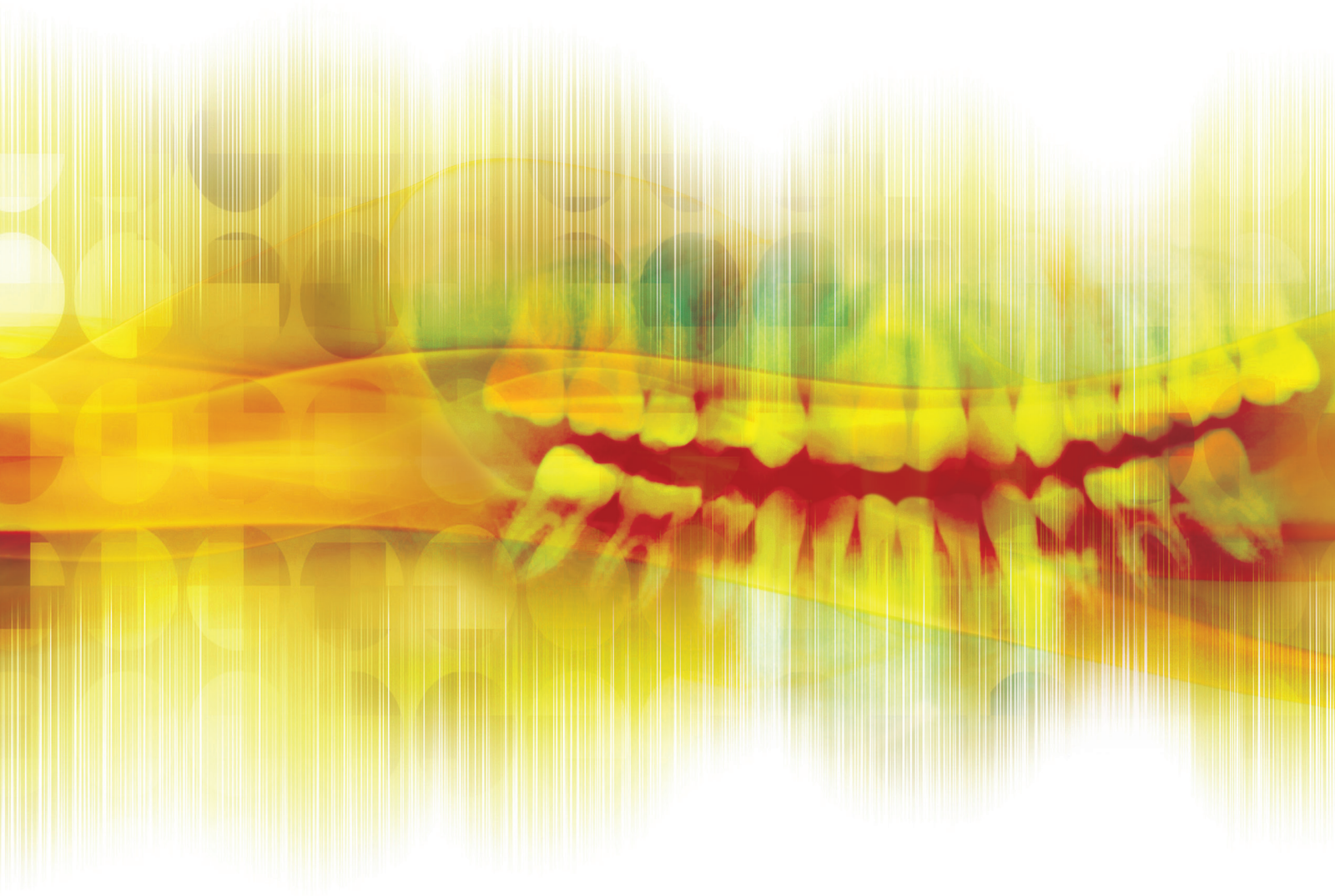
International Journal of Dentistry

Implants in the Anterior Maxilla: Aesthetic Challenges

Guest Editors: Sang-Choon Cho, Stuart J. Froum, Angela R. Kamer, Peter M. Loomer, Georgios Romanos, and Burak Demiralp



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Editorial Board

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Editorial

Implants in the Anterior Maxilla: Aesthetic Challenges

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Esthetic outcomes have become key elements that are critical to defining success in implant restorations. Long-term studies have demonstrated that single or multiple implants are highly predictable with high survival rates. However, in the anterior maxillary zone, the aesthetic success of implant therapy is, for many, as important as the implant survival rates. Several factors contribute to this "success" and can be objectively evaluated. These include the patient's healing capabilities, the level and condition of the existing soft and hard tissues, and the provisional and final restorations. In addition to these objective factors, esthetic perception also plays a significant role in achieving this "success." This special issue contributes to the growing body of existing literature by examining several important issues related to the aesthetic aspects of maxillary implants and their increasingly important role in implant dentistry. These include esthetic perception, surgical techniques for tissue augmentation, and the esthetics of final implant-supported restorations.

One of the esthetic determinants occurring after implant placement is the lack of papilla between implants or between teeth and implants. Whether or not the lack of the interdental papilla leads to significant cosmetic deformities depends on whether shorter papillae may be esthetically tolerated under certain circumstances. Y. C. P. Yu et al. investigated the difference in the perception of aesthetics according to dental specialty. To this goal, the authors used computer assisted asymmetric alteration of the papilla length in the esthetic zone. The results of this study showed that asymmetric deficiencies in papilla length of 2 mm or more are more likely to be perceived as "unattractive." It should be underlined that many dental professionals perceive even minor asymmetric shortening of the papilla as unattractive.

The stability and health of the peri-implant soft tissues are necessary for success and long-term maintenance of dental implants. A two-millimeter wide band of keratinized tissue has long been considered clinically desirable to provide a soft tissue seal around natural teeth. The absence of periodontal ligament and supracrestal fiber attachment around dental implants may increase peri-implant tissue susceptibility to the inflammatory process caused by biofilm accumulation. Therefore, creation of a band of keratinized gingiva around implants is desirable. A. Elkhaweldi et al. in a case series presented a novel surgical technique that can be utilized to augment keratinized soft tissue around implant-supported overdentures. The authors concluded that an apically repositioned flap, a relatively simple procedure, provided good esthetic outcomes, with newly formed tissue indistinguishable from the surrounding mucosa. The disadvantages of this technique are also discussed.

Full arch implant-supported prostheses have high success rates. A variety of materials have been used for this type of restoration including metal alloy-acrylic, metal alloy-composite, and metal alloy-ceramic. However, with these materials a number of complications may occur. To minimize these, using zirconia for the framework has been proposed. Several studies have shown that zirconia possesses excellent physical, mechanical, biological, and chemical properties. J. Carames et al. discuss this option and provide examples of monolithic zirconia restorations for full arch implant-supported restorations.

A. E. Borgonovo et al. investigated the survival and success rates, as well as the marginal bone loss (MBL) and esthetic indices of zirconia implants positioned in the esthetic jaw areas. The results of this study emphasized that one-piece zirconia dental implants show high biocompatibility, low plaque adhesion, and an absence of a microgap that may contribute to their clinical success in the esthetic areas.

Finally, A. L. Ioannou et al. provide a review of several surgical techniques aimed at optimizing anterior implant esthetics. Clinicians who practice implant dentistry need to strive for more than just osseointegration. They must also achieve excellent esthetic outcomes. Therefore, with careful treatment planning and use of a variety of esthetically focused techniques, clinicians will be able to meet patients' ever-increasing demands for ideal esthetic outcomes.

Acknowledgments

The guest editors would like to thank and acknowledge all the contributors (authors and coauthors) and the reviewers for their valuable cooperation and assistance while preparing this issue. We hope this special issue would contribute to the clinicians' knowledge as they practice dental implantology.

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Research Article

Interdental Papilla Length and the Perception of Aesthetics in Asymmetric Situations

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The purpose of the study was to determine if there was a difference in the perception of aesthetics, by dental specialty, using computer assisted asymmetric alteration of the papilla length in the aesthetic zone with an apical alteration of the contact point of the clinical crowns. Standardized photographs were presented to sixty-five randomly selected dentists from New York University College of Dentistry on a computer screen for evaluation. Then, the dental professionals were asked to rate the smile in each picture. Control and experiment photographs were used. Data was analyzed using the statistical package SPSS version 21 and one-way ANOVA. The perception of esthetics depends on the dental professional specialty; results provide evidence that asymmetric deficiency in papilla length of 2 mm or more is perceived as "unattractive" by the dental specialists.

1. Introduction

Over the past 30 years, replacing missing teeth with dental implants has become a viable solution to conventional fixed or removable prosthodontics [1]. However, the rehabilitation with implant supported prosthesis remains challenging particularly in the esthetic areas. The esthetic area is defined as the visible area during functioning and includes the anterior maxillary and mandibular teeth. Implant survival in these areas may reach 82.94% [2], while implant success varies significantly [3] reaching at times only 51.97% and even lower [2, 3]. The discrepancy between implant survival and success is not unexpected as their definitions are quite different. Implant "survival" definition is broad and encompasses all implants that are still in the mouth. The criteria of success can vary. However, it is restrictive and includes only the dental implants that present, in addition to proper integration and function, other features such as esthetic characteristics: soft tissue contours with an intact interdental papilla and a gingival outline that is harmonious with the gingival silhouette of the adjacent healthy dentition [2, 3].

One of the esthetic deficiencies occurring after implant placement is the lack of papilla between implants or between teeth and implants. The lack of the interdental papilla can lead not only to cosmetic deformities, but also to phonetic difficulty and food impaction. Therefore, achieving a predictable papilla is of outmost importance and it has been the subject of numerous studies. The vertical distance from the crest of the bone to the height of the interproximal papilla between adjacent teeth and between adjacent implants was evaluated by Tarnow et al. [4, 5]. When this distance was 5 mm or less between two adjacent teeth the papilla completely filled this space almost 100% of the time. However, the average height of tissue over the crest of bone between two adjacent implants was reported to be only 3.4 mm [4, 6] ranging from 3 to 9 mm. In addition, the anatomical features of the space between two implants are significantly different. Thus if a patient has normal interdental papilla and requires two other adjacent anterior teeth replaced, the interimplant papilla oftentimes will tend to be apical in position compared to the papilla of the adjacent teeth.

Many surgical and prosthetic techniques have been attempted to restore missed interdental papilla. However, predictable regeneration of the papilla between two adjacent dental implants remains a complex challenge [5, 7, 8]. In addition to the establishment of an anatomically correct

papilla, the success of the implant rehabilitation also depends on the "perceivement" of gingival and papilla contours. Studies showed that patient and clinician perceive papilla and gingival contour differently and this difference depends on gingival symmetry. Interestingly, this "perceivement" appears to differ among dental specialties. However, there is a paucity of studies comparing the perceivement of symmetry among different dental specialties.

Clinically, the presence of the black triangle is characterized by a receded papilla visible space between the papilla and the contact point of the restorations. Whether the presence of the black triangle translates into an unfavorable esthetic outcome depends on the size of the defect as well as on the "perceivement" of this defect. If the esthetic outcome is perceived as "unfavorable" by several clinicians, then attempts should be done to rectify or prevent the defect. For example, in aesthetic demanding cases, the clinician should also consider alternative treatment plans (i.e., one implant and a cantilevered pontic) for a two-tooth edentulous space in order to achieve an improved aesthetic outcome [9].

It is reported that minor alterations to teeth and surrounding tissue are discernable to dental professionals and lay people in varying degrees. Kokich Jr. et al. reported that orthodontists noted a 2 mm midline open gingival embrasure (between the central incisors) as less attractive, while lay people and general practitioners made critical note of a 3 mm open embrasure [10]. A recent study by LaVacca et al. showed that patients were not able to discern symmetric alteration of a shortened papilla length of 2 mm when soft tissue completely filled in the gingival embrasure as the contact point was relocated in an apical direction [11, 12]. To date, no studies have evaluated the influence of the asymmetric papilla length on the perception of aesthetics. Since the dental specialties emphasize different aspects of the dental care, they may also differ in their perceivement of gingival and papillary contour. We hypothesized that periodontists with their soft tissue management skills would perceive as an unfavorable outcome any deviation from normal compared to the orthodontists and general dentists. The purpose of the present study was to determine if there was a difference in the perception of aesthetics, by dental specialty. Towards this goal, we used computer assisted asymmetric alteration of the papilla length below the contact point of the clinical crowns in the aesthetic zone Figures 1, 2, 3, and 4.

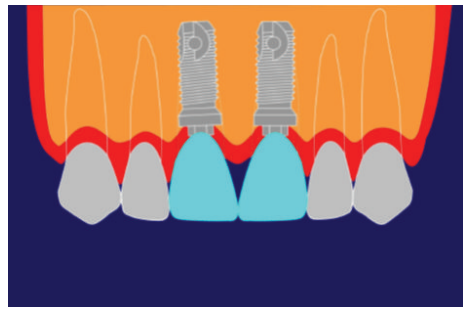

Figure 1: "Black triangle" between central incisors.

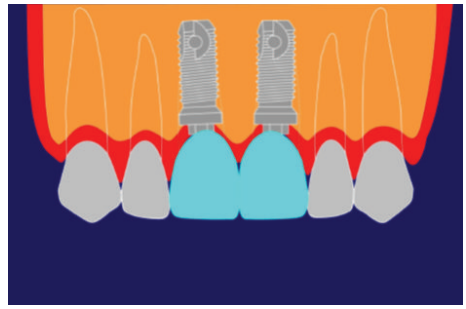

Figure 2: Acceptable long contact point.

2. Materials and Methods

2.1. Subjects. Sixty-five randomly selected dentists from New York University College of Dentistry participated in this study.

2.2. Protocol. Standardized photographs were presented to the dental professionals on a computer screen for evaluation. Then, the dental professionals were asked to rate the smile in each picture. Control and experiment photographs were used.

2.3. Control Photograph. A natural smile that correlated with Rufenacht's [11] tooth papilla-ideal gingival proportions was identified. A digital photograph as shown in Figure 5, limited to the lips and teeth within the smile (high smile-line), was obtained. Utilizing a computer software program (Adobe Photoshop 6.0, Adobe Systems Incorporated), the smile in the photograph was digitally enhanced. The coronal display of the papilla and gingival levels were symmetrically aligned on both sides of the arch and constituted "the gold standard" for esthetics. The purpose of this enhancement was to eliminate discrepancies and minimize any potential bias.

2.4. Experimental Photographs. Experimental photographs were obtained by digital alterations as shown in Figures 6, 7, and 8. The location of the papilla in the control photograph was first identified and then three alterations were digitally performed. These alterations shortened asymmetrically the papilla between right central and lateral incisors incrementally by 1 mm from the position of the control. As the papilla was shortened, the crown contour and contact point between these incisors were also altered to eliminate the presence of the "black triangle" in the gingival embrasures of the photographs. Below are the photographs presented:

photo A: control photograph;

photo B: 1 mm shortened papilla photograph;

photo C: 2 mm shortened papilla photograph;

photo D: 3 mm shortened papilla photograph.

