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Original Article
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The use of a custom anterior guide table for anterior guidance fabrication in single implant-supported anterior and tooth-supported restorations

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Abstract

Objective To describe the process of anterior guidance fabrication for the restoration of implant and teeth, which uses a custom anterior guide table to imitate anatomical details obtained from the anterior guidance of original restorations.

Materials and methods The patient was diagnosed with an edentulous tooth on tooth 12 (right maxillary lateral incisor) and poor esthetics of three existing tooth restorations on teeth 11, 21 and 22 (the right maxillary central incisor, the left maxillary central incisor and the left maxillary lateral incisor). The treatment plan was to place an implant on tooth 12 and to employ guided bone regeneration and crown replacements on teeth 11, 21 and 22 by mimicking the original anterior guidance operations using a custom anterior guide table. Properly adjusted occlusions for the implant and the tooth restorations were fabricated and installed.

Results The functional and esthetic results were satisfactory as indicated by the patient at the 12-month recall.

Conclusion The method of anterior guidance fabrication described in this article results in restorations exhibiting esthetically pleasing, congruent occlusions in tooth-supported and implant-supported restorations.

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Key words: *anterior guidance; case report; custom anterior guide table; single implant-supported restoration*

Introduction

The field of dentistry is facing increasing esthetic demands that require the integration of function and esthetics. Thus, treatment plans, particularly for the anterior region, face the challenges of combining esthetic demands (i.e., the length of the tooth, relative proportions of the anterior teeth and smile components) with biomechanical principles[1,2] (including occlusal force andocclusal scheme) that must ultimately be determined by the dentist.[2,3] The longevity of restorationsare clearly improved when good occlusions are achieved, and optimizing anterior guidance is the key to providing occlusal stability, esthetically pleasing results, and long-term success.[1]

Anterior guidance refers to the contact between the incisal edges of the lower anterior teeth to the lingual surface of the upper anterior teeth. It has been classified as a group function and a canine guidance in natural teeth.[4-6] Schuyler demonstrated the destructive forces associated with balanced contacts in balanced occlusions,[7] the basis of anterior guidance shifted from balanced occlusions to a group function. The first clinical applications of canine guidance, which refers to the disclusion of all other teeth by the canines in the lateral excursions,[3,4] were conducted by Stuart, *et. al.*[8] and McCollum.[9]

When multiple anterior teeth are restored, dentists should be aware of occlusions that include both centric and eccentric positions.[3] In the centric position, the contacts between anterior teeth must be lighter than those between posterior teeth.[10] Eccentric tooth contacts depend on the existing positions and angulations of the anterior teeth, which is described as anterior guidance.[4] The anterior guidance is essential for natural posterior teeth in eccentric positions.[11] Thus, the anterior guidance should be reproduced in harmony/combination with the existing occlusal scheme of the posterior teeth in all mandibular excursions.[1] In order for esthetically pleasing/harmonious anterior guidance to be obtained, there must be no sign or symptom associated with occlusal trauma (i.e., tooth mobility, fremitus, tooth migration, orpain and wear facets).[12]

Anterior guidance influences the directions of mandibular movements, including the disclusion of posterior teeth during jaw movements. Thus, anterior guidance can reduce the forces on posterior teeth during lateral excursion. The steepness of anterior guidance is influenced not only by the angles of anterior teeth but also by the extents of overjet and overbite.[13] Steep anterior guidance can cause restriction in the function envelope. Weinberg and colleagues has demonstrated that implant or prosthesis loading is affected by the steepness of anterior guidance.[14] A flatter angle of guidance reduces the loading on restorations. Every 10-degree decrease in the angle of tooth contact (and the related torsional stress) results in a 32% reduction in the loading. Fractures or decementations of provisional restorations usually indicate excessively steep excursive movements.

On the other hand, an anterior guidance that is too flat can interfere with the lip closure path, the neutral zone and functional phonetic relationships.[3] As Williamson has demonstrated, disclusion of all posterior teeth in eccentric movements reduces muscle contractions in two of the three elevator muscles, thereby reducing the loads on temporomandibular joints and posterior teeth in all excursive movements.[11] Gibbs and colleagues found that compared to posterior guidance, anterior or canine guidance decreased chewing forces.[15] For this reason, it is critically important to consider the relationship between anterior guidance and both muscle function and condylar movement. If the anterior teeth are altered by any means, they may lose their capacity for separating the posterior teeth. The elevator muscles are hyperactivated whenever any posterior tooth is contacted during excursive movement. In the case of a group function, loading increases on temporomandibular joints and teeth, particularly the anterior teeth.

