admitted with a chief complaint of anterior teeth fractures sustained from a bicycle fall six days earlier. Examination revealed multiple canal fractures in the anterior region, specifically from the right maxillary lateral incisor to the left maxillary incisor, along with a missing left maxillary lateral incisor (**Fig. 1**). Observations indicated fracture lines extending to the roots of the affected teeth, which were deemed hopeless. Consequently, an immediate implant procedure was planned for the right maxillary central incisor, the lateral incisor, and the left maxillary canine following tooth extraction.



Fig. 1a-b. (a) intraoral photograph
(b) radiograph showing multiple fractures of the maxillary anterior teeth.

Preliminary impressions of the maxilla and mandible were taken, along with facial scans and CBCT imaging to prepare a surgical guide. An implant planning software (exoplan; exocad GmbH) facilitated the guide preparation. A digital diagnostic wax-up of the teeth was aligned in the appropriate location, considering both the occlusal relationship and facial scans to ensure optimal placement as determined by CBCT (**Fig.2**). Guided surgery, which involved a bone graft, was performed, and temporary abutments were utilized for four months postoperatively.

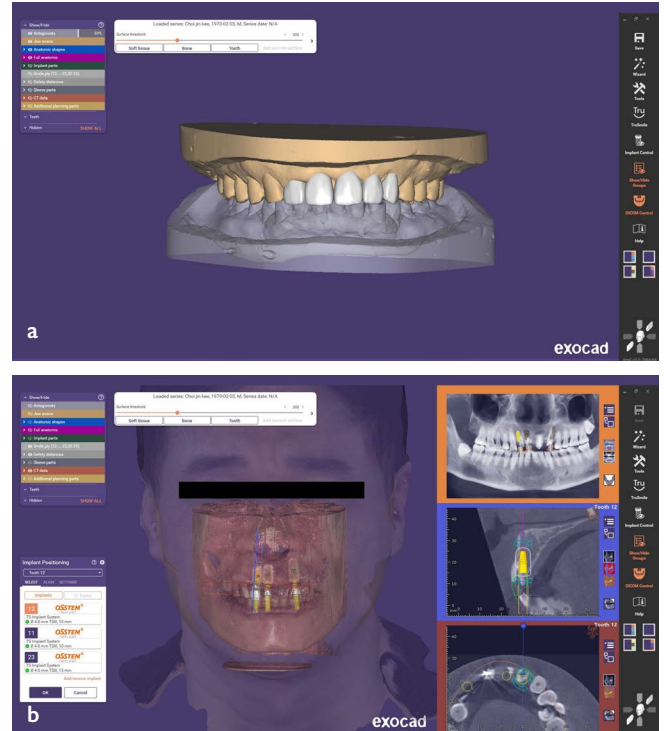


Fig. 2a-b. A digital diagnostic wax-up of the teeth was positioned accurately using the occlusal relationship and facial scan to determine the correct placement on the CBCT.

After implant osseointegration, an implant-level impression was taken for the fabrication of a temporary prosthesis. A model was created, and a diagnostic wax-up was conducted. The wax-up was scanned, and a screw-retained temporary prosthesis was fabricated.

(Fig. 3)

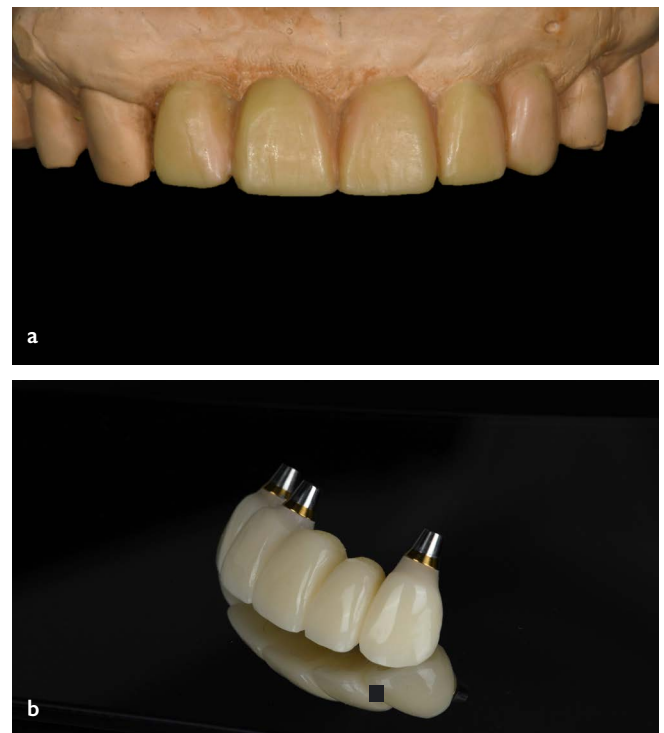


Fig. 3a-b. (a) Diagnostic wax-up.
(b) The wax-up was scanned, and a screw-retained temporary prosthesis was fabricated.