2.5. Perception Survey. A control and 3 altered photographs were placed on a sheet of paper. The control photograph was designated a rating order of 1. Evaluators viewed the other

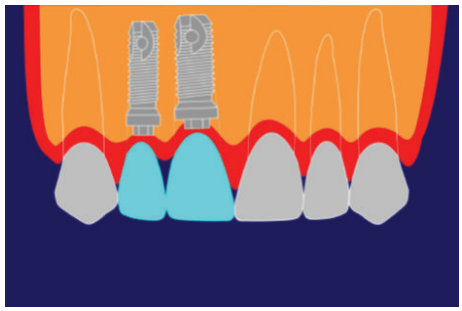

Figure 3: Asymmetric "black triangle."

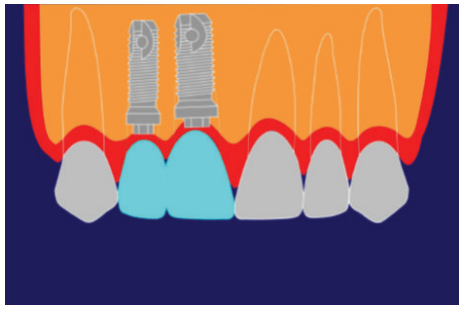

Figure 4: Unacceptable asymmetric long contact.

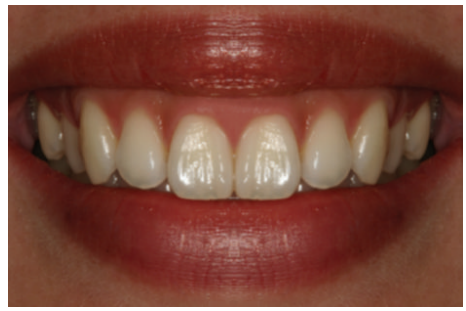

Figure 5: Control photograph (photo A).

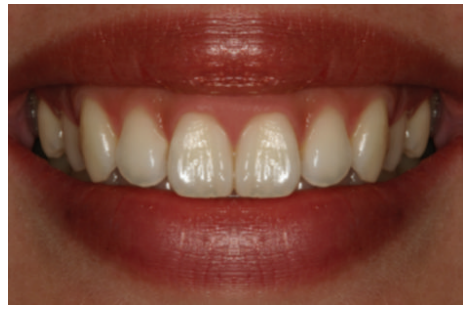

Figure 6: Shortened papilla b/w #7 and 8 (1 mm, photo B).

3 photographs and assigned an aesthetic rating order of 1–4, according to the following scale:

(1) very attractive;

(2) attractive;

(3) unattractive;

(4) very unattractive.

2.6. Data Analysis. Data was analyzed using the statistical package SPSS, version 21. The ratings assigned to each photograph by the evaluators were determined and allowed for ratings comparison by specialty. Attractive and very attractive ratings were merged into a single rating "the attractive rating." Unattractive and very unattractive ratings were also merged into "the unattractive rating." Then, the percentages of dental professionals rating the photographs as "attractive" and "unattractive" were calculated. One-Way ANOVA was used to determine whether there were differences in the percentage of the dental professionals rating the three experimental shortened papilla photographs.

3. Results

3.1. Population Characteristics. A total of 65 dental professionals participated in this study: twenty were prosthodontists, twenty periodontists, and twenty-five general dentists.

3.2. The Perception of Esthetics Depends on the Dental Professional Specialty. Figure 9 and Table 1 show the percentage of the dental professionals rating the smiles as attractive when the papilla was shortened by 1, 2, and 3 mm. The results show that when the papilla was shortened by 1 mm (photo B), 98% of the evaluators rated it as "attractive" with no difference among the specialists. In fact, 100% of prosthodontists, 95% of periodontists, and 100% of general dentists rated it as "attractive." When the papilla was shortened by 2 mm (photo C), overall, 66% of the evaluators rated it as "attractive." In fact, 55% of the prosthodontists, 65% of the periodontists, and 76% of the general dentists rated it as "attractive." However, when the papilla was shortened by 3 mm (photo D), only 66% of evaluators rated it as "unattractive." Among them, 85% of prosthodontists, 70% of periodontists, and 48% of general dentists rated it as "unattractive." These results show that the perceivement of the esthetics when the papilla is shortened depends on the dental professional specialty.

The esthetics is perceived as attractive only if the papilla shortening is very minor. Figure 10 shows the ratings of "attractiveness" among all the dental professionals. Our results showed that the percentage of dental professionals rating the esthetics as "attractive" differed by the magnitude of the asymmetric papilla shortening and these results were significant ($P = 0.002$). Post hoc tests showed that these differences were significant among all the experimental papilla shortening esthetics (between 1 and 2 mm: $P = 0.02$; between 2 and 3 mm: $P = 0.02$). These results show that the esthetic perception with only 1 mm papilla shortening is rated as "attractive" by most dental professionals regardless of their specialty. However, when the papilla is shortened by 2 or 3 mm, the esthetics is rated as "attractive" by only a few dental professionals. These results provide evidence that asymmetric deficiencies in papilla length of 2 mm or more are perceived as "unattractive."

Table 1: Rating of altered papilla by different specialties.

	0 mm				1 mm				2 mm				3 mm			
	Prs	Per	Gen	All	Prs	Per	Gen	All	Prs	Per	Gen	All	Prs	Per	Gen	All
I	20	20	25	65	2	2	9	13	0	1	3	4	0	0	1	1
II					18	17	16	51	11	12	16	39	3	6	12	21
III					0	1	0	1	9	7	6	22	14	11	8	33
IV					0	0	0	0	0	0	0	0	3	3	4	10
% of acceptance as attractive					100	95	100	98	55	65	76	66	15	30	52	33
% of acceptance as unattractive					0	5	0	1	45	35	24	33	85	70	48	66

Prs: prosthodontist, Per: periodontist, Gen: general dentist, I: very attractive, II: attractive, III: unattractive, and IV: very unattractive.

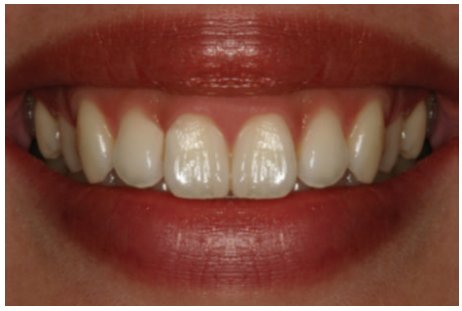

Figure 7: Shortened papilla b/w #7 and 8 (2 mm, photo C).

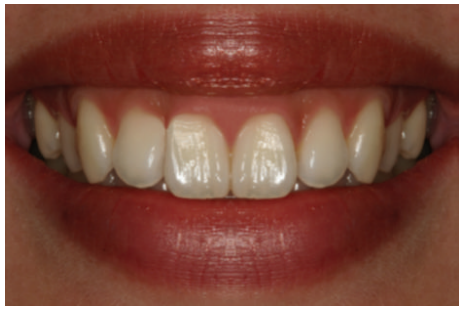

Figure 8: Shortened papilla b/w #7 and 8 (3 mm, photo D).

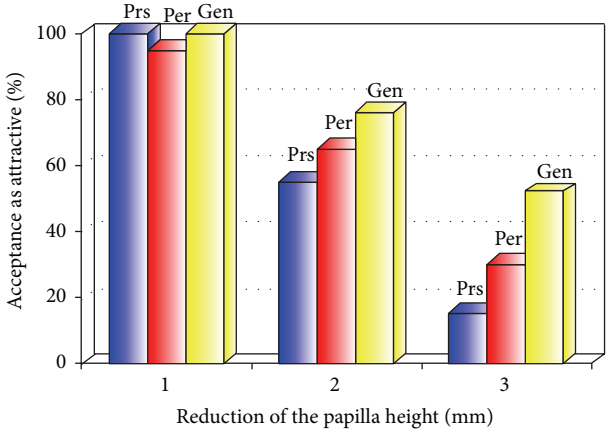

Figure 9: Rating of shortened papilla by specialties.

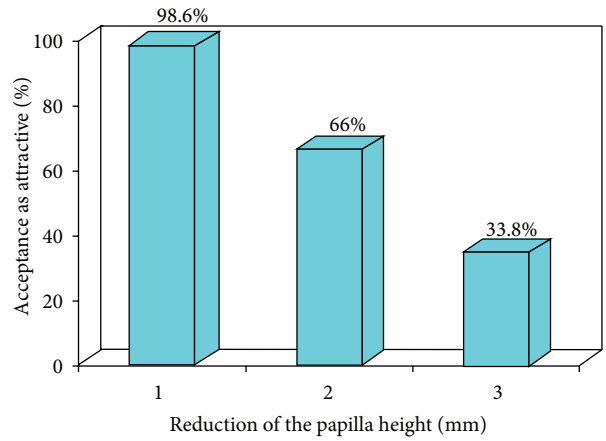

Figure 10: Acceptance of shortened papilla.

4. Discussion

Within the limitations of our study that is composed of 65 dental professionals, we showed that the perceivement of esthetics compared to "the gold standard" for the interdental papilla in the esthetic zone depended on the dental professional specialty. We also found that deficiencies in the papilla as low as 2 mm were perceived as "unattractive" esthetics by most dental professionals.

In a previous study by LaVacca et al. [12], the papilla length was shortened by 2 mm bilaterally obtaining a symmetrical smile [10]. Overall, both orthodontists and patients rated this esthetic change as attractive suggesting that if no black triangles are present, patients and orthodontists perceived dental aesthetics as attractive although some variation existed. In the present study, a unilateral, asymmetrical shortening of the papilla by 2 mm was rated as unattractive by two-thirds of the total evaluators. Since some of our evaluators were orthodontists, these appears to demonstrate that, in an asymmetric situation, a 2 mm shortened papilla is more detectable compared to a symmetric situation. A 3 mm shortened papilla was considered unattractive by one-third of the evaluators. In ideal situation the lateral incisor has approximately 80% shorter clinical crown than that of the central incisor and the gingival margin is located on slightly more coronal position compared to central incisor

[11]. This anatomical presentation results in a shorter papilla on the lateral incisor side than between the central incisors. Therefore, a 3 mm shortened papilla can make a lateral incisor appear squarer in form than of a central incisor. Prosthodontists appear to be more sensitive to changes in location of the contact point. As a result, they rated shortening of the papilla by 2 mm (45%) and 3 mm (85%) as unattractive when compared to periodontists (35%, 24%) and general dentists (70%, 48%), respectively. Further studies with well-characterized population will be needed to evaluate the dentist and patient perceptions regarding aesthetics and the "black triangle" and to see if changes in the papilla height between lateral and canine unilaterally and bilaterally result in similar rating by the 3 different groups of dentists.

5. Conclusion

Only 1.6% of evaluators rated as unattractive a papilla shortened 1 mm from the control. One-third of evaluators rated as unattractive a 2 mm shortened papilla and two-thirds of the evaluators rated as unattractive a 3 mm shortened papilla. We conclude that many dental professionals perceive even minor asymmetric shortening of the papilla unattractive. However, this is only "half" the story. Studies evaluating professionals and different populations would be needed for a more comprehensive understanding of this issue.

Conflict of Interests

The authors reported no conflict of interests related to this study.

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Clinical Study

Clinical Advantages and Limitations of Monolithic Zirconia Restorations Full Arch Implant Supported Reconstruction: Case Series

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Purpose. The purpose of this retrospective case series is to evaluate the clinical advantages and limitations of monolithic zirconia restorations for full arch implant supported restorations and report the rate of complications up to 2 years after insertion. *Materials and Methods*. Fourteen patients received implant placement for monolithic zirconia full arch reconstructions. Four implants were placed in seven arches, eleven arches received six implants, two arches received seven implants, two arches received eight implants, and one arch received nine implants. *Results*. No implant failures or complications were reported for an implant survival rate of 100% with follow-up ranging from 3 to 24 months. *Conclusions*. Monolithic zirconia CAD-/CAM-milled framework restorations are a treatment option for full arch restorations over implants, showing a 96% success rate in the present study. Some of the benefits are accuracy, reduced veneering porcelain, and minimal occlusal adjustments. The outcome of the present study showed high success in function, aesthetics, phonetics, and high patient satisfaction.

1. Introduction

Full arch implant supported restorations have been documented to have high success rates [1–6]. Many combinations of materials have been used for this type of restorations such as metal alloy-acrylic, metal alloy-composite, and metal alloy-ceramic [1, 5, 7]. However, complications including fractured or debonded acrylic resin teeth, wear of opposing surfaces, ceramic chipping, difficulty in shade matching of acrylic and pink ceramic, lack of passive fit, and extensive work for repair after framework breakage have encouraged dentists to look for other material options [1, 5, 7]. The use of zirconia for frameworks is an option that has been proposed [2, 7, 8].

Zirconium oxide is a material that has shown increased popularity in contemporary dentistry [3, 9]. Many studies have shown excellent physical, mechanical, biological, and chemical properties of this material [3, 5, 9, 10]. Fixed dental prostheses were designed and milled in a one-piece zirconia substructure and veneering porcelain was then directly fired onto the substructure [3, 4]. Nevertheless, some reports have documented veneering ceramic fractures (chipping) [1–12] and fractures of the zirconia substructure [1, 3–5].

To overcome these problems, CAD/CAM one-block milled monolithic zirconia was introduced as an alternative for the treatment of implant supported full arch reconstructions [3–5, 12]. The fabrication of the structure in one block reduces breakage possibilities and avoids chipping [4, 5]. Moreover, high strength, minimal occlusal adjustment, and accuracy are some of its advantages [3, 4, 6, 13].

Short-term available data indicates that full contour zirconia framework can be used successfully in implant dentistry [3, 7]. Seven articles involving full contour zirconia restorations have been published (Table 1). Five articles were

Table 1: Literatures of monolithic zirconia.

Author	Publication date	Study type	N (number of arches)
Papaspyridakos and Lal [12]	2008	Case report	1
Lazetera [13]	2009	Case report	1
Papaspyridakos and Lal [9]	2010	Case report	1
Larsson et al. [11]	2010	Prospective study	10
Rojas-Vizcaya [1]	2011	Case report	2
Sadid-Zadeh et al. [5]	2013	Case report	1
Pozzi et al. [10]	2013	Retrospective study	26

case reports [1, 5, 9, 12, 13]. One retrospective study with 3- to 5-year follow-up was published in 2013 [10], and one prospective study with 3-year follow up was published in 2010 [11]. Further research is required to evaluate the long-term outcome of monolithic zirconia restorations. Studies of material inherent accelerated aging [3] and wear of opposing dentition are necessary [5].

The purpose of this retrospective case series was to evaluate the clinical advantages and limitations of monolithic zirconia restorations for full arch implant supported restorations and report the rate of complications up to 2 years after insertion.

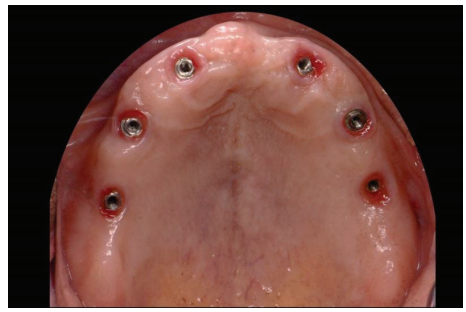

Figure 1: Maxillary occlusal view after tissue healing.