For implant restorations, controlling occlusal forces through implant bone interfaces is critical, particularly in the anterior region. The bone surrounding an implant is directly affected by occlusal forces, and stresses or loads can have both positive and negative consequences for the surrounding bone.[16] A particularly important positive consequence is that osseointegration is maintained along the surface of the implant, while a major negative consequence is the loss of bone around the implant.[17] It is inevitable that anterior-region implant restorations will be subjected to non-axial loading, which may cause bone resorption around the implant. Therefore, the manner in which anterior guidance is implemented on the restoration is crucial to the long-term success of an anterior implant restoration.

Especially with regard to the anterior region, the angulation and position of an implant have a major influence on the force transmitted during function. Leblebicioglu and colleagues have suggested that the implant should be oriented five degrees palatally and closer to the palatal cortical aspect in order to minimize buccal angulations. Moreover, the implant should provide enough space for retention screw. The most favorable position of the anterior implant crown should enable the screw hole to emerge through the cingulum area of the crown. In addition, the angulation of the screw hole should be parallel to the axis of the force transmission.[18]

The aim of this case report is to describe the process by which anterior guidance applied to final implant and tooth restorations imitates the existing anterior guidance using the custom anterior guide table.

Clinical case report

A 45-year-old Thai female patient was referred to the Esthetic Restorative and Implant Dentistry Clinic, Faculty of Dentistry, Chulalongkorn University. The patient was referred because of a color mismatch of her existing crowns on teeth 11, 21 and 22 (right maxillary central incisor, left maxillary central incisor and left maxillary lateral incisor) and a missing tooth 12 (right maxillary lateral incisor). The patient was also dissatisfied with the shapes of her crowns and requested longer crowns. Her medical record was unremarkable, and her dental history revealed that the lateral incisor was extracted over 10 years ago and

Fig. 1 Pre-operative photograph exhibiting marginal exposure of the anterior crowns and the missing right maxillary lateral incisor.

replaced with a removable acrylic partial denture. She had never been satisfied with the appearance of her dentures. In addition, teeth 12, 11, 21 and 22 had received root canals, endodontic surgeries, post-and-core treatments and crowns, which were completed 5 years prior to the extraction of tooth 12.

Clinical examination revealed a generally healthy periodontium with a thin gingival biotype. The metal margins of the crowns on teeth 11, 21 and 22 were exposed due to gingival recession (Fig. 1). The existing crowns exhibited stable centric contacts and mutually protected occlusions without any occlusal interferences. No tooth mobility or evidence of fremitus were detected in the existing anterior teeth, although there was a missing right lateral incisor that exhibited horizontal bone loss (of 1 to 1.5 mm compared to adjacent teeth) as well as recession of adjacent papillae. Computer tomogram examination (CBMercurat, Hitachi, Japan) showed reduced horizontal bone width (corresponding to 4.9 mm of bucco-lingual bone width at the bone crest and 15.9 mm of bone height) (Fig. 2). Tooth 12 was diagnosed as an edentulous area with a

