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Implant placement in the esthetic zone: a case report in patient with a maxillary canine tooth loss

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Abstract

Dental implant placement in the esthetic zone requires knowledge of various concepts and techniques, and a thorough oral examination of both hard and soft tissues. A meticulous treatment plan can then be developed, which ultimately will lead to an esthetically pleasing result. In this case report, the author has described key elements for successful implant restoration in the esthetic zone.

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Key words: *dental implant; implant in anterior teeth; implant in esthetic zone*

Introduction

The loss of a tooth in the esthetic zone can have a profound effect on a patient's appearance, mastication and speech. Therefore the goal of a successful esthetic implant is not only the replacement of a missing tooth, but also to mimic the anatomic form of a natural tooth on the contralateral side. According to the ITI Treatment Guide (Consensus Statement C.1, Standards for an Esthetic Fixed Implant Restoration): *"An esthetic implant prosthesis was defined as one that is in harmony with the peri-oral facial tissues of the patient. The esthetic peri-implant tissues including health, height, volume, color, and contours, must be in harmony with the healthy surrounding dentition. The restoration should imitate the natural appearance of the missing dental unit(s) in color, form, texture, size, and optical properties."*[1-4]

Successful dental implant treatment to replace missing teeth in the anterior maxilla requires preoperative treatment planning, specific surgical plan (three-dimensional implant position), and prosthetic rehabilitation which will be fabricated in consideration of function and soft-tissue support.

Preoperative treatment planning: High patient's expectation, a high smile line, poor gingival quality, poor papillary morphology, low bone volume and poor bone quality are considered to be esthetic risk factors which can often lead to patient dissatisfaction with implant dentistry outcomes. Suitable management of these factors is a prerequisite to the predictable results.[5]

In order to achieve esthetic soft tissue contours, the relationship between the final restoration and the surrounding bone height must be meticulously considered.[6,7] This planning step must include an assessment of the mesio-distal, bucco-lingual and interocclusal space available for implant, restoration and, importantly, biologic width. Furthermore, the clinician must determine whether the existing bony morphology is sufficient for an ideal three-dimensional implant position. If deemed inadequate, site development-including ridge augmentation, sinus lift, orthodontic movement of adjacent teeth, and soft tissue augmentation-should be considered.[8]

Specific surgical plan (three-dimensional implant position): In order to place a dental implant at the optimal position, the clinician has to understand basic principles of the dental implant. The esthetics of a maxillary anterior single restoration is often one of the most difficult challenges in restorative dentistry due to the different anatomy between dental implant and natural tooth. The implant is round in cross section and the diameter is often 5 mm or less. A natural maxillary anterior crown at the cervical region is 4.5 to 7 mm in mesio-distal dimension and is never completely round. In fact, the natural central incisors and canine teeth are often larger in their bucco-lingual dimension than in the mesio-distal dimension at the cemento-enamel junction level. After extraction, bone loss first occurs in the bucco-lingual dimension; hence the greater width of an implant would require even greater augmentation. As a result, the cervical esthetics of a single-implant crown must accommodate a round-diameter implant.

Furthermore, the maxillary anterior region also requires the ability to withstand high occlusal force, especially non-axial forces. Unfortunately there are no clear solutions for controlling lateral forces which are more detrimental than axial forces since the cortical bone is known to have the least resistance to shear force.[9]

Biomechanics has long been used to explain many kinds of complications in implant dentistry, and it has become evident that this discipline encompasses more than just screw loosening and prosthetic fit. When a force is applied along the axis of an implant (axial force), the stress will be well distributed around the implant since the implant and the supporting bone have high load-bearing capacity. However, if the force is

applied to an implant in a non-axial direction, it will result in a bending moment on the implant. In bending, only a small portion of the cross section of the implant will counteract the load. The bone will be mainly loaded at the terminal portions of the implant, thus increasing the stress levels in both implant and bone. The crestal bone around the implant could be a fulcrum point for this lever action when bending moment is applied, suggesting that implants could be more susceptible to crestal bone loss by non-axial mechanical force[10] (Fig. 1).[11]

A study by Weinberg and Kruger[12] supported the importance of biomechanics in implant dentistry. The authors revealed that the major cause of implant/prosthesis failure after second-stage surgery can be attributed to implant overload, and have drawn a very interesting conclusion that for every 10° increase in cuspal inclination, there was approximately a 32% increase in torsional stress on the prosthesis abutment.