2. Materials and Methods

Clinical data in this study was obtained from the implant database (ID) in the Ashman Department of Periodontology and Implant Dentistry at New York University College of Dentistry. This dataset was extracted as deidentified information from the routine treatment of patients in the department. The ID was certified by the Office of Quality Assurance at NYUCD. This study is in compliance with the health insurance portability and accountability act (HIPAA).

2.1. Study Subjects. Patients which referred to New York University Ashman Department of Periodontology and Implant Dentistry in need of prosthetic full arch fixed reconstruction in maxilla, mandible, or both were consecutively selected. The inclusion criteria included patients at least 21 years old, with edentulous maxilla and/or mandible and at least four to nine implants needed to be placed and osseointegrated. Fourteen patients (Four females and ten males with a mean age of 56 years old, range: 37–67) met the inclusion criteria. Each subject selected for this study from the ID had undergone the fabrication of monolithic zirconia frameworks for full arch implant supported reconstructions. Twelve of these patients required maxillary and mandibular full arch reconstruction, and two involved only the maxillary arch. In the two maxillary reconstructions the opposing dentition was in one patient natural teeth and a fixed prosthesis and in the other a complete mandibular denture. A total of twenty-six edentulous arches were restored: fourteen maxillary and twelve mandibular arches. Patients were informed about the prosthetic protocol, risks, and alternatives of treatment.

All complications after delivery were recorded at each follow-up visit up to 3 years. Failures were defined as any defect in the restorations that required the fabrication of a new restoration such as fracture and misfitting. Complications were defined as any defect in the restorations that required repair by laboratory technicians or correction of clinicians such as chipping of veneers (lab) and screw loosening (clinician).

2.2. Procedures

(1) Diagnostic alginate impressions (Jeltrate Plus, Denstply, Milford, DE, USA) were made and poured with model stone (Microstone ISO type 3, WhipMix, Louisville, KY, USA). Occlusal rims were fabricated and adjusted intraorally. Interocclusal records, face bow registration, and centric relation records were taken. Casts were articulated and artificial teeth arrangements (ATA) were performed. Additionally, ATA were duplicated to obtain radiographic and surgical guides. Patients were sent for Cone Beam Computed Tomography (CBCT) scans to evaluate bone dimension and implant positioning (Figures 2 and 3).

(2) Four to nine dental implants were placed in the edentulous arches using surgical guides. A one-stage surgical procedure was performed according to the implant planning. The surgical protocol followed the manufacturer's instructions. External connection implants were placed in twenty-three arches, and internal connection implants with intermediate abutments were placed in three arches. The healing time prior to the prosthetic phase was 12 weeks. (Figure 1).

(3) During the healing period and until the prosthetic phase was completed, patients wore transitional complete dentures.

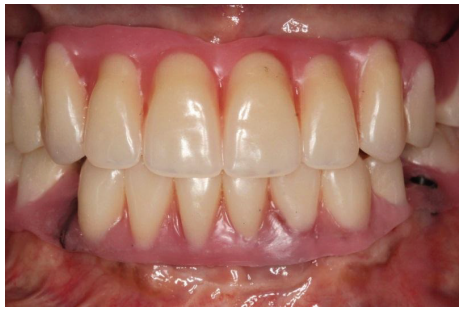

Figure 2: Intraoral frontal view of artificial teeth arrangement.

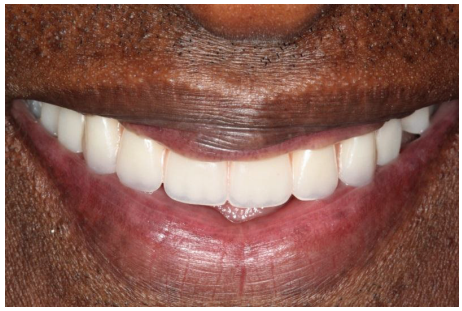

Figure 3: Smile view with artificial teeth arrangement.

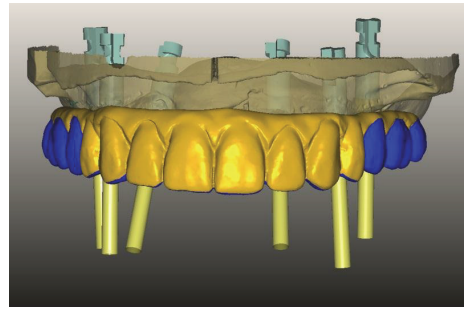

Figure 4: Digital preview of the maxillary monolithic prosthesis.

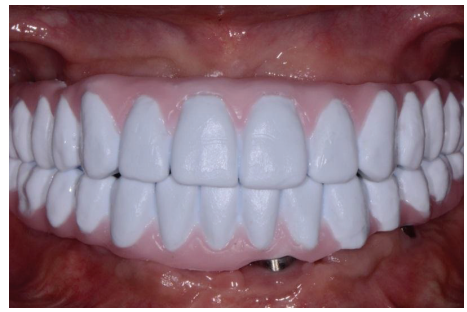

Figure 5: Intraoral frontal view with the epoxy resin prototype.

(4) Fixture level impressions were made of polyether impression material (Impregum, 3M ESPE, St. Paul, MN, USA) in custom light cure resin trays (TRIAD Blue TruTray Visible Light Cure, Dentsply, York, PA, USA). The master cast was made of a reproduction of the gingival soft tissue using a polyvinylsiloxane, addition-type silicone (GI-Mask, Coltene/Whaledent, Cuyahoga Falls, OH, USA) and resin fortified, low expansion die stone (ResinRock ISO Type 4, WhipMix, Louisville, KY, USA). In two patients, in which opposing arches were not restored as full arch reconstructions, alginate impressions were made (Jeltrate Plus, Dentsply, Milford, DE, USA) with stock disposable perforated trays (COE Spacer trays, GC America Inc, Chicago, IL, USA). Interocclusal registrations were made with wax rims (TRIAD Pink Denture Base Regular Pink Fibered, York, PA, USA and Pink Wax Bite Blocks, Keystone, Cherry Hill, NJ, USA). Face bow registration and centric relation record were taken. Artificial teeth arrangements with acrylic dentures teeth (Portrait IPN Dentsply, Milford, DE, USA) were placed in an adequate position to achieve esthetics, phonetics, and vertical dimension in occlusion. Bite registration was taken with vinyl polysiloxane material (BLU Bite HP, Henry Schein, Melville, NY, USA).

(5) The laboratory procedures were performed according to the manufacturer's instructions (Zirconia Prettau, Zirkonzahn, Neuler, Germany) at an authorized laboratory. The master cast, opposing cast articulated, and artificial teeth arrangement were scanned to determine the interocclusal relationship to the software (Zirkonzahn.software, Zirkonzahn, Neuler, Germany). According to the corresponding implant type, connectors are milled in titanium to fit in the master cast and scanned again. The prostheses were designed on the software. An epoxy resin prototype was milled and sent for try-in to ensure adequate fit, function, esthetics, and phonetics. After some minor adjustments, the restoration was milled in a monolithic zirconia block. Sixteen of the 26 full arch restorations were digitally cut back on the anterior area to improve esthetics. Characterizations of teeth were made in the monolithic framework (Colour Liquid Prettau, Zirkonzahn, Neuler, Germany). The final restorations were sintered in the oven (Keromikofen 1500, Zirkonzahn, Neuler, Germany). Framework fitting was verified in the master cast. Soft tissue ceramic (ICE Zirkon Keramik Tissue Shades, Zirkonzahn, Neuler, Germany) and ceramic (ICE Zirkon Ceramics and Stains Prettau, Zirkonzahn, Neuler, Germany) according to the shade selection was applied on the framework for esthetic results. Additionally, the prosthesis was sintered overnight. Last working step was placement and bonding of the titanium sleeves into the milled zirconia framework. Finally, prostheses were glaze-fired and sent for delivery. (Figures 4, 5, 6, 7,8, and 9).

(6) The final full arch prostheses were clinically verified with one screw test for passive fit. Moreover, periapical radiographs were taken for radiographic examination. All patients approved and agreed with shape and shade of finals restorations. (Figures 10, 11, and 12).

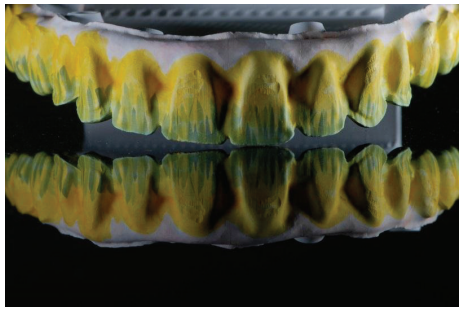

Figure 6: Maxillary monolithic prosthesis with teeth characterization.

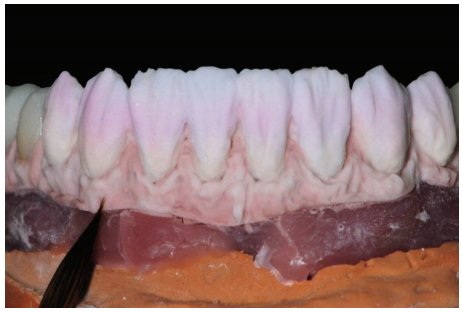

Figure 7: Ceramic application for gingiva colors and teeth ceramic.

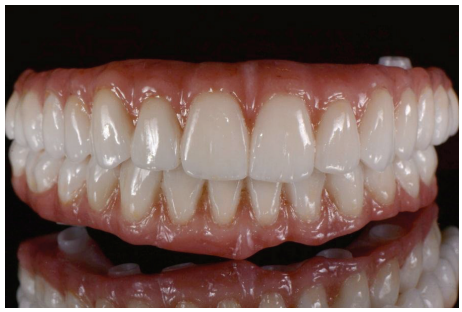

Figure 8: Prostheses after final sintering.

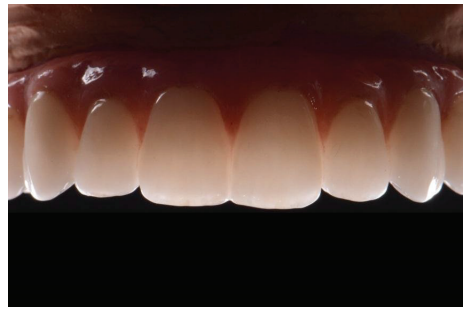

Figure 9: Translucency effect in the anterior maxilla after application of ceramics in the digital cut back.

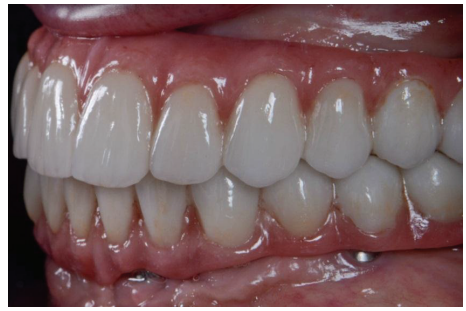

Figure 10: Intraoral lateral view of the final prostheses.

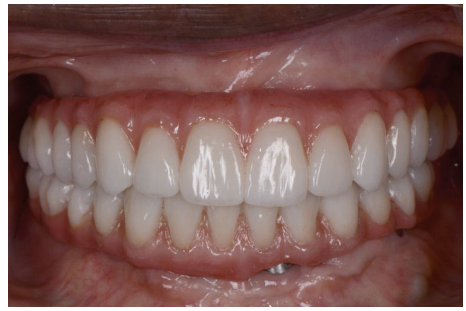

Figure 11: Intraoral frontal view of the final prostheses.

(7) Occlusal screws were torqued following manufacturer's instructions. Gutta-percha was placed in all access holes. In screw-retained restorations, a light-cure microhybrid composite (Z100 Restorative, 3M, St Paul, MN, USA) with proper shade was used to close the access hole. In screw-/cement-retained, fixed prostheses were cemented with temporary cement (TempBond, Kerr, Orange, CA, USA) and excesses were cleaned. The importance of removing the temporary cement and recementing every year, to avoid cement wear and loosening of the prostheses, was explained to the patients.

(8) On the day of delivery, alginate impressions were made to fabricate full-cover maxillary night guards. A week later, patients received the night guards and were instructed to wear them at night.

(9) Recall appointments were performed after 2 weeks and 3 months after insertion. A yearly appointment is required for clinical and radiographic examination.

3. Results

Fourteen patients received implant placement for monolithic zirconia full arch reconstructions. Four implants were placed in seven arches, eleven arches received six implants, two arches received seven implants, two arches received eight implants, and one arch received nine implants. No implant failures or complications were reported for an implant survival rate of 100% with follow-up ranging from 3 to 24 months (Table 2).

Previous restorations of the total arches were as follows: sixteen had nonrestorable teeth or previously failed fixed prostheses, five arches with teeth and removable partial

Table 2: Results of 14 cases in which monolithic zirconia framework for full arch implant supported reconstruction was used.

Subjects	Location	Number of implants	Type of restoration	Time of follow-up	Complications
1	Mandible	4	Screw-retained	10 months	None
	Maxilla	6	Screw-retained	10 months	None
2	Mandible	4	Screw-retained	1 year, 10 months	None
	Maxilla	7	Screw-retained	1 year, 10 months	None
3	Mandible	6	Screw-retained	1 year, 8 months	None
	Maxilla	6	Screw-retained	1 year, 8 months	None
4	Mandible	4	Screw-retained	5 months	None
	Maxilla	6	Screw-retained	5 months	None
5	Mandible	6	Screw-retained	1 year	None
	Maxilla	6	Screw-retained	1 year	None
6	Mandible	4	Screw-retained	7 months	None
	Maxilla	6	Screw-retained	7 months	None
7	Mandible	4	Screw-retained	3 months	None
	Maxilla	4	Screw-retained	3 months	None
8	Mandible	4	Screw-retained	1 year, 3 months	None
	Maxilla	8	Screw-retained	1 year, 3 months	Chipping #9, at 1-year follow-up
9	Mandible	6	Screw-retained	10 months	None
	Maxilla	7	Screw-retained	10 months	None
10	Mandible	6	Screw-retained	2 years	None
	Maxilla	8	Screw-retained	2 years	None
11	Mandible	7	Screw- and cement-retained	3 years, 6 months	None
	Maxilla	8	Screw- and cement-retained	3 years, 6 months	None
12	Maxilla	8	Screw-retained	3 years, 6 months	None
13	Maxilla	9	Screw-retained	1 year	None
14	Maxilla	6	Screw-retained	4 months	None
	Mandible	6	Screw-retained	4 months	None

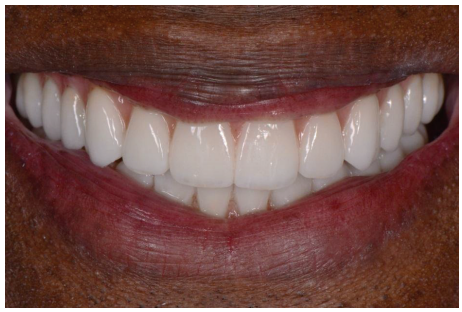

Figure 12: Smile view of the final prostheses.

dentures, three complete dentures, and two metal alloy-acrylic prostheses.