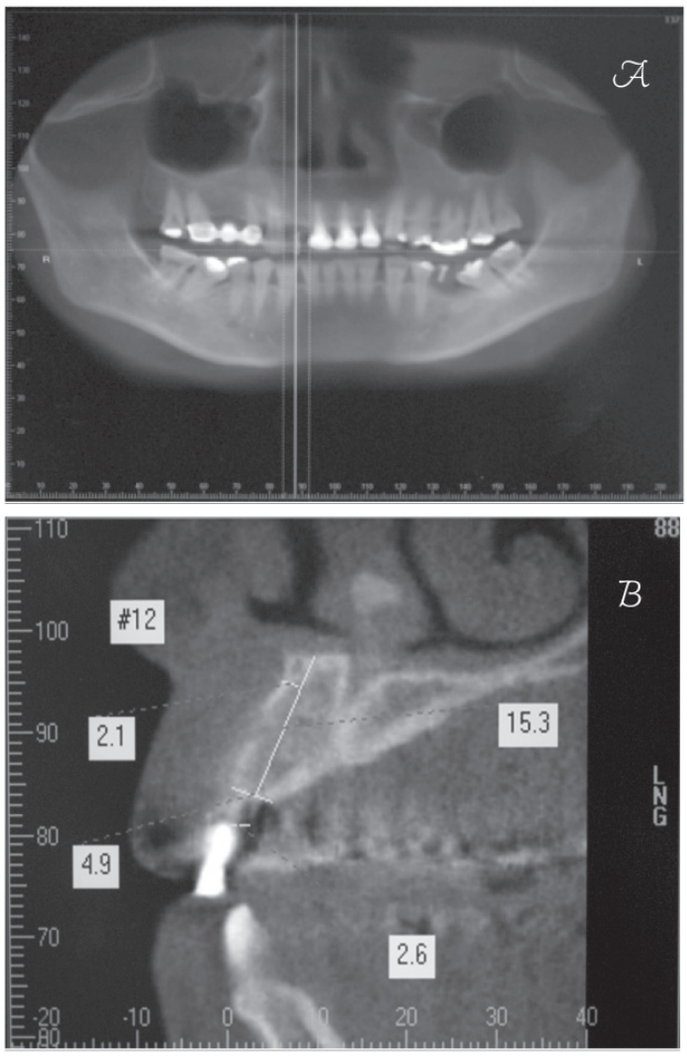

Fig. 2 **A** Simulated panoramic image of computer tomogram. **B** Cross-sectional image of computer tomogram in which a radiographic marker in the area of the missing tooth (tooth 12) demonstrates a bucco-lingual bone width of 4.9 mm at the bone crest and a bone height of 15.3 mm.

Class I defect (Seibert Classification),[19] and teeth 11, 21 and 22 were diagnosed with poor esthetic restoration.

The treatment plan was to place an implant on the right maxillary lateral incisor and to provide guided bone regeneration and crown replacement on each of the other teeth (teeth 11, 21 and 22), imitating the original anterior guidance.

Transferring condylar guidance and anterior guidance to the articulator

The upper diagnostic cast was properly mounted into a semi-adjustable articulator (Artex type CP, Jensen dental inc., USA) using a facebow (Artex facebow, Jensen Dental Inc., USA) to record the positional relationship between the upper jaw and the temporo-mandibular joint. Subsequently, the lower diagnostic cast was mounted using the bite registration record obtained for the maximum intercuspation position. The condylar guidance was obtained using the protrusive interocclusal record, which was placed on the lower cast. The condylar knops were then loosened, and attempts were made to adapt the upper cast to the protrusive interocclusal record by adjusting the condylar angle until complete surface contact of the upper cast and the bite registration was accomplished (Fig. 3). Next, the condylar guidance angle was obtained. The Benette angle was set according to the lateral interocclusal record, after which all excursion movements of the casts (in the articulator) were confirmed based on the movements in the patient's mouth.

The customized anterior guide table

A customized anterior guide table can be fabricated from either a flat plastic guide table or a mechanical anterior guide table using a round-end incisal pin. In the present case, a mechanical anterior guide table was used. The table was flattened to 0 degree. Self-curing acrylic resin (GC pattern resin, GC Inc., USA) was mixed until a homogeneous mixture was achieved, after which the mixture was left until it achieved a doughy consistence. The acrylic was then placed on the anterior table. The articulator was closed until the maximum intercuspation position was reached. The operator's left hand was used to hold the articulator, while his/her right hand was placed on the incisal pin. The model's excursive movements were simulated in all directions until the upper and lower

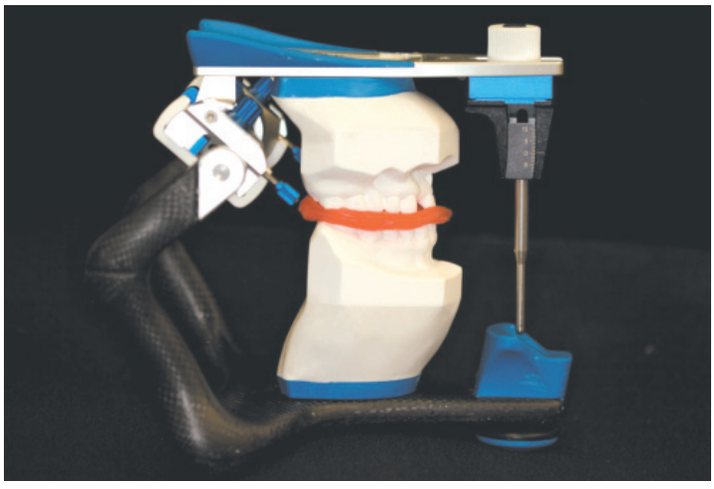

Fig. 3 Transferring condylar guidance. The protrusive interocclusal record was positioned to establish the condylar angle.