Moreover, osseointegrated implants are ankylosed to the surrounding bone without a periodontal ligament which has mechanoreceptors and a shock-absorbing function. Although these deficiencies do not affect a patient's overall ability to chew, they have important implications for implant survival.[13] To address the loss of a natural shock-absorbing property and the ability to sense overloading, most treatment protocols recommend that single-unit implant restorations be slightly out of occlusion in order to compensate for the axial compression of the periodontal ligaments in the adjacent natural teeth upon loading.[14] Failure to do so may cause occlusal overload, which is generally accepted as a major causative factor for late failure of osseointegrated implants.[15,16]

Grunder, *et al.*[17] stated that correct positioning of the implant is one of the key factors for a successful esthetic result. The optimal implant position is in the center of the tooth to be replaced,

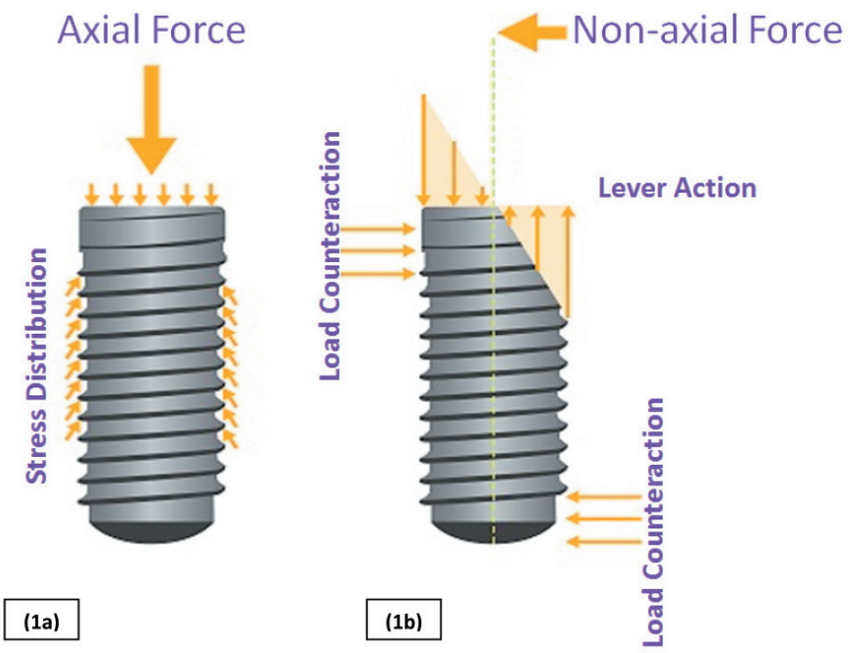

Fig. 1 (1a) When an axial force is applied along the axis of an implant, the stress will be well distributed around the implant. (1b) When the force is applied to an implant in a non-axial direction, it will result in a bending moment on the implant (This illustration was modified from Fig. 3-1 and Fig. 3-2 in reference 11).

1.5 to 2.0 mm more palatal than the expected buccal emergence profile at the gingival margin of the crown. The natural thickness of connective tissue overlying the bone around the implant is within a narrow range, from 2.8 to 3.8 mm.[18] The presence of a papilla depends on multiple factors such as the level of the bone, volume of the connective tissue, and proximal support of the crowns. However, in the case of an implant next to a tooth, the presence of the papilla is mainly determined by the bone attachment on the tooth side.[19,20] It is very important to take into consideration that a certain amount of bone resorption occurs around dental implants as soon as the implant comes in contact with the oral environment. On average, the first bone-to-implant contact is around 1.5-2.0 mm below the implant shoulder[15] shortly after implant exposure. This bone resorption occurs not only in a vertical but also in a horizontal direction, as pointed out by Tarnow, *et al.*[21] The mean horizontal bone loss is 1.3 to 1.4 mm. With this information, the distance between an implant and an adjacent tooth should not be less than 1.5 mm. This 1.5 mm resorption will also appear on the buccal side of the implant shoulder. Therefore the required buccal bone thickness should be at least 2 mm, and preferably 4 mm.[22]

Prosthetic rehabilitation: The apical positioning of the implant platform below the soft tissue is performed to make the implant-abutment attachment invisible. The depth of the platform is primarily dependent on the soft tissue thickness and the expected restoration margin. The implant fixture shoulder is placed 2-4 mm away from the cervical margin of the expected restoration to provide enough length to form a gradual emergence profile from the implant platform to the height of the contour of the restoration.[23,24]

In light of the situation described above, it is beneficial to avoid vertical and horizontal bone resorption. One of the solutions for this problem is platform switching. This concept originated from an observation that bone resorption seems to be minimized when the connection between the implant shoulder and abutment is moved horizontally away from the bone.[25] A review in 2009[26] revealed that platform switching is capable of reducing or eliminating crestal bone loss to a mean of 1.56 mm ± 0.7 mm. It also limits the circumferential bone loss.