The pontic base was trimmed at the model stage to enhance contour, and resin was periodically added intraorally to the pontic base to create an ovate surface (Fig. 4).

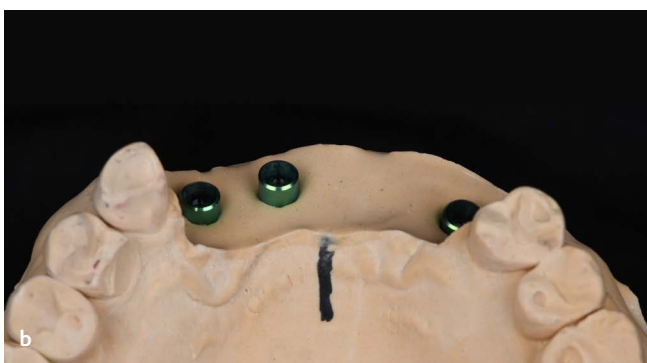
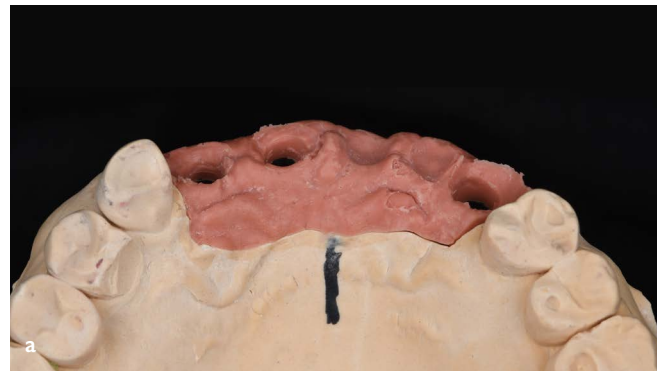


Fig 4a-c. Temporary prosthesis adjustment process.

(a) The pontic base was arbitrarily trimmed at the model stage to enhance contour, which was followed by periodic intraoral adjustments.
 (b-c) After adjustment of the temporary prosthesis, soft tissue naturally developed around the implant and the pontic base.

Once gingival settling was confirmed, the following steps were taken to transfer the shape of the gingiva formed by the temporary prosthesis to the final prosthesis:

1. Remove the silicone gum on the model used for temporary prosthesis fabrication (Fig. 5a, b)
2. Use a self-polymerizing resin (GC Pattern Resin; GC America Inc.) to apply the gingiva around the temporary prosthesis (Fig. 5c, d).
3. Place the temporary prosthesis on the model and inject the silicone impression material. (Fig. 5e, f)



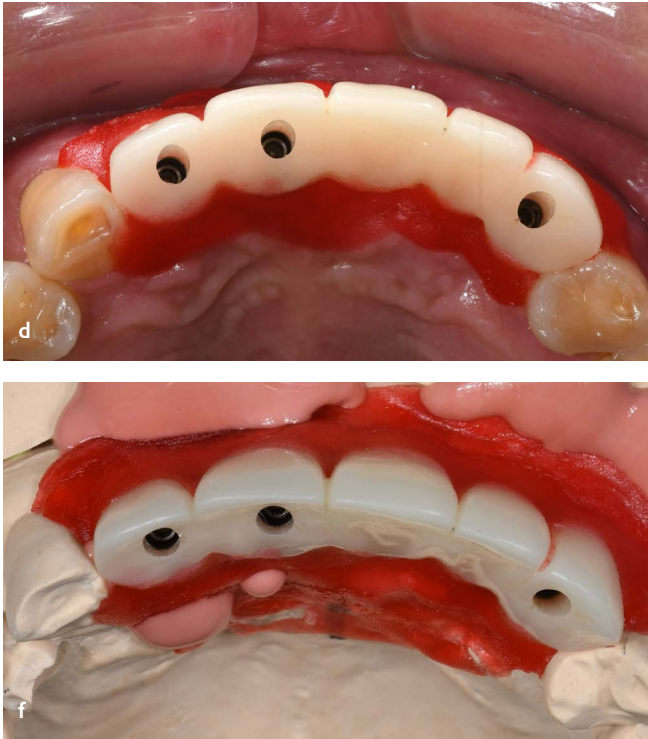


Fig. 5a-f. A series of procedures to transfer the shape of the gingiva formed by temporary prosthesis to the final model.