anterior teeth were in edge-to-edge position. In this manner, excess acrylic was removed by the incisal pin, thereby creating a smooth track for custom anterior guidance. This process was performed at least twice to compensate for the shrinkage of the acrylic. After completion of the above steps, the acrylic custom anterior guide table was smooth and had a trapezoidal shape (Fig. 4). Finally, the custom anterior guide table was verified by checking the contact between the incisal pin and the anterior guide table surface to ensure that this contact was maintained for all modes of anterior-tooth contact.

Diagnostic wax-up

Diagnostic wax-up of the anterior teeth used esthetic factors, such as crown lengths, axial inclinations, midlines, left-right symmetries, mesio-distal widths, inciso-cervical heights and width-length ratios, as a guideline (Fig. 5). Using this procedure, the incisal edge of the upper anterior teeth was established. The lingual surface of the diagnostic wax up was created following custom anterior guide table. In this case, the custom anterior guide table followed the existing restorations. The only alteration involved the lengths of the anterior teeth. The incisal edge

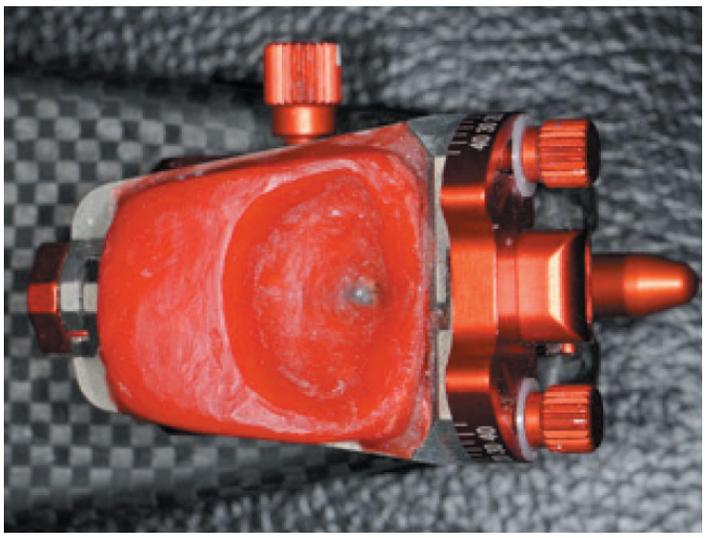

Fig. 4 Custom anterior guidance was established by moving the articulator through protrusive and lateral excursions. The incisal pin had to be moved in every possible position within the movement border.

Fig. 5 Construction of full contour wax-up to ascertain the esthetic appearance of the anterior restorations.

was lengthened by 1 mm (compared to the original restorations), as requested by the patient for esthetic purposes. This wax-up was then used to fabricate the provisional crowns.

Surgical stage

The template was fabricated following the determined wax-up full contour in order to gain the proper three-dimensional position of the implant. This template was used as both the radiographic template and the surgical template. An Astra Tech implant (Astra Tech Inc., Sweden), which had a diameter of 3.5 mm and a length of 13 mm, was selected. Simultaneously guided bone regenerations using autogenous bone, bone filler (Geistlich Bio-Oss, Germany) and collagen membrane (Geistlich Bio-Gide, Germany) were used to cover the exposed implant fixture by layering. Postoperative healing was uneventful. A radiographic record was taken, and the final abutment was inserted 5 months later.

Prosthetic stage

The provisional crowns were fabricated via an indirect technique using the preparation (wax-up) model. The occlusions of the provisional restorations were adjusted according to the custom anterior guide table (Fig. 6).

Next, the provisional restorations were evaluated in terms of their appearance and function (i.e., eating and phonetics), and the joint positions and patient comfort were evaluated. Once it was determined that the provisional restorations had achieved all the goals of the treatment plan, permanent restorations were fabricated accordingly.