Both cement-retained and screw-retained designs are acceptable treatment modalities for single-implant restoration. However the biggest challenge with a cement restoration is the complexity in clinical delivery. As previously mentioned, the desired depth of the implant platform is about 2 to 4 mm at the midbuccal area. Because of the scallop of the gingival tissues, this implant fixture depth can be about 5 to 7 mm from the tip of the papilla to the implant platform at the interproximal area of an anterior tooth. The margins of anterior restorations are usually placed subgingivally, leading to an increased risk of leaving excess cement in the peri-implant tissues that result in severe clinical consequence. Therefore, screw-retained restoration is preferable for replacement of a natural tooth. It provides an excellent esthetic appearance and is easily retrieved. A single-component screw-retained prosthesis is recommended in conditions where the anatomy of the alveolar ridge allows the implant axis to pass through the occlusal or lingual surface of the planned restoration. Correct abutment selection is required to avoid phonetic compromises from a bulky palatal aspect.

Preliminary indications suggest single-unit implant-retained restorations have the potential for long-term success. Multiple studies have reported five-year implant survival rates upwards of 95%.[27-29] Risk factors such as poor patient oral hygiene, poor alveolar bone quality, and smoking have been shown to have a negative effect on implant survival rates, but the true extent of these effects has yet to be determined.[30]

The objective of this case report is to review and describe the key elements of successful dental implant restoration in the esthetic zone. The following case report illustrates a single-unit implant restoration in patient with a maxillary canine tooth loss.

Clinical case report

A 40-year-old male presented at the Esthetics and Implant Clinic, Chulalongkorn University, upon referral from a private clinic, with the chief complaint of a space at the area of tooth 23. Evaluation of the patient's condition confirmed that restoration of the tooth 23 area could be best accomplished with a single-unit implant-supported restoration. The permanent maxillary left canine was congenitally absent, and the deciduous maxillary left canine had been extracted as a result of trauma 3 months prior to his presence at the Esthetics and Implant Clinic, Chulalongkorn University. His medical history was unremarkable except for a smoking habit (10-15 cigarettes/day) for 5 years. There were no contraindications for surgical procedures. Periodontal and occlusal examinations revealed 4-5 mm probing depths with bleeding upon probing in posterior teeth. No significant mobilities were detected. However, there were multiple missing teeth: 18, 23, 28, 38 and 48. An Angle's classification I was present on both left and right sides, with normal horizontal and vertical overlap. However, on the patient's left side a crossbite between tooth 24 and tooth 34 was observed, with supra-eruption of tooth 33 into the tooth 23 space. The final outcome could thus be expected to be shorter tooth length than usual due to the existing limited space (Fig. 2).

Radiographic evaluation of the tooth 23 area revealed a mild class I type with buccal concavity/ridge defect, according to Seibert's classification[31], with a bucco-lingual width of 7.7 mm, mesio-distal width of 7 mm, and apico-coronal length of 6.6 mm (Fig. 3). An implant esthetic risk profile[1] was reviewed with the patient and a medium esthetic risk was determined. (Table 1).

The following finalised treatment plan was developed, consisting of:

- Smoking cessation: By providing resources and useful information about smoking cessation and pointing out the negative effect of smoking on the patient's periodontal health as well as the impact on failure rate of dental implant restoration.

- Periodontal evaluation with nonsurgical approach.

- Orthodontic treatment in order to correct a crossbite between tooth 24 and 34 as well as supra-eruption of tooth 33.

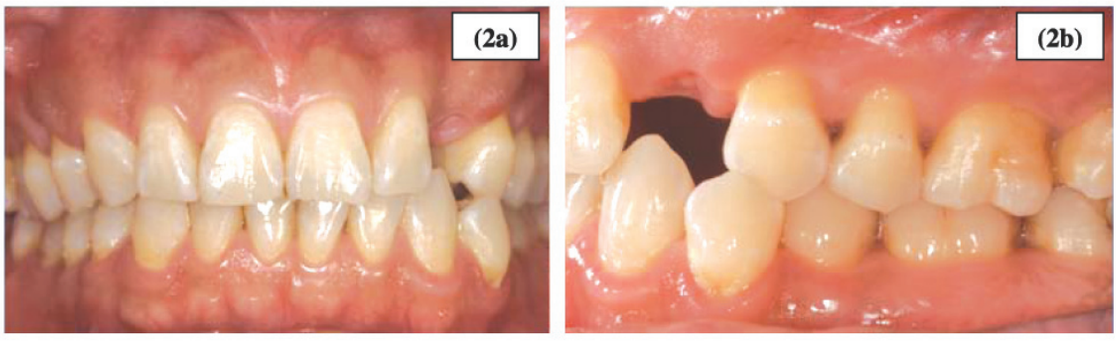

Fig. 2 Frontal view (2a) and buccal view (2b) of the patient's intra-oral pictures show limited vertical space at the area of tooth 23 due to supra-eruption of tooth 33.