Of the twenty-six full arches, twenty-four were implant supported screw-retained, and two full arches were combined implant supported screw-/cement-retained (Table 2). Seventeen full arch restorations were digitally cut back on the buccal surface of the anterior area to improve esthetics. Nine full arch restorations were designed without veneering porcelain. All prostheses were in function at the time of the follow-up, which was from 3 months up to 3 years and 6 months, whereas fourteen arches were followed up up to 1 year. All monolithic zirconia prostheses were clinically and radiographically examined. No defects of the prosthesis were detected and no frameworks needed to be remade. However, a chip-off fracture of the ceramic veneer occurred in 1 of 26 restorations (Table 2, case #8), giving a prosthetic success rate of 96%. The only chip-off fracture occurred in the buccal surface of the veneer in a left central incisor after one year of insertion. A ceramic laminate was used to restore the chip-off. No fracture of the monolithic zirconia frameworks or any other mechanical complications such as screw loosening or decementation of the prostheses were reported. No patient complaints regarding their prosthesis esthetic or function were record.

4. Discussion

Improved clinical performance can be expected to be achieved by using monolithic zirconia restorations [2, 10, 11]. Clinical studies have shown increased values of strength

and toughness for monolithic zirconia compared to zirconia frameworks with laminate veneering [3, 5]. It has also been shown to result in high standards of esthetics and a reduced amount of metal used in the oral cavity [5, 10]. Full arch monolithic zirconia restorations have shown similar overall survival when compared with high-nobel alloy-based metal ceramic restorations [14]. No bulk fractures or failures in the framework had been reported in the literature with a follow-up of 8 years [2]. The result of the present retrospective case series is in accordance with these trends as no flaws in the monolithic framework occurred during the follow-up examinations.

Several different complications have been related to the use of hybrid prostheses with implants, such as fractures of titanium framework and gold alloys over 5 years [15] and fracture or wear of acrylic teeth due to poor bonding of acrylic to the framework [16]. With ceramometal restorations, chipping or fracture of the ceramic is due to different factors. These include impact and fatigue load, occlusal forces, differences in thermal expansion coefficients, low elastic modulus of the metal, improper design, microdefects, and trauma. Extensive work for repair is required after framework failures [1]. A full monolithic zirconia occlusal contour appears to be a solution to this complication [5, 9, 11, 12]. The present study supports these findings, as twenty-five of 26 monolithic zirconia restorations presented no complications during the follow-up period.

However, chipping of veneering ceramic is a frequent complication of zirconia-based restorations on teeth and implants [3, 4, 7, 9, 11] and sometimes cannot be solved by ceramic polishing [10]. The exact reason for veneer chipping in zirconia core restorations is unclear. Three factors generally play an important role such as interfacial bonding, match of the core-veneer materials, and strength of the veneering ceramic. Also the veneering technique has a potential effect on the chipping of the ceramic due to the processing methods of ceramic, which include repeated sintering in the oven [4]. To overcome chipping fractures of veneered zirconia restorations, laboratory technicians and clinicians should follow precise steps in manufacturing zirconia-based restorations with the knowledge that zirconia as a framework material is highly susceptible to surface modifications and improper laboratory and clinical handling technique [3]. Chip-off fractures of the veneering ceramics have been associated with roughness of the veneering ceramic because of grinding or occlusal function [3, 11]. Analysis of crack propagation direction showed that the chipping failure had originated from roughness of the ceramic at the occlusal region of the cusps. Occlusal adjustments should only be performed with fine grain diamonds, followed by thorough polishing sequence [3]. The use of digital cut back in the monolithic zirconia prevents roughness on the surface that produces the crack propagation and chipping of the veneering. In reference to the present study, of the seventeen arches that were digitally cut back in the anterior area, only one veneer chipping was recorded at 1-year follow-up.

Translucency has been considered one of the primary factors in controlling the esthetic outcome of ceramic restorations. Zirconia has been considered an opaque material compared to other dental ceramic. A recent report has shown some degree of translucency in the zirconia, which was less sensitive to thickness compared to lithium disilicate and leucite-free porcelain. However, translucency of the zirconia ceramics also increased exponentially as the thickness decreased [17]. The digital cut back in the monolithic zirconia allows the restorations to have some degree of translucency. One of the problems with glass ceramics for monolithic restorations is that due to low flexural strength values (360–400 MPa for lithium disilicate) frameworks are prone to fracture when subjected to occlusal loads. Moreover, the use of zirconia frameworks with glass ceramic veneers has been described to have high rates of chipping. In our study zirconia veneers in monolithic restorations resulted in high esthetic, good mechanical properties, and less complications.

Wear rates of the enamel opposing zirconia ceramic have been reported, showing cracks or even fractures in all the ridges. The hardness and thickness of enamel, chewing behavior, parafunctional habits, and neuromuscular forces as well as abrasive nature of food can influence clinical wear. Due to the elasticity modulus of 210 GPa of zirconia and hardness of 1200 Vickers Hardness, some enamel wear is expected. Moreover, some reports have shown that polished monolithic zirconia has the lowest wear rate on an enamel antagonist compared to veneered zirconia, glazed zirconia using a glaze spray, monolithic base alloy, or glazed zirconia using glaze ceramic [18, 19]. However, the use of night guard is recommended after the delivery of the final monolithic zirconia to prevent wear of the opposing dentition.

Screw-retained implant restorations are often chosen because they offer better retrievability, decreased space requirements, and healthier soft tissue. On the other hand, cement-retained restorations offer improved occlusal accuracy, enhanced esthetics, increased chances of achieving a passive fit, and decreased instances of retention loss [18]. Moreover, some systematic reviews have shown that differences between cement- and screw-retained restorations are not statistically significant. These reports concluded that screw-retained restorations are equally suitable [18–20]. However, the preferred technique in this study was screw-retained implant restoration due to their retrievability, less biological complications, and easy repair of technical complications. In accordance to this idea, 88% of the restorations in this study were screw-retained. No complications such as screw loosening or decementation were reported in the present study. And only one veneer chipping was found after 1-year follow-up.

5. Conclusions

(1) Monolithic zirconia CAD/CAM-milled framework restorations are a treatment option for full arch restorations over implants, showing a 96% success rate in the present study. Some of the benefits are accuracy, reduced veneering porcelain, and minimal occlusal adjustments. The outcome of the present study showed high success in function, aesthetics, phonetics, and high patient satisfaction.

(2) A full occlusal contour monolithic framework can diminish chipping of the veneered porcelain. However, the fabrication is technique sensitive and should follow the appropriate steps discussed in this study.

(3) The digital cut back for veneer placement in the monolithic zirconia was an effective option to avoid surface roughness that can produce crack propagation and veneer chipping.

(4) Twenty-three of 26 restorations were screw-retained due to their retrievability, less biological complications, and easy repair of technical complications. Only, one veneer chipping was found in one these restorations. Of the three cement-retained restorations no complications were reported.

(5) Within the limitations of the present study monolithic zirconia CAD/CAM milled prosthetic restorations were a successful treatment option for full arch implants supported restorations.

(6) More long-term data studies are required for the full arch monolithic zirconia restorations in order to evaluate success and complications over the time.

Conflict of Interests

The authors reported no conflict of interests related to this study.

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Research Article

Various Techniques to Increase Keratinized Tissue for Implant Supported Overdentures: Retrospective Case Series

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Purpose. The purpose of this retrospective case series is to describe and compare different surgical techniques that can be utilized to augment the keratinized soft tissue around implant-supported overdentures. *Materials and Methods*. The data set was extracted as deidentified information from the routine treatment of patients at the Ashman Department of Periodontology and Implant Dentistry at New York University College of Dentistry. Eight edentulous patients were selected to be included in this study. Patients were treated for lack of keratinized tissue prior to implant placement, during the second stage surgery, and after delivery of the final prosthesis. *Results*. All 8 patients in this study were wearing a complete maxillary and/or mandibular denture for at least a year before the time of the surgery. One of the following surgical techniques was utilized to increase the amount of keratinized tissue: apically positioned flap (APF), pedicle graft (PG), connective tissue graft (CTG), or free gingival graft (FGG). *Conclusions*. The amount of keratinized tissue should be taken into consideration when planning for implant-supported overdentures. The apical repositioning flap is an effective approach to increase the width of keratinized tissue prior to the implant placement.

1. Introduction

Dental implant-supported overdentures have been documented to be a predictable and successful option to treat edentulous patients [1, 2]. Currently, with the evolution of implant surfaces, osseointegration of implants is less of a challenge [3]. However, the stability and health of the peri-implant soft tissue is necessary for the success and the long-term maintenance of dental implants [4]. Two millimeters wide band of keratinized tissue has been considered clinically desirable to provide a soft tissue seal around natural teeth [5]. However, controversy still remains over the necessity for a band of keratinized tissue around dental implants [6–9]. The role of dental plaque in the etiology of peri-implant diseases is well documented in the literature [10, 11]. The absence of periodontal ligament, supracrestal fibers attachment around dental implants may make peri-implant tissue more susceptible to an inflammatory process caused by plaque accumulation [12].

Several studies have reported increased gingival and plaque index scores, mucosal recession, and marginal bone resorption in areas around implants with less than 2 mm of keratinized tissue [4, 8, 13–16]. Conversely, some authors have claimed that, with adequate plaque control, peri-implant tissues can be maintained in a healthy state with a minimum amount of keratinized tissue [6–9].

However, patient discomfort has been reported to be associated with insufficient keratinized tissue in implant-supported overdentures [17]. In many cases, performing oral hygiene was reported to be painful as a result to the absence of the keratinized tissue surrounding the implant. Moreover, discomfort has been related to mechanical irritation due to the mobility of the nonkeratinized tissue under function [17, 18].

In 1999, Kaptein et al. investigated the peri-implant tissue health of loaded implants. There was a significantly higher gingival index and probing depth in overdenture versus fixed prosthesis cases [18]. It has been reported that

implants supporting overdentures had more risk for bone loss, based on poorer peri-implant tissue health [18]. Adibrad et al. investigated the association between the width of the keratinized tissue and the health status of the soft tissue around implants supporting overdentures. They concluded that the absence of adequate keratinized tissue was associated with a higher plaque accumulation, gingival inflammation, bleeding on probing, and mucosal recession [17].

To date, there are a limited number of studies that discuss peri-implant tissue health and the presence of keratinized tissue around implants supporting overdentures [17–19]. These studies conclude that the presence of keratinized tissue around implant-supported overdentures is a factor effecting bone maintenance and soft tissue health around those implants [17, 18].

Various surgical procedures have been developed to preserve and/or reconstruct keratinized tissue around dental implants [20–24]. These techniques, including apically positioned flaps, pedicle grafts, free gingival grafts, and connective tissue grafts, can be performed prior to implant placement, during the second stage surgery or after delivery of the final prosthesis. Allogenic and xenogenic soft tissue grafts have also been used as other options for increasing peri-implant keratinized tissue [24–27].

The purpose of this retrospective case series was to describe and compare different surgical techniques that can be utilized to augment the keratinized soft tissue around dental implant-supported overdentures.

2. Materials and Methods

Clinical data in this study was obtained from implant database (ID). This data set was extracted as deidentified information from the routine treatment of patients at the Ashman Department of Periodontology and Implant Dentistry at New York University College of Dentistry. The ID was certified by the Office of Quality Assurance at NYUCD. This study is in compliance with the Health Insurance Portability and Accountability Act (HIPAA) requirements.

2.1. Study Subjects. Eight edentulous cases were selected from the ID to be included in this retrospective study. Patients were treated for lack of keratinized tissue prior to implant placement, during the second stage surgery or after delivery of the prosthesis. The population consisted of 2 females and 6 males, with a mean age of 65 years (range: 54 to 83). In 7 out of 8, the augmentation procedure was performed in the mandible.

2.2. Inclusion Criteria

(1) Patients who underwent implant surgery and were restored with a maxillary and/or mandibular implant-supported overdenture.

(2) Patients wearing a maxillary and/or mandibular implant-supported overdenture.

(3) Clinical symptoms of discomfort or difficulty to perform oral hygiene due to insufficient keratinized tissue around implant-supported overdentures. Insufficient was defined as <2 mm of keratinized gingiva.

(4) Patients who underwent a surgical procedure to increase keratinized tissue around implant-supported overdentures.

2.3. Exclusion Criteria

(1) Presence of systemic diseases that influence bone or soft tissue metabolism.

(2) Smoking habit of more than a pack a day, and unwillingness to stop.

(3) Radiotherapy to head/neck region in the past 12 months prior to surgery.

(4) Chemotherapy in the past 12 months prior to surgery.

(5) Unwillingness to commit to a long-term maintenance program after treatment.

2.4. Description of the Protocol

(1) Preoperative measurement of the width of keratinized tissue, in the area of the planned implants, or around already placed implants, measured in millimeters using a periodontal probe from the free soft tissue margin to the mucogingival junction. All the measurements were performed by the same investigator.

(2) Antibiotic premedication: 2 g Amoxicillin 1 hour prior to surgery or 600 mg Clindamycin in case of penicillin allergy.

(3) Infiltrative local anesthesia using Lidocaine HCl 2% containing epinephrine 1 : 100,000 or Carbocaine 3% without epinephrine in cases where a vasoconstrictor was contraindicated.

(4) One of the following techniques was utilized to increase the amount of keratinized tissue: apically positioned flap, pedicle graft, connective tissue graft, or free gingival graft. The technique was selected depending on the time the surgery was performed and operator preferences (Table 1).

(5) Postsurgically, the patient was instructed to not wear their prosthesis for 3 weeks.

(6) Postoperative antibiotics (Amoxicillin 500 mg tid or Clindamycin 150 mg qid) and analgesics (Ibuprophen 600 mg q 4–6 hrs) were prescribed for a week.

(7) Postoperative care instructions were given, including use of Clorhexidine gluconate 0.12% rinses 3 times a day and soft diet, for two weeks.

(8) Postoperative measurement of the width of keratinized tissue taken 1 month and 3 months after the surgery, using a periodontal probe and measured from the free gingival margin to the mucogingival junction in the area where the preoperative measurement was taken and where the surgical technique was performed. Photos of the surgical procedure were used to duplicate the area ofmeasurement.

Table 1: Gain in keratinized tissue three months after surgical procedure.