The final/permanent restorations were porcelain fused to metal. For each permanent restoration, the lingual metal was designed for occlusal contact, and the metal-porcelain junction was located at least 1.5 mm (and perhaps as much as 2 mm) from the occlusal contact point to reduce chipping of the porcelain. A full contour wax-up was constructed for each final restoration. The lingual surface of each crown was constructed according to the custom anterior guide table. The incisal edges of the wax patterns were constructed in accordance with the provisional crowns. After the full contour wax-up was fabricated, room was made for the porcelain using a cut back technique. In this case, due to the patient's financial status, non-precious metal was used. Trials utilizing bisque porcelain baked in castings were performed to verify the occlusion, shape,

Fig. 6 Temporary restorations were delivered to enable the patient to evaluate/approve their appearance and function.

alignment, proportion, contour and color of each restoration. A shim stock was used to check centric contact. All natural teeth were required to hold the shim stock at the same time, while the implant crown only held the shim stock when the patient had a heavy occlusal contact. In each case, the eccentric contact was confirmed as an anterior group function. All crowns were placed in the mouth, and their contacts were checked in every direction, as indicated by the custom anterior guide table. After occlusion and color were determined to be satisfactory, the porcelain crowns were glazed and polished. All crowns were cemented with glass ionomer cement (Ketac™ Cem Easy Mix Glass Ionomer Cement, 3M ESPE, USA) (Fig. 7). The patient returned for postoperative care and evaluation after 1 week, 4 weeks, 3 months, 6 months and 1 year, and examinations via radiographic record and Computer tomogram (CBMercurat, Hitachi, Japan) were performed at the 1-year mark (Fig. 8).

Result

The patient was satisfied with both the esthetic and functional aspects of the restorations which were constructed according to the custom anterior guide table. There were no signs or symptoms of traumatic

Fig. 7 **A** The final restoration was cemented with minimal occlusal adjustment. **B** Occlusions of the final restorations. The thickness of the carbon paper is 20 microns. Tooth number 12 had a lighter color band compared to the others resulting from lighter contacts in the maximum intercuspation position and during excursive movements.

occlusions. The one-year follow-up showed excellent clinical and radiographic results, exhibiting very stable peri-implant soft tissues and optimal crestal bone heights.

Discussion

Occlusal forces can be categorized into two groups, axial loading and non-axial loading. In implant dentistry, these forces affect bone tissue in different ways. In one study that used histological sections of a beagle dog model, the quiescent remodeling gradually decreased from the coronal aspect to the apex of the axial loaded implants. In contrast, non-axial loading required more remodeling along the implant surface of surrounding cortical and trabecular bone tissue.[20] Furthermore, a non-axial loading group exhibiting more osteoclastic activity was identified. Isidor suggested that this marginal bone may have loss, if the experimental period was longer than 7 weeks.[17] Non-axial forces could also have affected the prosthesis screw, because the highest stress was found in this area. Compared to the axial load, the oblique load generated a higher stress value and a greater concentration of the force to the prosthesis screw, which likely contributed to the loosening or fracturing of the implant screw.[21] Nevertheless, an implant on the upper anterior region will inevitably receive a non-axial load because of the anatomical limitations of the alveolar bone.

In the present case, the implant was placed in the cingulum area of the template of tooth 12, but the angulations were inclined toward the incisal edge of the tooth. Using this implant angulation, the only prosthetic option was a cement-retained crown. In addition, this implant angulation resulted in a non-axial load on the implant. Therefore, if occlusion after the restorations has not been adjusted properly, the bone at the labial aspect of the implant might be resorbed. The consequence of this bone resorption is gingival recession, which leads to a compromised esthetic result.

Mulemann reported movement of the natural tooth in the range of 56-108 microns,[22] while the osteointegrated implant reportedly moved 10-50 microns.[23] This difference of movement interferes