Table 1 An implant esthetic risk profile was reviewed with the patient and a medium esthetic risk was determined.

Esthetic Risk Factors	Low	Medium	High
Medical status	Healthy patient and intact immune system		
Smoking habit			Heavy smoker (> 10 cig/d)
Patient's esthetic expectation			High
Lip line		Medium	
Gingival biotype		Medium-scalloped, medium-thick	
Shape of tooth crowns	Rectangular		
Infection at implant site	None		
Bone level at adjacent teeth		5.5 mm to contact point	
Restorative status of neighboring teeth	Virgin		
Width of edentulous span	1 tooth (7.0 mm)		
Soft-tissue anatomy	Intact soft tissue		
Anatomy of alveolar bone		Buccal bone concavity	

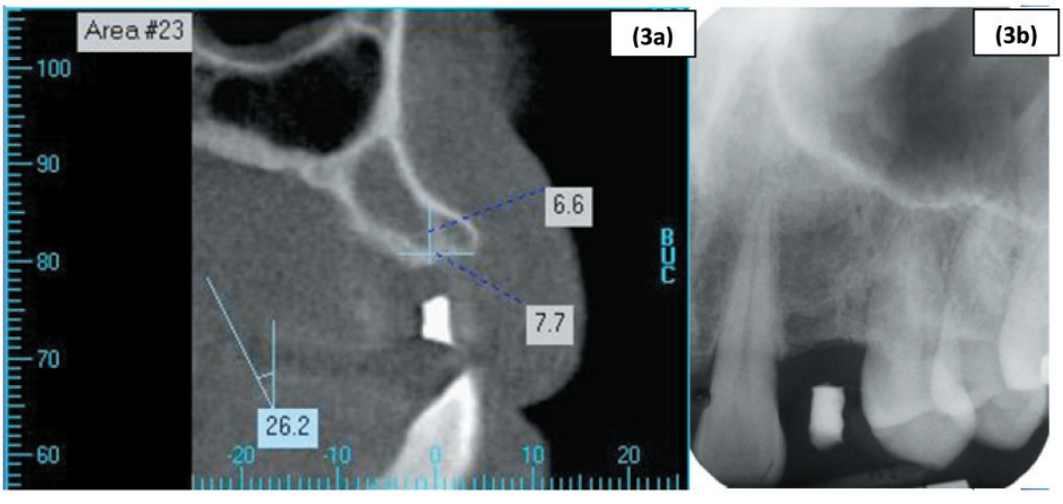

Fig. 3 CT scan (3a) and radiographic peri-apical view (3b) at the implant site show definite implant position which allows forces to be distributed along the axial direction. At this position, fenestration at the apical area was expected.

- Implant surgical placement (4.1 x 10 mm Bone Level Implant; Straumann®, Basel, Switzerland) with guided bone regeneration (GBR) at the tooth 23 area (Bio-Oss® and Bio-Gide®; Geistlich Pharma, Wolhusen, Switzerland).

- Connective tissue graft to correct soft tissue concavity on the buccal aspect

- Implant screw-retained provisional restoration in order to create tissue "sculpting"

- Enameloplasty on tooth 33 (1 mm)

- Completion of screw-retained zirconium crown on implant 23, after 3 months of provisionalization

- Periodontal maintenance phase

The patient refused orthodontic treatment and connective tissue graft. He was satisfied with the existing alignment and soft tissue contour. After the patient studied the smoking cessation information, he tried to reduce his cigarette intake down to 5 cigarettes a day and will try to stop his smoking habit permanently

Implant Surgical Phase: The patient was treated using local anesthesia (4% Articaine hydrochloride with 1/100,000 epinephrine, Septanest SP®, Septodont, Saint-Maur-des-Fossés Cedex, France) and was premedicated with a nonsteroidal anti-inflammatory drug (Ponstan® 500 mg), an antibiotic (amoxicillin 2,000 mg) and a surgical rinse of chlorhexidine 0.012%, 60 minutes before surgical procedure. A mid-crestal incision (from tooth 22 to tooth 24) with sulcular incisions (on buccal of tooth 22 and tooth 24) and a distal vertical releasing incision (at tooth 24) were performed. A surgical stent was positioned and used throughout the procedure to judge proper positioning of the implant in three dimensions. For bone-level implants, a 3-4 mm apically from mid-buccal of the surgical stent is desired in order to create the necessary distance for an emergence profile. The osteotomy site was prepared for a 4.1 x 10 mm (Bone Level Implant; Straumann®, Basel, Switzerland). The implant was carefully installed into the prepared osteotomy site.