Case	Gender	Age	Site	KT initial (mm)	KT final (mm)	Increase KT (mm)	Time of surgery	Technique
1	Male	65	#22	3	8	5	Prior to implant placement	APF
			#27	4	9	5		
2	Male	72	#22	0-1	4	3-4	2nd stage	APF
			#27	1-2	5	3-4		
3	Female	54	#22	1	4	3	2nd stage	APF
4	Male	59	#22	1	4	3	2nd stage	APF
			#27	0-1	3	2-3		
5	Male	61	#22	1	3	2	2nd stage	PG
			#27	1	4	3		
6	Male	60	#11	1	4	3	After	FGG
			#13	1	3	2		
7	Female	65	#22	1	2-3	1-2	After	CTG
			#27	1	2-3	1-2		
8	Male	83	#22	0-1	0-1	0	After	CTG
			#27	0-1	0-1	0		

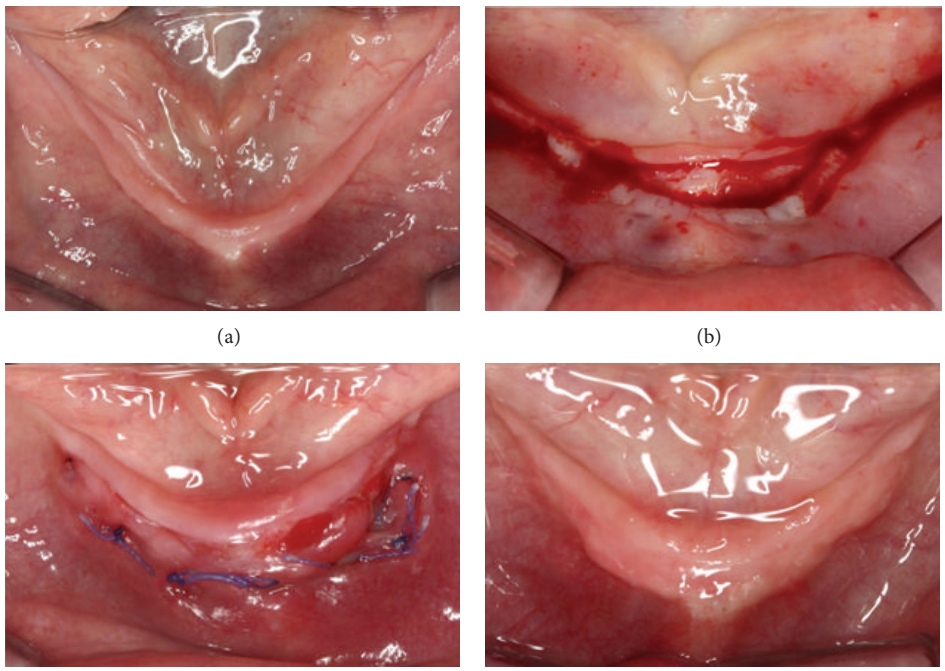
3. Results and Discussion

Over time, clinicians have used different surgical techniques to increase the width of keratinized tissue around natural teeth. These techniques have also been applied around implant-supported restorations. Each of these techniques has advantages and limitations. Understanding these techniques would help the clinician to decide which one to use in specific circumstances. In this study, fifteen sites in eight patients were treated to increase the amount of keratinized tissue. All 8 patients in this study were wearing a complete maxillary and/or mandibular denture for at least a year before the time of the surgery. One of the following surgical techniques was utilized to increase the amount of keratinized tissue: apically positioned flap (APF), pedicle graft (PG), connective tissue graft (CTG), or free gingival graft (FGG). In seven out of the eight cases, the surgery was performed in the mandible. The augmentation procedure was performed on three cases with the implants already restored with the final prosthesis. Four cases had the procedure done as part of the second stage implant surgery. However, in one case the augmentation utilized before the implants were placed.

When planning for implant-supported overdentures, a preoperative assessment of the amount of keratinized tissue is an important step. When necessary, augmentation of keratinized mucosa should be done prior to implant placement. In case 1, an apically positioned flap was performed one month before the stage 1 surgery to allow adequate soft tissue closure (Figure 1). The initial measurement of the band of keratinized tissue in sites #22 and #27 was 3 and 4 mm, respectively. A single horizontal beveled incision was made into the attached gingiva (Figure 1(b)). The mesiodistal extension of the incision was made from #21 to #28, making it possible to elevate a partial thickness flap which was apically repositioned by suturing the flap to the periosteum with Vicryl 4.0 (Polyglactin 910) (Figure 1(c)). As a result of this procedure, a 5 mm increase in the width of keratinized tissue was obtained at both sites (Figure 1(d)). When a surgery to increase the width of keratinized tissue is performed during implant placement, the incision should be designed to maintain the amount of keratinized tissue. This incision design will allow the implant to be surrounded by at least 2 mm of keratinized tissue all around.

A second stage surgery is a good opportunity to increase the width of keratinized tissue (Figures 2(a), 2(b), 2(c), and 2(d)). This approach was utilized in cases 2, 3, and 4. In three patients, an apically repositioned flap was used as described in case 1, which resulted in a mean increase in the width of keratinized tissue of 3.1 mm. Case 5 was also treated as part of the second stage surgery utilizing pedicle flap with a mean increase of 2.8 mm. The pedicle flap technique is an approach similar to an apically repositioned flap and should be used when there is adequate keratinized tissue adjacent to the implant. A beveled horizontal incision of approximately 6 mm was made distal to the implant, with a small vertical incision at the distal end part of the first incision. A partial thickness flap was then elevated and the pedicle flap sutured apically (Figures 3(a), 3(b), and 3(c)).

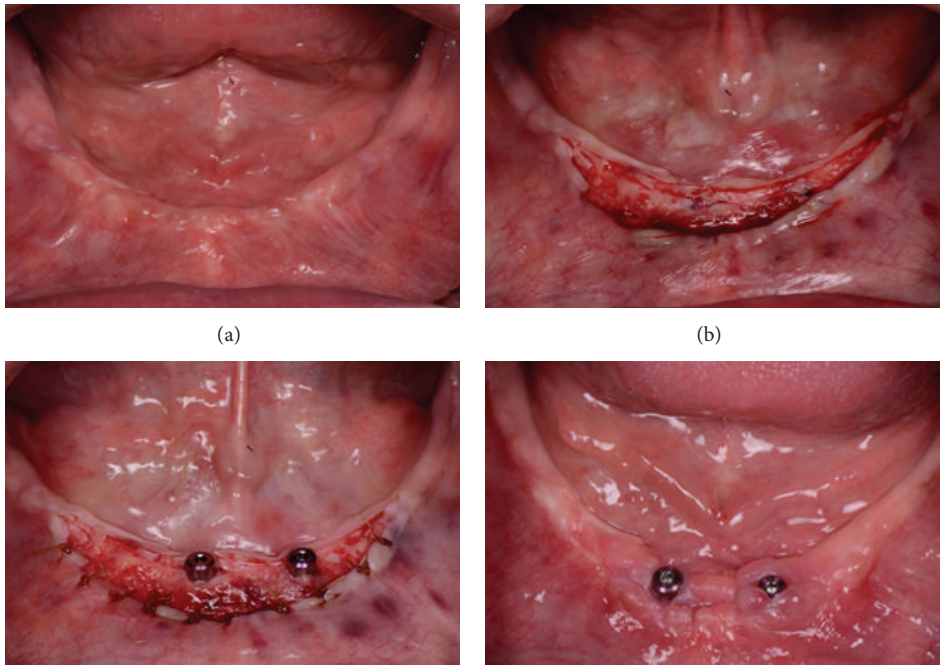
In some cases, a lack of keratinized tissue is evident after the insertion of the final prosthesis, causing discomfort and restricting oral hygiene performance. Moreover, since implant-supported overdentures are a removable prosthesis, patients often experience pain when taking the overdenture on and off. In this retrospective case series, three patients had surgery to increase the amount of keratinized tissue around 6 implants supporting overdentures, either by utilizing free gingival grafts or connective tissue grafts. The selection was based on the anatomy of the palate. Preference was giving to connective tissue graft when the patient had high vault palate, which allows harvesting a good amount tissue and reduces the risk of endangering the greater palatine artery. In case 6, an autogenous free gingival graft was harvested from the palatal premolar area, around #12, 13, and then sutured to the periosteal recipient bed of #11 and #13 (Figures 4(a), 4(b), and 4(c)). After healing and maturation of the soft tissue



(a) (b)

(c) (d)

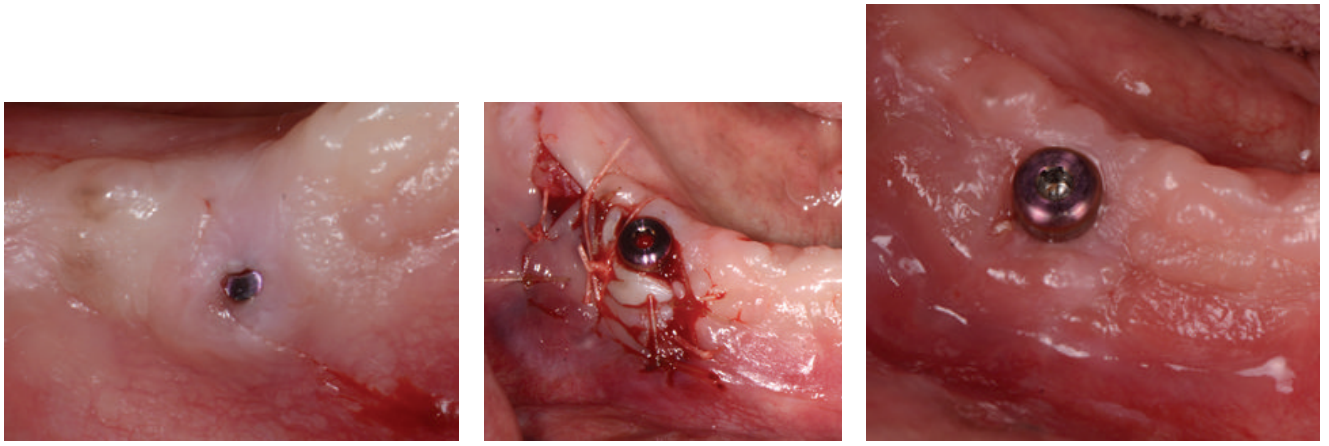
Figure 1: (a) Initial clinical appearance of the mandibular ridge with 3-4 mm of keratinized tissue. (b) Crestal horizontal beveled incision made. (c) The flap sutured apically with Vicryl 4.0 to the periosteum. (d) Final result 3 months after the surgery showed 5 mm increase in the width of keratinized tissue.



(a) (b)

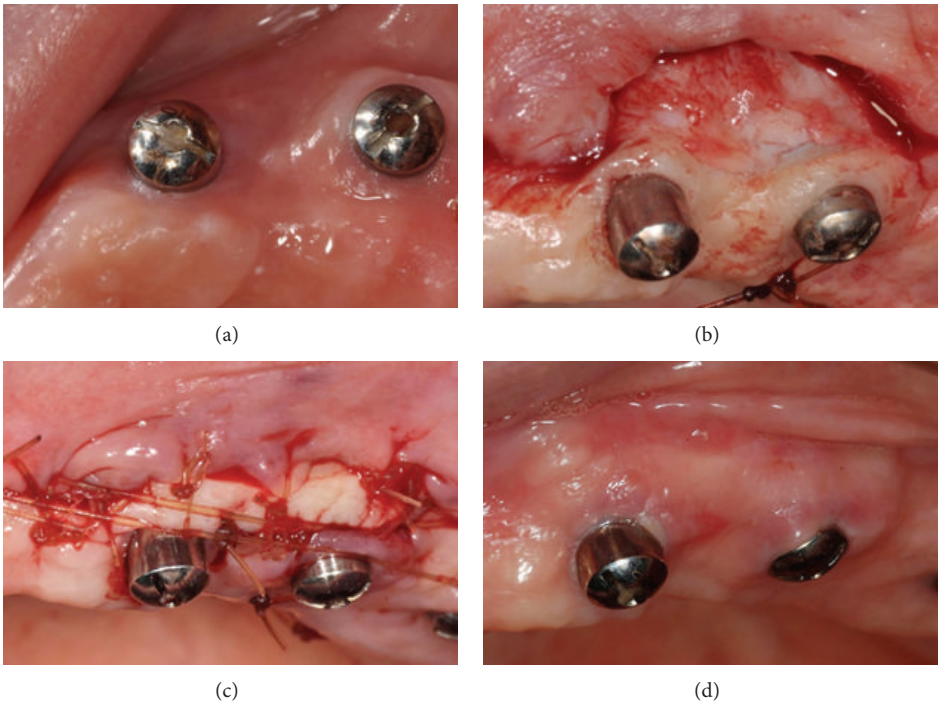
(c) (d)

Figure 2: (a) Presurgical appearance of mandibular ridge with 0-1 mm of keratinized tissue. (b) Partial thickness flap reflection. (c) Apical suturing of the flap to the periosteum using Chromic Gut 4.0. (d) Final result after the surgery showed a 2-3 mm increase in keratinized tissue.



(a) (b) (c)

Figure 3: (a) Presurgical appearance of an implant supporting overdenture, 1 mm keratinized tissue. (b) Pedicle graft elevated and suture buccally. (c) Final result with 3 mm gain of keratinized tissue.



(a) (b) (c) (d)

Figure 4: (a) Presurgical appearance of two implants with 1 mm of buccal keratinized tissue. (b) Partial thickness flap on the recipient bed prepared for the FGG. (c) Interrupted and horizontal mattress sutures to stabilize the FGG obtained from the palate. (d) Three-month follow-up showing an increase of 2-3 mm of keratinized tissue.

an increase of 3 and 2 mm was obtained, respectively, (Figure 4(d)). Cases 7 and 8 were treated with connective tissue grafts harvested from the premolar area of the palate. At the same time, the recipient site was prepared; a vertical incision mesial to the implant was made and a partial thickness flap was then elevated, creating a tunnel where the connective tissue graft was inserted and sutured. One of them (case 7) resulted in no increase of keratinized tissue as a result of significant decrease of the vestibular depth following the excessive amount of alveolar bone resorption. In case 8, the healing was accompanied with nonkeratinized soft tissue growth over the implant which made it very difficult both to perform oral hygiene and to insert the overdenture. A customized healing abutment was designed to control the excessive growth, and two more implants were placed, converting the overdenture prosthesis.

Each of the soft tissue augmentation techniques has advantages and limitations. The apically repositioned flap is a relatively simple procedure that provides a good esthetic outcome, as the newly formed tissue is indistinguishable from

the surrounding mucosa. Moreover, shorter operative time and low morbidity is involved [20]. The main limitation of this technique is the need for at least 0.5 mm millimeters of keratinized tissue preoperatively. In cases where less than 0.5 mm of keratinized tissue is present preoperatively, autogenous free gingival grafts present an effective option. Free gingival grafts have been proven to be successful and predictable. However, these also present disadvantages. They involve two surgical sites with the consequent morbidity in both areas. Moreover, discrepancies in color and texture with the surrounding mucosa oftentimes result in a compromised esthetic outcome [24]. When using these techniques, some percentage of shrinkage should be expected. After one year, it has been reported that in the case of a free gingival graft, shrinkage of 38 to 45% occurs in relation to the thickness of the graft [28]. This shrinkage is even greater in cases where acellular dermal allografts are used [24]. Connective tissue graft was utilized in two cases. Although the augmentation was not successful in one case, this technique can still be an option to augment the keratinized tissue around implants restorations. There was average of 1.5 mm increase in the width of the keratinized tissue. Zucchelli et al. reported a similar result for CTG around single implant restoration. However, the author believes that the stability of the graft is very important for this technique to be successful. Pedicle Graft was utilized in one case as part of second stage surgery. This technique was less invasive and resulted in up to 3 mm increase in the keratinized tissue. This technique can be very useful in unilateral single implant cases where only small areas of narrow keratinized tissue need to be augmented [29].