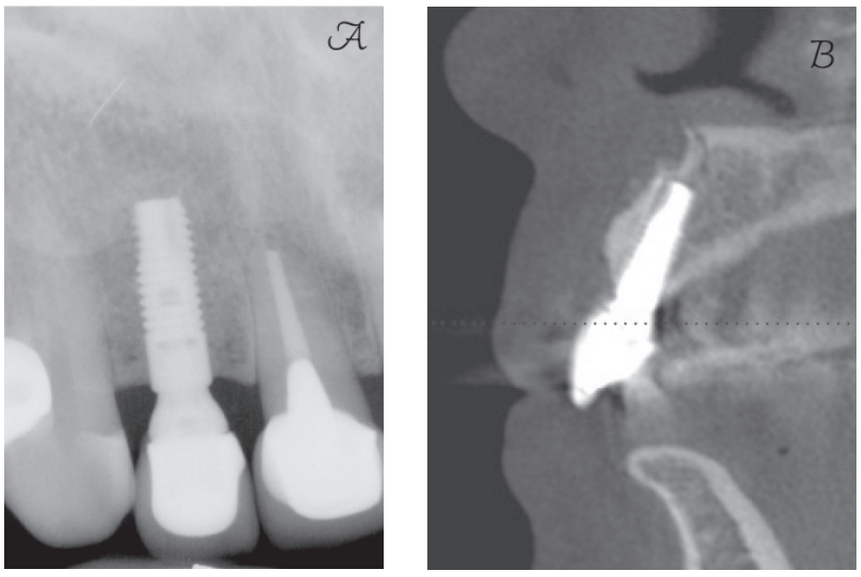

Fig. 8 **A** The radiographic record obtained at the 1-year follow-up. **B** Computer tomogram obtained at the 1-year follow-up.

with control of the occlusal force. If loading of equal magnitude and direction is placed on both an implant and a natural tooth, the implant will bear a higher proportion of the load. Therefore, additional considerations must be made regarding the occlusal contacts of the conventional crown and the implant crown. For centric light occlusal contacts, all upper anterior teeth should have even occlusal contacts (Fig. 9), excepting the implant crown, which is less occluded by one shim stock. The implant crown should only make contact during heavy occlusions (Table 1).[24] For eccentric movements, the anterior teeth should exhibit anterior group function, whereas the implant crown should be free of contact except when it is in the edge-to-edge position (Fig. 10). In the present case study, the existing occlusion was considered optimal because there was no sign/symptom of overload during either centric contact or eccentric movement. In addition, The one-year follow-up radiographic examinations suggested that the bone level was being maintained. An evenly distributed centric contact was found for every tooth in the centric occlusion, while anterior contact discluded the posterior teeth during eccentric movements, a result that was categorized as anterior group-function occlusion.

It is essential to control the force when restoring anterior teeth. In this present case, using the custom anterior guide was the technique we applied. This technique allowed making esthetic changes to the case but still maintain a familiar occlusal scheme that the patient will feel comfortable with. Trying to preserve and then to reproduce the anterior guidance provided by the original restorations in waxed up restorations. The dental technician can compare the shapes of the lingual surfaces and the incisor edge positions of the upper anterior teeth of the final restorations to those of the natural teeth. This ensures that, when the procedure is complete, all excursive movements are accurately imparted to the restorations. Moreover, using the custom anterior guide table, the technician can fabricate restorations that accurately represent the patient's maxillomandibular relationship.

Table 1 Occlusal contact at each position. The thickness of the shimstock is 8 microns. On the implant restoration, the shimstock should be able to be extracted under light occlusal forces to ensure that no implant crown contact occurs. When pressure was applied to the teeth, the first/primary movement occurred via the periodontal ligament, and the secondary movement occurred via the bone. The implants moved only slightly and in a manner that was similar to the secondary movement (via the bone). Therefore, each implant should be able to hold the shimstock during secondary movement (heavy contact occlusion). No excursive contact was observed except at the edge-to-edge position. (modified from Misch and colleague[24])

	Hold Shimstock			
	Maximum intercuspation position		**Anterior guidance (under heavy contact)**	
Closure	Under light contact	Under heavy contact	During movement	Edge-to-edge position
Tooth to tooth	Yes	Yes	Yes	Yes
Tooth to implant	No	Yes	No	Yes

Furthermore, this procedure, which minimizes occlusal adjustments, can reduce chair-times during visits scheduled for patients to try on their restorations.