The desired osseous thickness of 2 mm was noted. However, fenestration at the apical area of the implant occurred, as was anticipated. Guided bone regeneration (GBR) was the treatment of choice to correct this defect. A non-resorbing grafting material (Bio-Oss®, Geistlich Pharma, Wolhusen, Switzerland) was carefully placed into the defect and was covered with a resorbable collagen membrane (Bio-Gide®, Geistlich Pharma, Wolhusen, Switzerland). A 4 mm bottleneck healing abutment was placed to prevent any pressure on the buccal flap. The area was sutured with fine periodontal absorbable surgical sutures (5-0 Vicryl, Ethicon, New Jersey, USA) (Fig. 4). The patient went home after post-operative instructions were reviewed.

Post-operative phase: At the 2-week post-operative appointment, the stitches were removed. Clinical examination revealed normal wound healing, the patient did not report any discomfort, the surgical area was slightly red, no signs of inflammation. Plaque deposit was found on the healing abutment and adjacent teeth. Home-care instruction was given and he was appointed for follow-up appointment. At the 5-month postoperative appointment, soft tissue at the surgical area was completely healed and the bottleneck healing abutment was removed. Bone healing was tested without anesthesia using a RC implant carrier device with a reverse torque of 35 Ncm (Straumann, Basel, Switzerland). The torque driver increased the torque slowly up to the 35 Ncm line, and then was reversed and removed. The patient did not feel any discomfort or movement of the implant; therefore the case was ready for prosthetic completion.

Prosthetic Phase: The development and appearance of the soft tissue region can determine the treatment success. It is important to use the provisional restoration to sculpt the peri-coronal tissue to duplicate the contralateral canine. According to the ITI 3rd Consensus Conference *"To optimize the esthetic outcomes, the*