4. Conclusions

The amount of keratinized tissue should be taken into consideration when planning for implant-supported overdentures. When the initial amount is considered insufficient, surgical augmentation procedures should be performed. An apical repositioning flap is an effective approach to increase the width of keratinized tissue prior to the implant placement if 0.5 mm of keratinized tissue was preoperatively available. During the second stage surgery, lingualized incision designs and pedicle grafts are a less invasive alternative to increase a limited zone of keratinized mucosa. Although free gingival graft or connective tissue graft could also be utilized but around implants, they can impose some challenges to the clinician during the surgery or throughout the healing. When patients experience discomfort after insertion of the final prosthesis due to a lack of keratinized mucosa, free gingival or connective tissue grafts are a feasible alternative. In some cases, a change of design of the prosthesis could be performed, placing more implants and converting from overdenture to a fixed restoration.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Clinical Study

Zirconia Implants in Esthetic Areas: 4-Year Follow-Up Evaluation Study

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Objectives. The aim is to evaluate the survival and success rates, as well as the marginal bone loss (MBL) and periodontal indexes of zirconia implants positioned in the esthetic jaw areas. *Materials and Method.* 13 patients were selected and 20 one-piece zirconia implants were used for the rehabilitation of single tooth or partially edentulous ridge in the esthetic jaw areas. Six months after surgery and then once a year, a clinical-radiographic evaluation was performed in order to estimate peri-implant tissue health and marginal bone loss. *Results.* The survival and success rates were 100%. The average marginal bone loss from baseline to 48 months after surgery was +2.1 mm. Four years after surgery, the median and the mode for visible Plaque Index and Bleeding On Probing resulted 1 whereas Probing Pocket Depth amounted to 3 mm (SD = ±0.49 mm). *Conclusion.* One-piece zirconia dental implants are characterized by high biocompatibility, low plaque adhesion, and absence of microgap that can be related to the clinical success of these implants even in the esthetic areas.

1. Introduction

The original concept of implant surgery as described by Branemark [1] is that the fixture is placed in the bone and completely covered by mucoperiosteal flaps. After the healing period of at least 3 months in the mandible and up to 6 months in the maxilla, the implant is exposed and a healing abutment is connected.

Since the material composition and the surface topography of the implants play a fundamental role in osseointegration, various chemical and physical surface modifications have been developed in order to reduce the time of osseous healing, and it was observed that increased surface roughness of dental implants resulted in greater bone apposition [2] and reduced healing time [3]. However, even if the original protocol by Branemark was modified by modern works of research, patients expect a rehabilitation to be finalized within the shortest time span possible especially if the edentulism involves the esthetic regions. Moreover, patients require implants that are esthetic as well as functional and, for this reason, more recently higher interest is directed towards the esthetic of the prosthetic rehabilitations.

The use of ceramic components based on alumina or yttrium-stabilized zirconium oxide in conjunction with all-ceramic restorations allows to achieve implant osseointegration, which was examined in several animal experiments [4–6], and to solve esthetic problems. In fact, even if several studies reported high success rates for titanium dental implants [7], it is important to consider that bone resorption of the vestibular cortical bone and recession of the peri-implant soft tissue can occur over time [8]. Consequently, the titanium components may be visible and cause discoloration

of the gingiva, particularly in cases of thin biotype and high smile line [9]. The first ceramic material that was used in the past for dental implants was aluminium oxide. This material showed good osseointegration but it did not have sufficient mechanical properties for long-term loading [10]. More recently, new generation ceramic materials such as zirconia were introduced. Zirconia is characterized by more favorable mechanical properties (high flexural strength (900–1200 Mpa), hardness (1200 Vickers), and Weibull modulus (10–12)) than aluminium oxide. In addition, this biomaterial has a high biocompatibility and low plaque adhesion [11], and several animal studies showed bone-to-implant contact similar to titanium [5, 6, 12]

The aim of this study is to evaluate the survival and success rates, the marginal bone loss (MBL), radiographic measurements, and periodontal indexes (Plaque Index (PI), Bleeding On Probing (BOP), Probing Pocket Depth (PPD), and implant mobility) of zirconia dental implants positioned in the maxillary and mandibular esthetic areas.

2. Materials and Methods

At the Department of Implantology, Dental Clinic, Fondazione IRCCS Cà Granda Policlinico, University of Milan, the authors did a retrospective study of patients treated using monocomponent endosseous zirconia dental implants for the rehabilitation of esthetic areas.

22 one-piece endosseous dental implants made of sintered and yttrium-stabilized zirconium oxide were used for the rehabilitation of single tooth or partially edentulous ridge in the esthetic areas in the maxilla or the mandible. It was considered that the esthetic zone of the jaw includes the central and lateral incisors, the canines, and the first premolars.

The implants used in the clinical study are made of sintered and yttrium-stabilized zirconium oxide (WhiteSky, Bredent, Senden, Germany) and are featured by a conical implant body and a double, cylindrical thread. The endosteal portion has a sandblasted surface, whereas, transmucosally, the implant includes a machined neck with a height of 2 mm. The implant surface is treated with a sanding process. The microscopical surface characteristics of medium rugosity (Ra 0.9-1 m) are similar to the surface of last-generation machine-finished titanium implants.

The abutment surface is smooth and it has a length of 6.8 mm which can be modified by grinding after implant positioning.

For this study, 14 patients in need of a single or multiple teeth replacements in the maxillary esthetic areas were selected (Figures 1, 2, and 3). All sites should present adequate bone volume (minimum bone height and thickness, respectively, of 8 and 5.5 mm). Implants positioned in regenerated bone were excluded from this protocol because the regenerative procedures associated with implant rehabilitation can influence the results in terms of marginal bone loss. In fact, it has been demonstrated that the marginal bone loss is greater in the regenerated bone than in the native bone [13]. Moreover, patients with oral problems such as

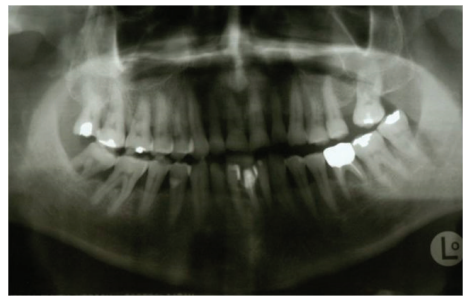

Figure 1: Preoperative orthopantomography.

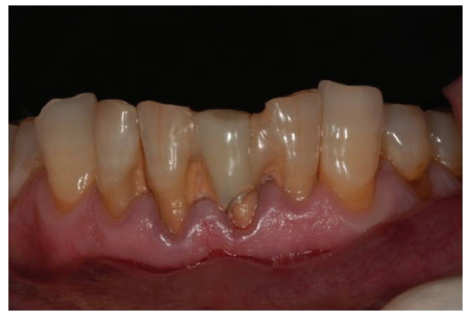

Figure 2: Preoperative clinical view.

active periodontal disease or parafunctions, bisphosphonates treatment, smoking more than 10 cigarettes per day, poor oral hygiene, and low compliance and patients with previous or concomitant systemic diseases such as immunodeficiency, head and neck radiotherapy, metabolic disorders, and hematological diseases, together with patients under 18 years of age were not included in this study.

All patients were previously informed about zirconia implants and possible alternatives and gave a written consent. Seven days before surgery, the patients underwent professional oral hygiene and they were instructed to start rinsing mouth twice a day with chlorhexidine 0.2% (Corsodyl, Glaxo, UK) until two weeks after surgery. Antibiotic prophylaxis with 2 gr of Amoxicillin and Clavulanic Acid (Laboratori Eurogenerici, Milan, Italy) was prescribed 1 hour prior to surgery.

The surgical procedure has involved the positioning of implants according to the protocol suggested by Bredent Medical, which is similar to the standard surgical protocol for titanium dental implants. All implants were inserted using a guide device prepared on a diagnostic wax-up (Figure 4). Mucoperiosteal flaps were elevated avoiding vertical releasing incisions in order to reduce the risk of blemishes. After preparing the implant sites, fixture insertion was performed by a surgical microengine. The fixtures were screwed until the rough surface of the implant body was positioned completely inside the bone, whereas implant abutment with smooth neck performed the function of the transmucosal element (Figure 5). All the implants were placed in the correct three-dimensional positioning according to esthetic protocol by Tarnow et al. [14]. Flaps were released through periosteal incisions to attain primary wound closure, and, at the end,

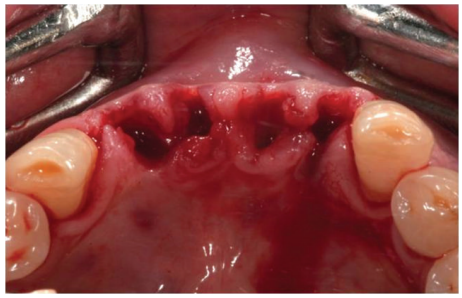

Figure 3: Dental extractions.

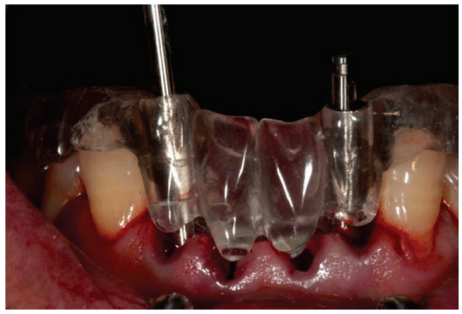

Figure 4: Surgical guide.

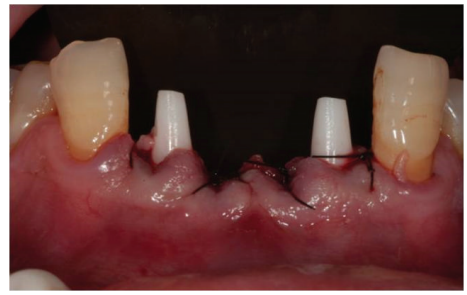

Figure 5: Two monocomponent zirconia implants are placed in the areas 3.2 and 4.2.

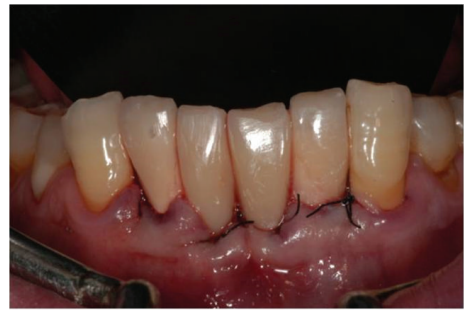

Figure 6: Immediate temporary restoration.

flaps were sutured with 4/0 monofilament suture (Premilene, Braun Melsungen, Germany).

After implant insertion, standardized periapical radiography using the Rinn alignment system (Dentsply, Constanz, Germany) with customized silicon bites (Orthogum Zermack, Badia Polesine, Rovigo, Italy) was obtained. The radiographic control was permitted to evaluate the correct positioning of implants.

Immediately after surgery, considering that zirconium oxide ceramics are bad thermal conductors, implant abutments were refined in order to correct their axis, length, or undercuts if present, using double diamond burs suited for zirconia (ETERNA Bredent, Senden, Germany) and water cooling. Temporary restorations obtained from diagnostic wax-up were relined with acrylic resin and luted with temporary cement (TEMPBOND, Kerr West Collins Orange, CA, USA). Single restorations were attached to the adjacent teeth by means of composite bonding, whereas multiple implants were connected together by provisional restoration in order to reduce the risk of implant mobility or extra occlusal load (in particular, tongue and lips movements) (Figure 6).

Patients were given oral hygiene suggestions and were instructed not to chew or eat on implant site until healing was completed. Antibiotic therapy (1 gr every 8 hours) and chlorhexidine mouth rinses were continued for 7 days, and Paracetamol 500 mg (Tachipirina, Angelini, Rome, Italy) was prescribed to use if necessity was felt. Sutures were removed 7 days after surgery and follow-up controls were programmed after 1 week, 2 weeks, and, subsequently, once a month for the following 6 months.

Six months after the surgery (Figures 7 and 8), definitive impressions (IMPREGUM, 3M, ESPE, St Paul, MN, USA) were taken using a retraction cord (Ultrapak Cord, Ultradent, South Jordan, UT, USA) or an impression cap to register implant shoulder margins. The definitive restorations were made with CAD-CAM system (LAVA, 3M, ESPE, St Paul, MN, USA) (Figure 9) and cemented with glass ionomer cement (GC Fuji CEM, GC America, Alsip, IL, USA) (Figure 10).

One week after definitive restorations delivery and, subsequently, every year after implants placement, clinical-radiographic evaluation was performed. The periodontal evaluation was performed using a calibrated probe (Hu-Friedy, N. Rockwell Chicago, IL, USA) and the following periodontal indexes were investigated: Plaque Index (PI), Bleeding On Probing (BOP), Probing Pocket Depth (PPD), and implant mobility.

Moreover, the follow-up protocol included the radiographic control examination (Figures 10 and 11). The radiographs were taken using the customized silicon bite record prepared immediately after surgery. The radiographs were converted in digital images with a scanner (Epson 1680 Pro, Seiko Epson Cooperation, Nagano, Japan) and saved in JPG format. Each image was processed with a specific piece of software (CorelDraw 10.0; Corel Corp and Coral Ltd., Ottawa, Canada) and analyzed at ×20 magnification in order to calculate marginal bone loss. Mesial and distal marginal bone levels of all the implants were measured at baseline and on recall evaluations. The known length of the implant (measured from the implant shoulder to the implant apex) according to the manufacturer was used as a reference point. The distance from implant shoulder to crestal bone level was measured on the magnified images. To analyze the variability,

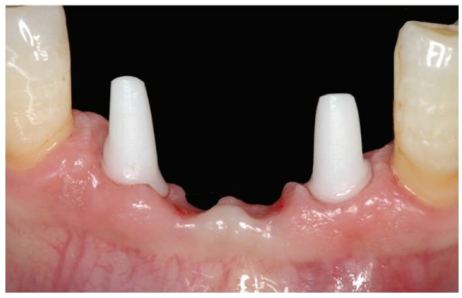

Figure 7: Soft tissue health 6 months after surgery.

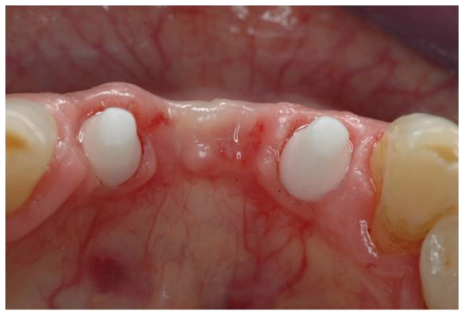

Figure 8: Occlusal view.

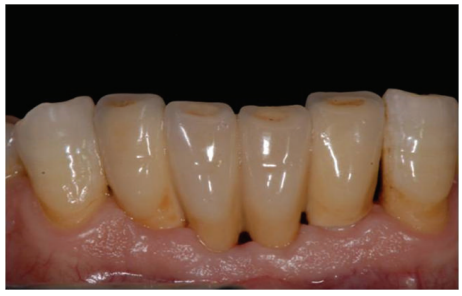

Figure 9: Definitive restoration.

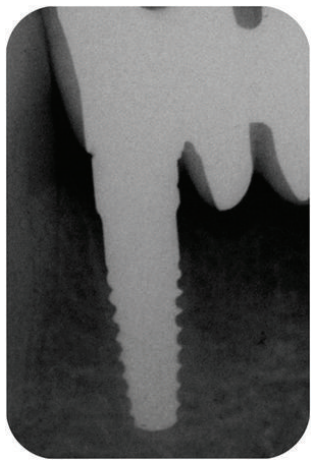

Figure 10: X-ray image of the zirconia implant placed in area 4.2, six months after surgery.