The custom anterior guide table is usually made from either high viscosity polysiloxane (putty type)[25] or acrylic resin.[26] Acrylic resin is more accurate and durable compared to polysiloxane. However, acrylic resins exhibit a volumetric shrinkage (7.9%)[27] during polymerization, a critical disadvantage in using this material for impressions. Thus, to confirm the shape of

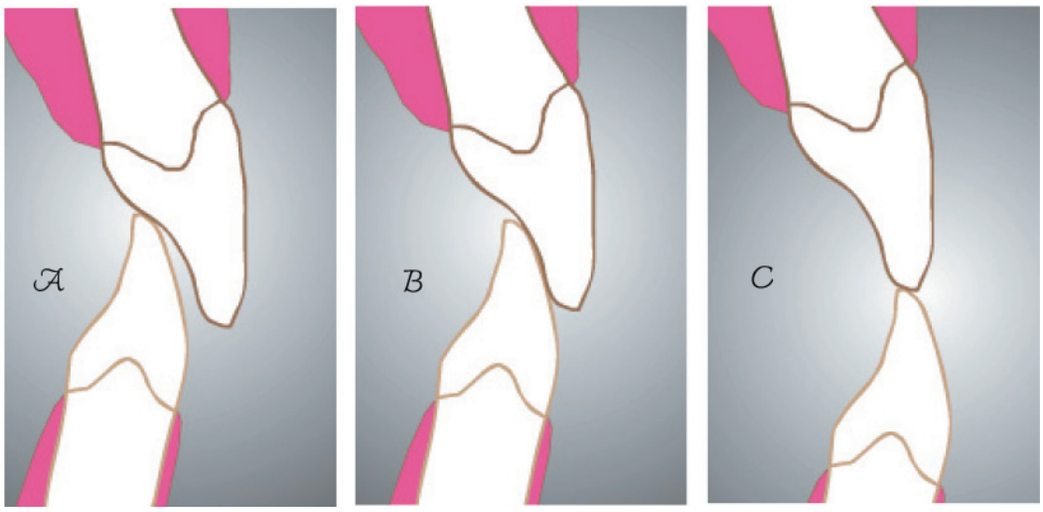

Fig. 9 Occlusal contacts between natural teeth. **A** demonstrates tight contact at the maximum intercuspation position. **B** demonstrates tight contact during anterior guidance. **C** demonstrates tight contact at the edge-to-edge position. (modified from Dawson[3])

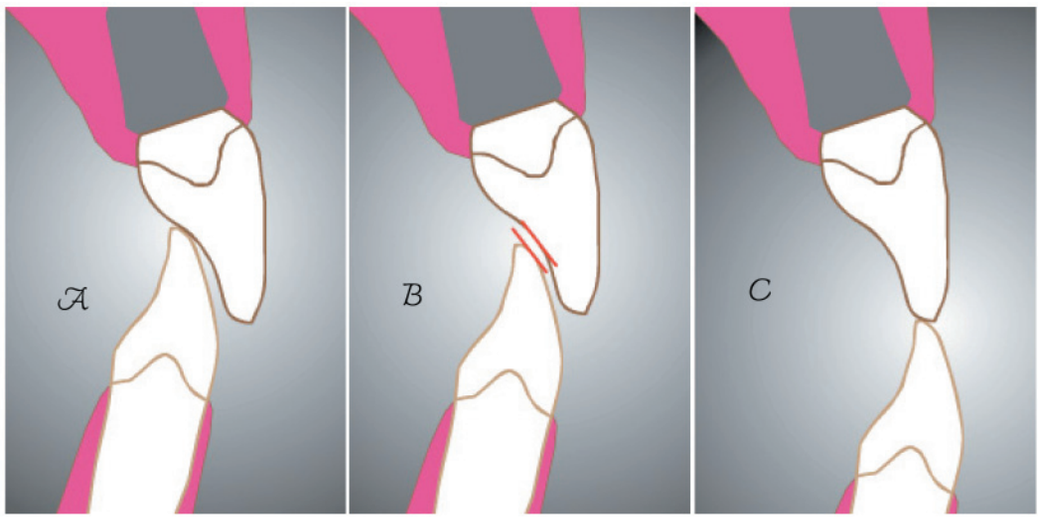

Fig. 10 Occlusal contacts between an anterior implant crown and a natural tooth. **A** demonstrates tight contact at the maximum intercuspation position. **B** demonstrates reduced contact during eccentric movement. **C** demonstrates tight contact at the edge-to-edge position. (modified from Dawson[3])

the table, when using acrylic resin, the custom anterior guide table must be created at least twice to compensate for the shrinkage of the resin.