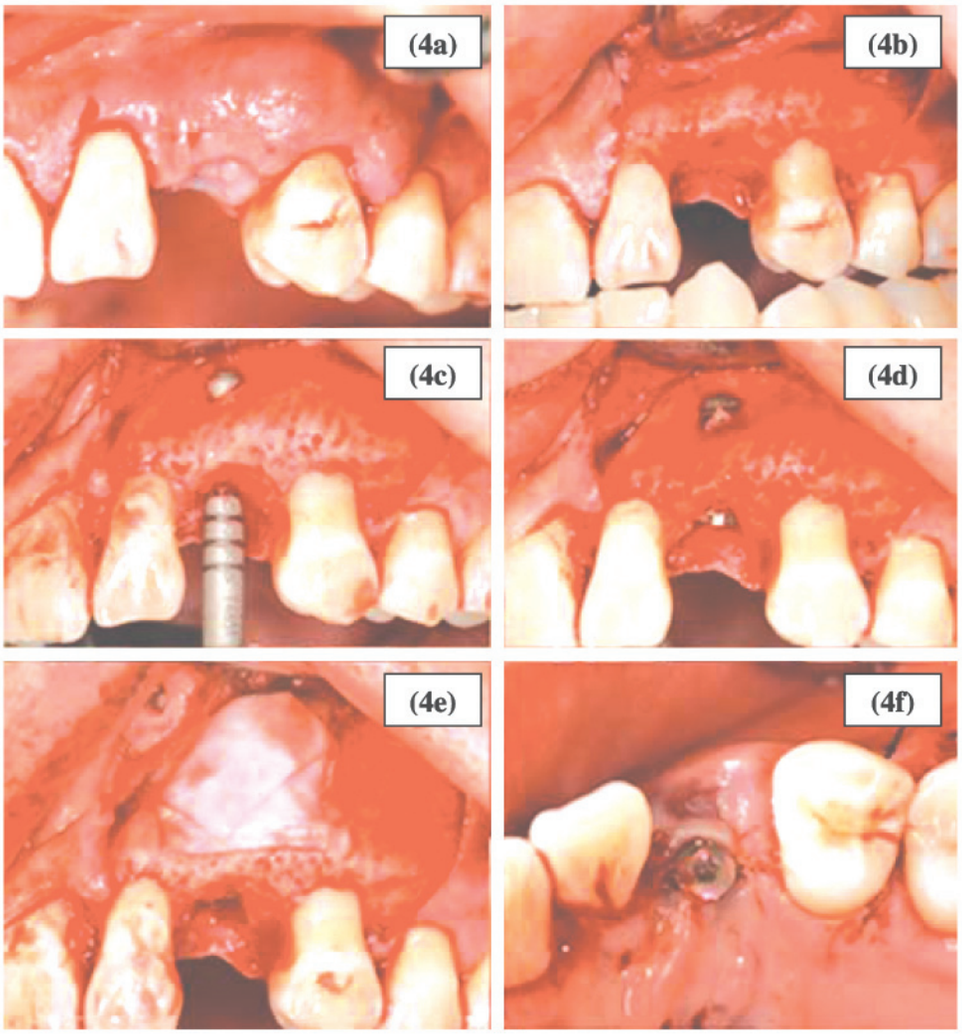

Fig. 4 Shows implant surgical phase. A mid-crestal incision with sulcular incision (tooth 22 and 24) and distal releasing incision was performed (4a). Flap elevated (4b), then the osteotomy site was prepared (4c). After the implant was properly positioned into the prepared osteotomy site, fenestration at the apical area of the implant occurred, as was anticipated (4d). Guided bone regeneration procedure was performed to correct this defect (4e). A 4 mm bottleneck healing abutment was placed and the area was sutured (4f).

use of provisional restorations with adequate emergence profiles is recommended to guide and shape the peri-implant tissue before definitive restoration".[1,3] A primary goal in the development of the soft tissue contours is to have predictability and long-term stability. To achieve this, adequate time must be allowed for maturation of the soft tissue prior to making the final impression.

A screw-retained provisional was fabricated using a Straumann® RC temporary abutment (Straumann, Basel, Switzerland). A screw-retained provisional was used because it could be easily removed and the soft tissue contour modified as the emergence profile developed. In addition, there would be no danger of leaving residual subgingival cement, which can significantly compromise wound healing.

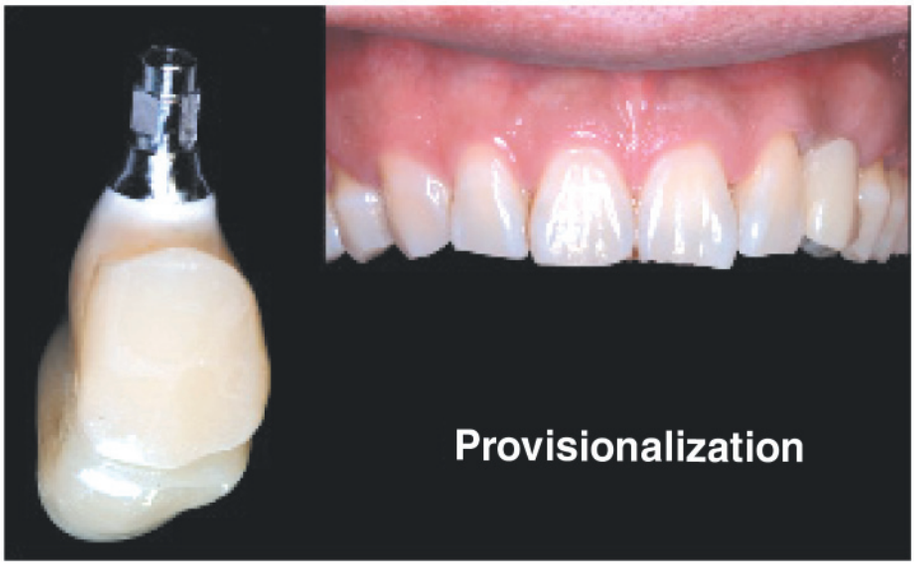

Fig. 5 Five months after implant placement, a screw-retained provisional was fabricated using a Straumann® RC temporary abutment.