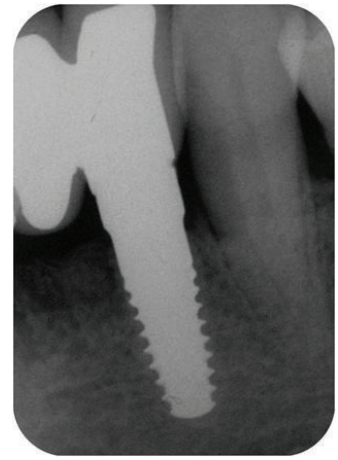

Figure 11: X-ray picture of the zirconia implant placed in area 3.2, six months after surgery.

the implant dimension (length) on the magnified X-ray was measured and compared to the real dimension, and ratios were calculated to adjust for distortion. Bone level changes were calculated at the distal and mesial surfaces of all implants by applying the distortion coefficient.

Data analysis was performed with descriptive statistics and the arithmetic mean; the median and the standard deviations were calculated. Clinical and radiographic control examination was repeated every year (Figures 12, 13, and 14).

At the end, success criteria and survival criteria were formulated in accordance with Albrektsson criteria for implants success [15]. Survival criteria were identified as the survival of loaded functionalized asymptomatic implants, whereas success criteria refer to four parameters, absence of implant mobility, absence of self-reported pain or paresthesia, absence of peri-implant radiolucency, and marginal bone loss inferior to 1.5 mm in the first year and to 0.2 mm in the following years.

3. Results

At the Department of Implantology, Dental Clinic, IRCCS Fondazione Cà Granda Ospedale Maggiore Policlinico, University of Milan, 14 patients were treated for the rehabilitation of the esthetic jaw areas. Average age was 60 years (ranging from 38 to 75 years), 13 male patients and one female. Starting from January 2007 and recruited in a period of one year, 14 patients were included in the study. The data were recorded to July 2012 when the implants had a minimal observation period of 4 years.

17 implants were placed in the maxilla, whereas 5 implants were placed in the mandible.

Considering the maxillary implants, 10 zirconia dental implants were used for the rehabilitation of single or multiple cases of edentulism in the incisor region; 3 implants replaced the canines, and the other 4 maxillary implants were placed in place of the missing first premolars. All mandibular implants were used for the rehabilitation of edentulism in the incisor

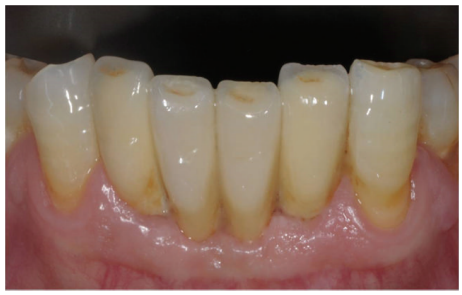

Figure 12: Clinical control 4 years after surgery.

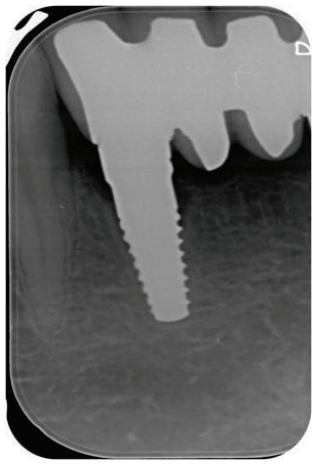

Figure 13: Radiographic control 4 years after implant insertions.

region, except 2 implants that were positioned in area of the missing right mandibular first premolar.

Considering patients' selection criteria, one patient with two implants placed in places of the upper right canine and the first premolar was excluded from this protocol because regenerative procedures were performed. For this reason, the data reported in this study refer exclusively to 20 implants. The follow-up period ranged from 6 to 48 months after implant insertion.

During the 48 months of follow-up, no implant failure was reported, with no pain or paresthesia, and, at the radiographic evaluation, peri-implant radiolucency was not detected. Thus, the cumulative survival rate was 100% after 4 years.

At follow-up controls, the median for PI and BOP was 1 and 0, respectively, and the mean values of PI and BOP were 0.54 and 0.23, respectively.

48 months after surgery, the median and the mode for visible Plaque Index (PI) and Bleeding On Probing (BOP) resulted 1. Overall Probing Pocket Depth (PPD) amounted to 3 mm (SD = ±0.49 mm). Mobility was not present at any site, and no pain (spontaneous or on percussion) or paresthesia was reported.

The mean marginal bone level after 4 years was +2,1045 mm, without a difference between mesial and distal sites. In particular, mean marginal bone loss was +1.50 mm (SD = ±1.03) 6 months after implant insertion and +0.446 mm (SD = ±0.64) 6 months after prosthetic finalization.

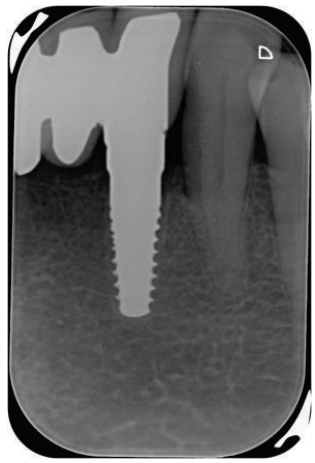

Figure 14: Radiographic control 4 years after implant insertions.

From 1 year up to 2 years after implant positioning, an improvement of peri-implant bone level value was observed probably due to the formation of new bone trabeculae as a result of maturation of bone (−0.198 ± 0.50 mm).

A minimal bone remodeling with a further marginal bone loss of +0.18 mm (SD = ±0.28) and +0.17 mm (SD = ±0.11), respectively, was also observed at 3 and 4 years follow-up.

For implants placed in the maxilla, the average marginal bone loss from baseline to 6 months after surgery was +1.50 ± 1.03 mm, from 6 months to 1 year was +0.65 ± 0.7 mm, from 1 year to 2 years was −0.12 ± 0.57 mm, from 2 years to 3 years was +0.12 ± 0.25 mm, and from 3 years to 4 years was −0.17 ± 0.11 mm.

Four patients were treated for multiple cases of edentulism with 8 zirconia dental implants, and, after surgery, all multiple implants were splinted together by provisional restoration. Considering the marginal bone loss adjacent to free-standing implants and multiple implants, it was observed that there is a statistically significant difference between the two groups ($P = 0.799$).

The success rate was 100%.

4. Discussion

The clinical success of the implant rehabilitation is in connection with the interface between bone tissue and implants surface. Several studies showed successful osseointegration of zirconia dental implants in different animal models [5–7, 12]. In the work by Thomsen et al. [16], the interface between the rabbit tibia bone tissue and the surfaces of gold, titanium, and zirconia implants was investigated, and the histological examination disclosed that the bone-implant contact ratio (BIC) is similar for zirconia and titanium implants, whereas gold implants had a lower degree of BIC. In the study by Scarano et al. [17], a great amount of newly formed bones was observed in close contact with the surfaces of zirconia implants positioned in rabbits, and the BIC ratio was 68%. Furthermore, the BIC ratio was better investigated by

Akagawa et al. [18] who demonstrated that the bone-implant contact ratio ranged from 54% to 69.8% at 12 months and from 66.2% to 67.7% at 24 months.

The bone-implant contact ratio is the result of bone formation, and it is related to the characteristics of implant surface. Sennerby et al. [19] evaluated the bone tissue reaction to titanium implants and zirconia dental implants with and without different surface modifications. The titanium implants and the zirconia implants with the surface modifications showed the highest surface roughness in comparison to the nonmodified zirconia implants, and, consequently, machined implants presented a lower degree of BIC than titanium and modified zirconia implants.

The reported studies demonstrate a bone-implant contact for zirconia dental implants, similar to those of titanium implants, and these findings suggest that zirconia dental implants can reach firm stability in bones.

More recently, the osseointegration of zirconia dental implants was histologically demonstrated in one human patient [20]. In this study, a two-piece zirconia implant was placed in the maxilla of a healthy woman and 6 months after surgery, the retrieval of the dental implant was performed. The surrounding soft and hard tissues were harvested and processed for histological evaluation. The processed sample of zirconia dental implant provided the histological evidence of osseointegration. Moreover, the scanning electron microscopic analyses showed a good maintenance of the crestal bone level; in fact, it was possible to evaluate that the first bone-to-implant contact was occlusal to the implant-abutment junction.

This finding can be related to the excellent characteristics of zirconia dental implants which present high biocompatibility and low plaque adhesion [17, 21]. In fact, it is important to note that a bacterial adhesion to implant surfaces is the first stage of peri-implant mucositis and peri-implantitis with the resulting loss of the supporting bone in the tissues surrounding the implants [22]. On the contrary, the reduction of bacterial adhesion on the surface of zirconia dental implants promotes early formation of the biological width and, therefore, the formation of a mucosal seal that stops early marginal bone resorption. As demonstrated by Scarano et al. [23], zirconium oxide surfaces showed a significant reduction of the presence of bacteria, and this fact is probably important for the health of the peri-implant soft tissues.

Moreover, the implant system adopted in our study is characterized by monocomponent dental implants. Several studies have shown that bone resorption around the implant neck is related to the presence of the microgap between implant and abutment [14, 24, 25]. This microgap leads to bacterial leakage and a microbial colonization of the gap at the bone level. Peri-implant soft tissues develop an inflammatory response which promotes osteoclast formation and activation to result in alveolar bone loss. According to the authors, the reduction of marginal bone loss is mainly due to the one-piece morphology of zirconia dental implants, through which there is no implant-abutment microgap and its microbial contamination; there are no micromovements of the prosthetic component and repeated screwing and unscrewing [26, 27].

For these reasons, it has been proposed that peri-implant marginal bone loss is more extended around two-piece implants than around one-piece implants as a result of the location of the microgap [28–30].

Another retrospective study suggests that zirconia endosseous implants can achieve a survival rate similar to that of titanium implants with healthy and stable soft and hard tissues. In the work by Brüll et al. [31] 121 zirconia implants (66 two-piece implants and 55 one-piece implants) were inserted in 74 patients. After a mean observation period of 18 months, the cumulative implant survival rate was of 96.5%. The clinical examination revealed that PPD and BOP were statistically significantly lower around implants than around teeth (mean PPD of 1.8 ± 0.4 mm − mean BOP scores of $4.1\% \pm 4.2\%$), whereas the radiographic evaluation demonstrated that peri-implant marginal bone levels were stable (mean bone loss of 0.1 ± 0.6 mm) after 3-year follow-up.

Even if the results regarding the rehabilitation of the esthetic areas with zirconia monocomponent implants are encouraging, further scientific information concerning the clinical use of zirconia dental implants is needed, as well as prospective long-term clinical studies in order to understand whether zirconia implants may represent a valid alternative to titanium implants.

5. Conclusion

In this study, it was evaluated that there is a preservation of the crestal bone adjacent to zirconia dental implants. In particular, the radiographic measurements of marginal bone loss showed values below 0.9–1.6 mm during the first year in function and not exceeding 0.2 mm 1 year up to 4 years after surgery in accordance with Albrektsson implant success criteria [15]. This finding can be related to some properties which characterize zirconia dental implants. These properties are the high biocompatibility of zirconia surfaces, the low plaque adhesion on zirconia dental implants, and the absence of microgap between fixture and abutment [32, 33].

Conflict of Interests

All the authors declare that they do not have any conflict of interests regarding the publication of the current work.

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Review Article

Soft Tissue Surgical Procedures for Optimizing Anterior Implant Esthetics

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Implant dentistry has been established as a predictable treatment with excellent clinical success to replace missing or nonrestorable teeth. A successful esthetic implant reconstruction is predicated on two fundamental components: the reproduction of the natural tooth characteristics on the implant crown and the establishment of soft tissue housing that will simulate a healthy periodontium. In order for an implant to optimally rehabilitate esthetics, the peri-implant soft tissues must be preserved and/or augmented by means of periodontal surgical procedures. Clinicians who practice implant dentistry should strive to achieve an esthetically successful outcome beyond just osseointegration. Knowledge of a variety of available techniques and proper treatment planning enables the clinician to meet the ever-increasing esthetic demands as requested by patients. The purpose of this paper is to enhance the implant surgeon's rationale and techniques beyond that of simply placing a functional restoration in an edentulous site to a level whereby an implant-supported restoration is placed in reconstructed soft tissue, so the site is indiscernible from a natural tooth.

1. Introduction

Implant dentistry has been definitively established as a predictable treatment modality for replacing missing or nonrestorable teeth which yields excellent clinical success rates. During the last decade, the focus of implant research has shifted from the functional stability of the implant to its esthetic integration in the smile. The esthetics of implant restorations is dictated by two fundamental components: the reproduction of the natural tooth characteristics on the implant crown and the establishment of a soft tissue housing that will intimately embrace the crown. Therefore, the success of implant rehabilitation in the esthetic zone relies heavily on the preservation or the augmentation of peri-implant soft tissue by means of periodontal surgical procedures.

The aim of this paper is to enhance the implant surgeon's armamentarium with rationale and techniques that extend beyond the placement of a functional restoration in an edentulous site to the restoration of soft tissue harmony so that the implant-supported restoration is indiscernible from a natural tooth. This is especially important in areas of esthetic concern but not negligible in posterior sites where the added benefits of enhanced tissue contours cannot be overlooked.

2. Indications

It may not be an overstatement that every surgical implant procedure in the esthetic region constitutes an indication for soft tissue grafting. The inevitable alteration of the alveolar ridge dimensions that follows a tooth extraction often results in the placement of the implant in a site that has undergone a reduction in soft and hard tissue volume in comparison to its neighboring dentate sites [1–3]. This discrepancy is even more pronounced in single-implant sites where a concavity forms between the edentulous site and the root prominences of the neighboring dentition. Subepithelial connective tissue grafts (SCTG) or free gingival grafts (FGG) can be employed

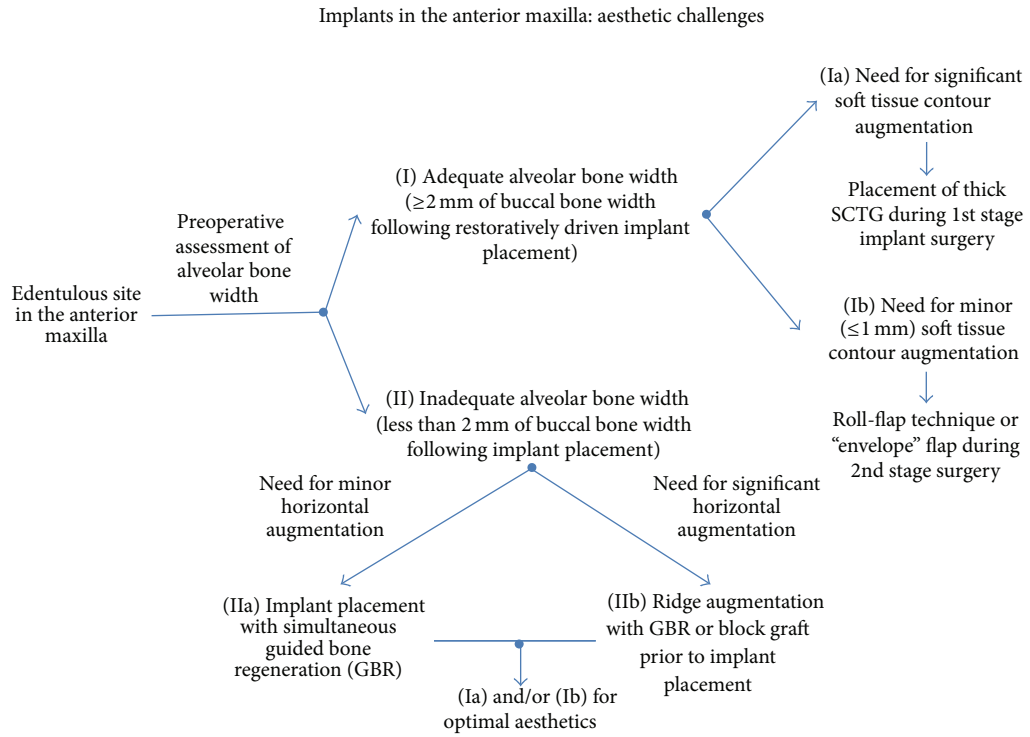

Figure 1: Implants in the anterior maxilla: a clinical decision-tree for overcoming aesthetic challenges.

in these cases to reconstruct the buccal dimensions of the site improving the tissue thickness. In addition, they create the illusion of root prominence and increase the width of the crestal peri-implant mucosa in order to provide an emergence profile for the restoration and enable the constructed site to closely resemble a natural tooth.