(a-b) The silicone gum on the model used for fabricating the temporary prosthesis was removed.

(c-d) A self-polymerizing resin was applied to create the gingiva around the temporary prosthesis.

(e-f) The temporary prosthesis was positioned on the model and the silicone impression material was injected.

The gingival contour established by the temporary prosthesis was successfully transferred to the final model (**Fig. 6**). The zirconia prosthesis was designed to achieve a passive fit with the model, facilitating more accurate and predictable prosthesis fabrication.

The esthetics of the anterior maxilla were restored following the application of the final screw-retained prosthesis (**Fig. 7, 8**).



Fig. 6. The shape of the gingiva formed in the temporary prosthesis was successfully transferred to the final model.



Fig. 7. The final screw-retained prosthesis was crafted from full-contoured zirconia



Fig. 8. Final prosthesis in position.

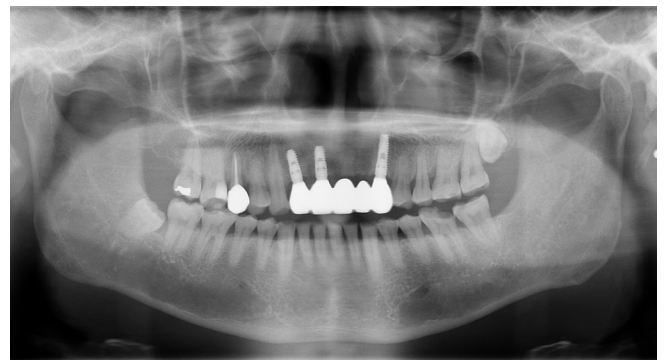


Fig. 9. Postoperative radiograph.

Discussion

In fixed implant prosthesis restoration, the contour of the mucosal penetration is captured using an impression coping when conventional impression techniques are employed. Consequently, the final prosthesis is fabricated with the mucosal penetration area arbitrarily removed, potentially leading to an unexpected gingival appearance. To mitigate these limitations and enhance predictability, Hinds customized impression abutments were introduced, and more recently, digital methods for replicating the shape of a temporary prosthesis have gained popularity. However, as previously noted, the main limitation of the custom impression coping is that the model can only be fabricated after the custom impression coping is created and the pick-up impression is obtained chairside. Additionally, when using the digital method, the choice of material for the final prosthesis is restricted to zirconia.

In this case report, we presented a method that addresses the limitations of conventional techniques, inspired by the approach of Noh et al. (2014), who adapted the technique for capturing the shape of soft tissue formed around temporary restorations for natural teeth.⁴ Noh et al.'s method involves creating a Geller cast, trimming the gingival area around the abutment, applying a temporary prosthesis with a self-polymerizing resin to the Geller cast as shown in this case, and then injecting silicone impression material to accurately replicate the shape of the gingiva. However, the fabrication of the Geller cast can be demanding. The method introduced in this case report eliminates the need for a Geller cast, allowing for greater convenience in clinical practice. Additionally, this approach offers advantages over the digital method, as it does not impose limitations on the choice of material for the final prosthesis due to the existence of a model.

A limitation of this method is that the existing model cannot be utilized if the temporary prosthesis was created without taking the implant impression. In such cases, it may be favorable to use custom impression abutment or conventional methods, including digital techniques. Furthermore, the interdental papilla may not be perfectly reproduced due to undercuts between the embrasures. Nonetheless, as shown in the accompanying figures, while the shape of the reproduced soft tissue may not be ideal, it is sufficiently accurate to enable the fabrication of a prosthesis with a reasonable degree of predictability.

Conclusion

To achieve more predictable outcomes in fixed implant prosthesis treatment, it is essential to accurately transfer the shape of the soft tissue formed by the temporary prosthesis to the final model. The methodology introduced in this case report addresses the shortcomings of conventional techniques and will prove beneficial in various clinical scenarios and for different types of final prostheses.

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