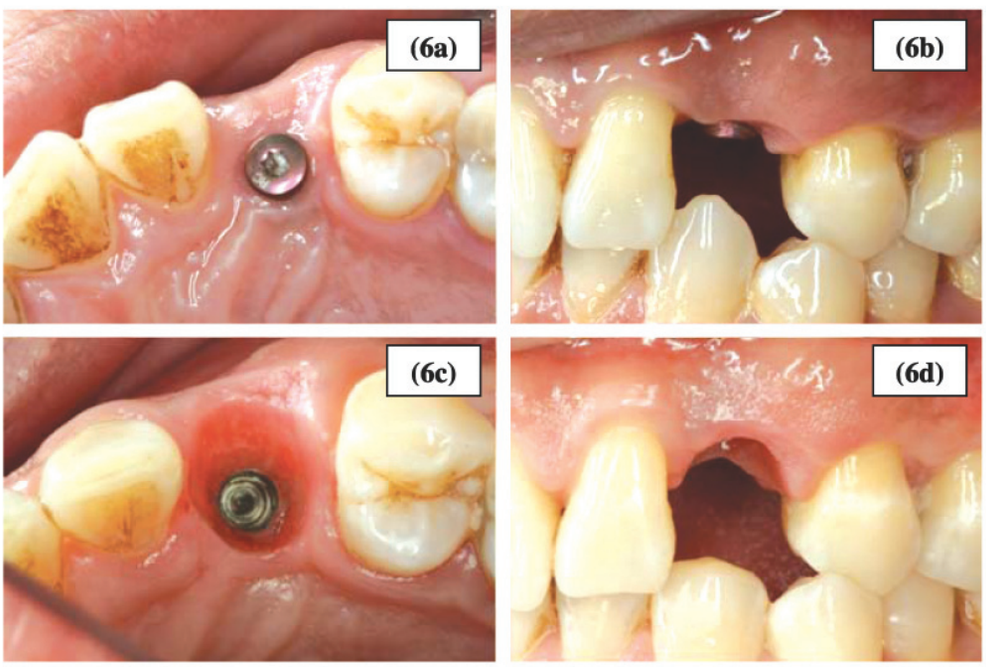

Fig. 6 The peri-coronal tissue at 5-month after surgery (6a-6b) and at 3-month after soft tissue sculpting (6c-6d), the desired emergence profile had been established.

The provisional was examined every 3 to 4 weeks for the next 3 months to evaluate the tissue contours (Fig. 5), modify the provisional as needed, and to allow adequate time for maturation of the soft tissue. At 3 months, the peri-coronal tissue was mature, the desired emergence profile had been established, and the patient was ready for the impression for the master cast (Fig. 6).

To prevent the collapse of the peri-coronal tissue, and to accurately transfer the developed emergence profile established by the provisional restoration to the working model and then communicate the situation to the laboratory technician, a custom impression coping must be used. Enameloplasty was performed on tooth 33 (1 mm) to ensure an esthetically pleasing result of the final restoration.

After the impression was taken with polyether (Impregum®, 3M ESPE, Minnesota, USA), bite registration (Occlufast®, Zhermack, Rome, Italy), and color mapping, the impression and photographs were sent to the laboratory for fabrication of a screw-retained zirconium crown. The abutment and zirconium crown were cemented extraorally with Panavia F 2.0® (Kuraray, Tokyo, Japan). The abutment was delivered with torque up to 35 Ncm, as per Straumann recommendations, and the screw access was then sealed with resin composite.

The final restoration was delivered (Fig. 7), the soft tissue was sculpted to mimic the contralateral maxillary canine and the restoration was fabricated with flurosis on the cervical 1/3 portion to imitate the special characteristics on natural appearance. The patient was very satisfied with the harmony of both the soft tissue region and the restoration.

This patient returned for follow-up appointment at 3-month, 6-month, and periodically recall every 6 months. At 1-year recall, the patient reported satisfaction with both function and esthetics, however, the patient could not stop smoking permanently as planned (10-15 cigarettes/day). Therefore, tobacco stain and plaque deposit were detected, no gingival recession, no bleeding, no exudate, no implant mobility. The peri-apical radiograph shown marginal bone loss at 1.2 mm. Oral prophylaxis, smoking cessation motivation and home-care instruction were given (Figs. 8 and 9).

Fig. 7 Final restoration on the day of delivery, revealed the natural appearance of the peri-implant soft tissue and prosthetic restoration.

Fig. 8 6-month (8a) and 12-month (8b) after treatment, shows natural appearance of both soft tissue and final restoration.

Fig. 9 Peri-apical radiograph revealed 1.2 mm marginal bone loss at 1-year after insertion.

Discussion

Successful esthetic results of dental implant placement in the esthetic zone require knowledge of various concepts and techniques. Careful preoperative treatment planning, augmentation of hard and soft tissues, and attention to the details of implant surgical and prosthetic techniques are issues that must be addressed when treating the anterior maxilla.