An alternative technique for setting up the anterior guidance uses a mechanical anterior guide table. However, mechanical anterior guide tables have flat surfaces, while the shapes of lingual surfaces vary depending on the curvature of the lingual fossae on the incisors. Thus, using a mechanical anterior guide table could cause overcontouring of restorations' lingual surfaces, thereby making this procedure detrimental for restorations and abutments.[28]

In the present case study, for esthetic purposes, the restorations were 1 mm longer than the original restorations. Lengthening the restorations increased the overbite, but this increased overbite did not alter the slope/steepness of the anterior guidance, which would have caused more activation of muscles during excursive movements, especially in the edge-to-edge position. The restorations' effects on (increasing) muscle activation were determined using the provisional restorations, which were regularly evaluated and equilibrated (stabilized). The final restorations were fabricated based on the provisional restorations.

Conclusion

Combining natural tooth restoration and implant-supported restoration in the area of the anterior maxilla is complicated. The occlusal contact must be analyzed carefully to achieve the proper contacts between different foundations. The procedure described in this article achieved harmonious occlusions in tooth-supported and implant-supported restorations in a patient that already had harmonious anterior guidance in their original restorations.

The procedure of transferring anterior guidance from original restorations to final restorations is summarized below.

1. Transfer original anterior guidance from natural teeth or old restorations to custom anterior guide table.

2. Transfer custom anterior guide table to diagnosis wax-ups and provisional restorations.

3. Verify anterior guidance using provisional crowns to ensure all reconstructive and esthetic goals are met.

4. Transfer custom anterior guide table to final restorations.

5. Establish implant-protected occlusion by reducing implant-restoration occlusion/contact in the maximum intercuspation position and during excursive movements.

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การใช้แท่นแนวนำฟันหน้าเฉพาะบุคคลเพื่อสร้างแนวนำฟันหน้าในการบูรณะฟันหน้าบนในรากเทียมซี่เดี่ยว และฟันธรรมชาติ

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บทคัดย่อ

วัตถุประสงค์ เพื่ออธิบายถึงขั้นตอนการสร้างแนวนำฟันหน้า โดยมีลักษณะเลียนแบบแนวนำกายวิภาคของครอบฟันหน้าบนเดิมที่มีอยู่แล้วโดยละเอียด ด้วยการใช้เทคนิคแท่นแนวนำฟันหน้าเฉพาะบุคคลสำหรับการบูรณะโดยการทำครอบฟันที่รองรับโดยฟันธรรมชาติ และครอบฟันที่รองรับโดยรากเทียม

วัสดุและวิธีการ ผู้ป่วยถูกวินิจฉัยว่ามีสันเหงือกว่างที่ตำแหน่งฟัน 12 (ฟันตัดหน้าซี่ข้างด้านขวา) และครอบฟันบนฟัน 11 21 และ 22 (ฟันตัดหน้าซี่กลางด้านขวา ฟันตัดหน้าซี่กลางด้านซ้าย และฟันตัดหน้าซี่ข้างด้านซ้าย) ขาดความสวยงามโดยมีแผนการรักษา คือ ฝังรากเทียมตำแหน่งฟัน 12 พร้อมกับการปลูกกระดูก และเปลี่ยนครอบฟันบนฟัน 11 21 และ 22 โดยการสร้างครอบฟันใหม่จะลอกเลียนแบบแนวนำฟันหน้าของครอบฟันเดิม โดยใช้วิธีการสร้างแท่นแนวนำด้านหน้าเฉพาะบุคคล ซึ่งครอบฟันที่สร้างเสร็จจะถูกปรับแต่งการสบฟันเป็นอย่างดีก่อนที่จะใส่ให้แก่ผู้ป่วย

ผลการศึกษา หลังจากที่ได้ใส่ให้ผู้ป่วยไป 12 เดือน ผู้ป่วยมีความพึงพอใจในความสวยงามและการใช้งานของการบูรณะด้วยครอบฟัน

สรุป การสร้างแนวนำฟันหน้าที่ได้บรรยายในบทความนี้สามารถบูรณะฟันหน้าบนให้มีการสบฟันที่กลมกลืนกันระหว่างครอบฟันบนฟันธรรมชาติและครอบฟันที่รองรับโดยรากเทียม

(ว ทันต จุฬาฯ 2555;35:259-72)

คำสำคัญ: *ครอบฟันบนรากเทียมหนึ่งซี่; แท่นแนวนำด้านหน้าเฉพาะบุคคล; แนวนำฟันหน้า; รายงานการรักษาผู้ป่วย*