Biomechanics has long been used to explain many kinds of complications, and it has become evident that this discipline encompasses more than just screw loosening and prosthetic fit. Forces may be described as compressive, tensile, or shear. Compressive forces tend to maintain the integrity of the bone-to-implant interface, whereas tensile and shear forces (non-axial force) tend to distract or disrupt such an interface. Shear forces are most destructive to implants and bone compared with other load modalities. In general, compressive forces are accommodated best by the complete implant-prosthesis system. Cortical bone is strongest in compression and weakest in shear.[9]

Non-axial loading on single-tooth restoration results in bending moment. As a result, an increase in tensile and shear force components is often found. Compressive forces typically should be dominant in implant prosthetic occlusion. Thus, the dental implant should be surgically placed in a position where the non-axial forces are minimized, allowing the occlusal force to be axially transmitted to the implant body. Therefore, three-dimensional implant position is of foremost importance in occlusal force distribution, leading to long-term predictable results.

To achieve optimal implant angulation, the screw must be placed transversely in the restoration between the incisal edge and cingulum.[32] This angulation is optimal because the screw is in the center of the restoration in all dimensions, which enables the fabrication of a restoration with a proper emergence profile.

Both cement-retained and screw-retained designs are acceptable treatment modalities for single-implant restoration. However, prosthetic restorations on dental implant in esthetic zone usually place the margin deep subgingivally for esthetic purpose which increase the risk of incomplete cement removal in the peri-implant soft tissue that will contribute to severe clinical consequence in the future. Therefore, screw-retained restoration is preferable in the esthetic zone in order to avoid the complexity of the restoration delivery.

In this particular case, in order to achieve excellent biomechanics, the dental implant was surgically placed where the screw transverses the restoration between the incisal edge and cingulum to allow appropriate force distribution and an emergence profile of about 2 mm. Therefore, screw-retained restoration was preferable: it provides excellent esthetic results, is easily retrieved, and eliminates difficulties in excess cement removal.

Esthetic dentistry is essential in osseointegrated implant restoration, especially in the esthetic zone, as esthetics encompasses the morphological appearance (width, length, color and texture) of the final restoration. However, occlusal objectives must be addressed and achieved. If dentists desire to recreate ideal esthetics, they must first thoroughly investigate, diagnose and establish an ideal occlusal scheme.

The maxillary canine in natural dentition is classified as one of the incisors; however, the location of the canines reflects their dual function, as they complement both the premolars and incisors during mastication. Nonetheless, the most common action of the canines is tearing. Therefore, osseointegrated implant restorations at this particular location must be able to withstand the tremendous lateral pressure caused by chewing, as in natural dentition.[33,34]

In the present case, the operative occlusal scheme was anterior and posterior group function in smile design; the morphological appearance was not

problematic since it corresponded to the adjacent premolars. This occlusal scheme also enhances the lateral force which is expected to be loaded on this osseointegrated implant restoration. However, in cases with different occlusal schemes, there will be more factors that must be taken into consideration.

Conclusion

This clinical case report described and reviewed the key elements and challenges for single implant-supported restoration in esthetic zone. In order to achieve successful result, the clinician has to be equipped with various knowledge and concepts from multiple disciplines because it is not only to replace a missing tooth but also to mimic the anatomic form of both hard and soft tissue of the contralateral side. Biomechanics is one of the important principles to ensure the long-term treatment result, therefore in three-dimensional implant position decision the clinicians should also take this into consideration. Soft tissue sculpting may requires much longer time to finish the case, however, it will contribute to more harmony in final outcome and patient's satisfaction.

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การฝังรากเทียมในบริเวณที่ต้องการความสวยงาม: รายงานการรักษาในผู้ป่วยที่สูญเสียฟันเขี้ยวในขากรรไกรบน

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บทคัดย่อ

การฝังรากเทียมเพื่อทดแทนการสูญเสียฟันในบริเวณที่ต้องการความสวยงามนั้นต้องใช้ความรู้และวิธีการรักษาทางทันตกรรมในหลายสาขาวิชา รวมไปถึงการตรวจทางคลินิกทั้งเนื้อเยื่ออ่อน ฟัน และกระดูกขากรรไกรอย่างละเอียด ซึ่งจะนำไปสู่แผนการรักษาที่รอบคอบ และทำให้ได้ผลการรักษาที่สวยงามเป็นที่น่าพอใจ ในรายงานผลการรักษาผู้ป่วยนี้ ผู้เขียนได้อธิบายปัจจัยและหลักที่จะมีผลต่อความสำเร็จในการฝังรากเทียมในบริเวณที่ต้องการความสวยงาม

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คำสำคัญ: *ทันตกรรมรากเทียม; รากเทียมในบริเวณที่ต้องการความสวยงาม; รากเทียมในฟันหน้า*