The long-term stability of pink esthetics around dental implant prostheses has been strongly correlated with adequate peri-implant soft tissue thickness, that is, a thick peri-implant biotype [4, 5]. When a thin biotype is diagnosed, a SCTG or a FGG can be used to prevent potential long-term recession of the facial mucosal margin or permeation of a gray color from the implant [6–8].

Factors that should be considered when evaluating the need for soft tissue grafting include the level of clinical attachment on adjacent teeth to support papillary height, the thickness of the coronal soft tissue margin to ensure a proper emergence profile, the thickness of labial soft tissue to simulate root eminence and prevent transillumination of underlying metallic structure, and the position of the mucogingival junction and amount of keratinized tissue so as to blend harmoniously with that of the adjacent teeth [9, 10] (Figure 1).

3. Contraindications and Limitations

General and specific limitations apply to the use of a soft tissue augmentation technique around dental implants. Certain medical conditions are considered general contraindications to surgical intervention. Collagen disorders, such as erosive lichen planus and pemphigoid, may pose a risk to the viability of autogenous connective tissue grafts placed on a recipient bed that exhibits a pathologic healing response. There is no published evidence to either support or discourage the use of soft tissue grafting techniques in such cases.

Smoking is another relative contraindication. It is well established that a key determinant of soft tissue augmentation success is revascularization of the graft. Nicotine contained in cigarettes causes vasoconstriction to the surgical site, often resulting in necrosis of the graft [11]. This nicotine-associated vasoconstriction, in combination with lack of adherence of the fibroblasts [12] and alteration in immune response [13, 14], diminishes the likelihood for a successful outcome. Preoperative assessment should attempt to identify such at-risk patients whereby the clinician must inform the patients of the potential adverse effects associated with smoking. Local factors that may also limit patient selection include lack of adequate tissue thickness at the palatal donor site or restricted surgical access to intraoral donor sites such as the posterior of the hard palate or maxillary tuberosity.

4. Treatment Planning and Timing for Soft Tissue Grafting Procedures

A thorough 3-dimensional preoperative evaluation of the edentulous site is critical to properly planning an implant case that will result in an esthetic outcome. Two diagnostic variables that should be taken into account preoperatively are bone and soft tissue volumes [15]. Long-term stability

of esthetics for an implant requires the implant to be surrounded by ~1.8–2.0 mm of vital bone [16]. Lack of adequate bone necessitates hard tissue grafting. Sites should also be evaluated for soft tissue profile. A discrepancy of soft tissue contours with adjacent teeth can be addressed with augmentation.

Soft tissue augmentation can be performed simultaneously with implant placement and/or during the second stage surgery, as will be described in the following technique section. There is no evidence in the literature to support any advantage of simultaneous soft tissue augmentation over augmentation during second stage surgery. Both treatment modalities have been shown to lead to better esthetics and increased soft tissue thickness [17]. Even though both techniques yield favorable esthetics, the earlier the intervention is performed, the more opportunities the clinician has to better control the final outcome. For instance, in a case where the residual ridge has undergone significant atrophy, the simultaneous soft tissue augmentation in conjunction with first stage surgery will allow sufficient healing time to properly assess the site during second stage surgery. Consequently, additional soft tissue augmentation can be performed simultaneously when uncovering the implant(s) in order to achieve a more ideal outcome.

Soft tissue grafting can also be utilized as a "rescue procedure" to manage esthetic complications associated with implants. Labial inclination of implants, buccal placement, or use of wide body contributes to a thin tissue biotype or thin buccal bone that may lead to recessions [18], permeation of gray from the implant structure through the tissue, and exposure of the titanium implant neck, all of which contribute to an inharmonious emergence profile of the implant-supported restoration and an ersatz appearance of the patient's smile [19, 20]. Additionally, soft tissue grafting following implant placement can be used to correct complications associated with soft tissue color mismatch to a level below clinical perception [21].

5. Free Gingival Graft

The use of autogenous FGG in mucogingival surgeries predates that of any other type of graft. FGGs are considered a reliable and efficacious approach for augmenting peri-implant soft tissue defects and are most often utilized to increase the amount of keratinized tissue around an implant. FGGs are the gold standard in cases when an increase in keratinized tissue is desired.

The most common donor site of a FGG is the highly keratinized hard palate. That being said, the color and shade of the augmented recipient site do not often blend naturally with the adjacent soft tissues. This produces a nonesthetic result, contradicting the initial purpose of the procedure. Even so, a FGG to increase the keratinized tissue is recommended for "rescue" procedures to cover exposed implant threads. In addition, a FGG can be used for patients with low smile lines, when extensive soft tissue augmentation is needed, or where the color of a FGG will not compromise the esthetic appearance of the implant site (Figure 2).

6. Subepithelial Connective Tissue Graft

SCTG procedures have been used successfully throughout the years for the management of recession and soft tissue defects around natural teeth and for augmenting alveolar ridge contours [22, 23]. Some may argue that the traditional approaches for connective tissue grafting do not fare well when one attempts to graft and achieve cover of a nonvital implant surface since the soft tissues around the implant do not respond in the same manner as a vital tooth. Nonetheless, many of these procedures can be translated directly to peri-implant soft tissue modification and esthetic optimization. When indicated and properly utilized, these surgical procedures can provide stable and significant gains in soft tissue volume and contour that can contribute to the successful esthetic management of implant sites (Figure 3).

7. Technique for Soft Tissue Grafting during 1st Stage Implant Surgery

Step 1: Treatment Planning. As in all surgical procedures, treatment planning is the cornerstone of success. Preoperative identification of potential soft and/or hard tissue deficiencies allows for the construction of an implant restoration that will closely mimic that of the natural dentogingival complex and blend with the existing dentition in a pleasing and esthetic fashion. A decision should be made preoperatively whether soft tissue augmentation alone will be adequate to develop the desired treatment outcome or if bone augmentation is also needed to achieve ideal implant position and soft tissue esthetics.

Step 2: Graft Harvesting. The three most common intraoral donor sites for harvesting connective tissue grafts are the tuberosity [24], the single incision-deep palatal [25], and the free gingival graft method-superficial palatal [26]. Donor tissue for FGGs is routinely harvested from the hard palate since this area provides an ample surface area of keratinized tissue. Nonetheless, relatively any intraoral site with adequate tissue thickness that displays keratinization, such as the keratinized epithelium apical to the gingival crest of the maxillary molars, may be utilized to procure a FGG. The amount and quality of soft tissue available for harvesting depend on donor site, that is, tuberosity versus palate. The tuberosity generally provides enough tissue to cover a single or two implant site(s), while adequate tissue can be obtained from the palate to cover an area two or three times wider than that of the tuberosity, depending on the incision design. The quality of the tissue harvested from the tuberosity is superior to that obtained from the palate since the tuberosity offers a graft composed of dense connective tissue, whereas the portion of the palatal connective tissue donor usually consists of adipose tissue. Tissue obtained from the tuberosity usually permits the harvesting of a significantly thicker graft than that obtained from the palate [27]. This broad piece of tuberosity can be longitudinally sectioned to increase the amount of donor tissue.

Figure 2: (a) Patient had previous bone grafting and numbers 8 and 9 implant placement. Note minimal keratinized attached gingiva over grafted area of numbers 8 and 9 due to coronal advancement of the flap. (b) Note the deficient soft tissue profile following placement of a provisional prosthesis with appropriate tooth emergence. (c) Donor site and graft procurement. (d) Collagen tape and cyanoacrylate to reduce discomfort over donor site. (e) Graft secured and well adapted to recipient bed with multiple sutures. (f) Recipient site following healing. Note the increase in height and thickness of the keratinized attached gingiva. (g) Numbers 8 and 9 implant sites prepared for second stage surgery. (h) Recipient site after numbers 8 and 9 implant restorations, showing stable keratinized attached gingiva. (i) Lateral view of recipient site. Note the thick buccal keratinized attached gingiva, establishing an esthetic emergence profile for the implant restorations.

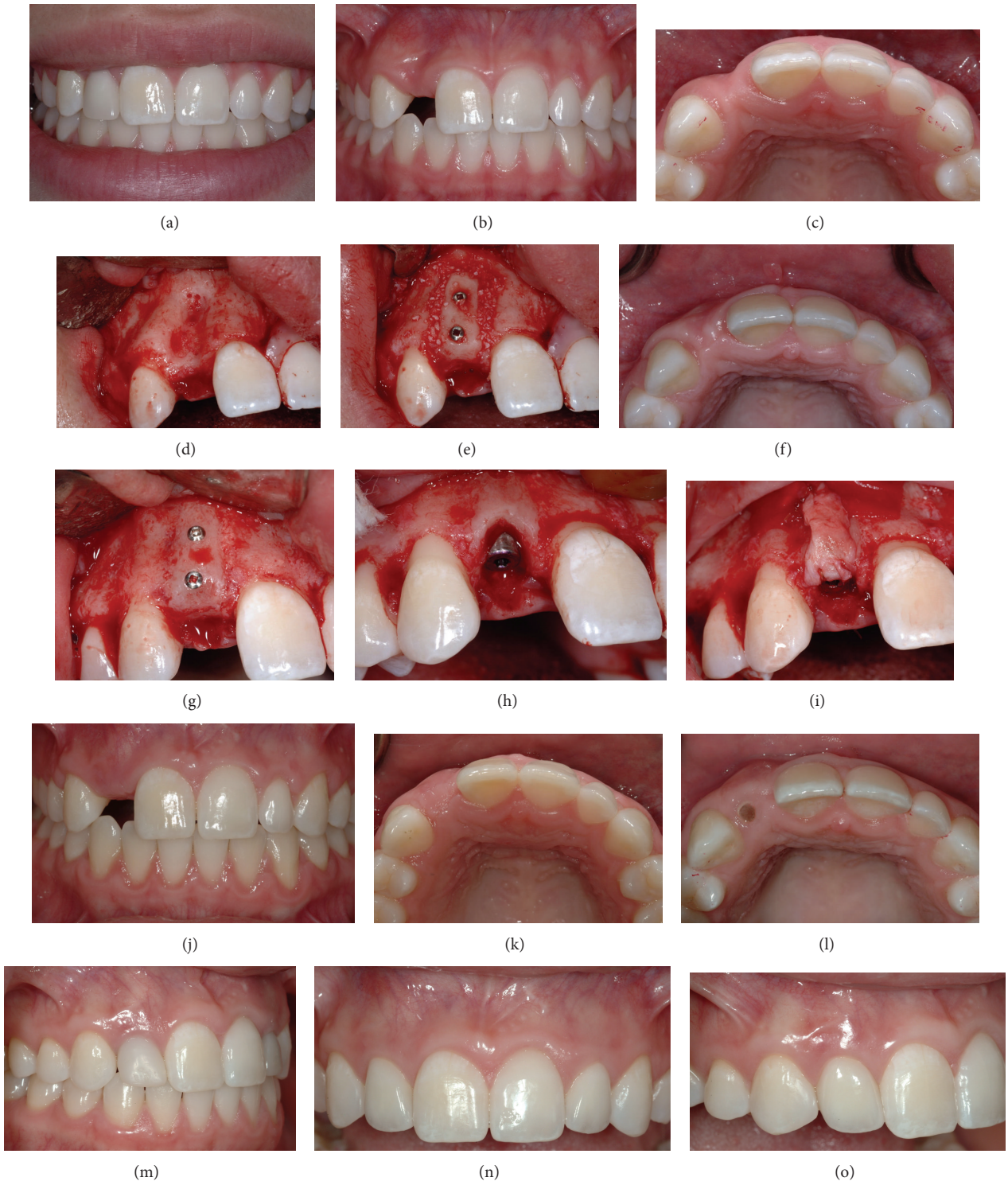

Figure 3: ((a), (b), and (c)) Patient presented for implant rehabilitation of number 7 lateral incisor. Not the high interdental smile line that poses an esthetic challenge. Following ridge resorption, a concavity consistent with a Seibert Class I defect is seen in the edentulous site. ((d), (e), and (f)) A block autograft was screwed in place to achieve horizontal ridge augmentation prior to implant placement. Particulated allograft was utilized to graft the area between the block and the recipient bed. Note the significant enhancement of the tissue profile postsurgically. ((g), (h), and (i)) At four months after grafting the site was reentered and an implant was placed in the ideal 3-dimensional position. A SCTG was utilized to replicate the root eminence and provide a natural emergence profile. ((j), (k), (l), and (m)) Postoperative healing view shows excellent tissue contours at the site. A customized healing abutment was selected to mold the tissues after 2nd stage surgery. Note the excellent positioning of the mucosal zenith at the time of provisionalization. ((n), (o)) Intraoral view of the final restorations in place. Crown lengthening was performed on the adjacent teeth to address the patient's overall esthetic demands. Note the excellent replication of gingival characteristics on the peri-implant mucosa and the natural appearance of the restoration as it emerges from the augmented hard on soft tissues at the site.

7.1. Harvesting from the Tuberosity. On the distal aspect of the tuberosity a single, crestal beveled incision is made from the mucogingival junction to the distofacial line angle of the most distal tooth. The incision is located on the buccal aspect of the ridge crest rather than midcrestal and connected to the distal surface of the most posterior tooth via a sulcular incision. Use of an Orban knife enhances the access to performing the sulcular incision. At this point, the palatal flap is raised until the distopalatal surface of the most distal tooth is exposed. Then, a new blade (15c) is used to meticulously dissect the connective tissue from the flap and the underlying periosteum. Tissue forceps and the suction tip should be delicately employed during procurement of the graft in order to minimize excessive trauma to the donor tissue and prevent inadvertent loss of the graft through the suction tip. Once the graft has been obtained, it is stored in saline to prevent dehydration while the recipient bed is prepared. The donor site flap is sutured closed at this time, preferably using 4-0 chromic gut and a continuous interlocking suturing technique.

7.2. Harvesting from Deep Palatal Tissue. If a deep palatal donor site is selected for harvesting the connective tissue graft, the donor site should be sounded to bone. This is performed to verify that the incision will not involve a periodontal pocket or bony dehiscence of a palatal root in order to avoid postoperative recession. A single, full-thickness horizontal incision is made at a right-angle to the alveolar bone of the palatal keratinized tissue approximately 3 mm from the free gingival margin of the maxillary teeth. This first incision extends from the mesial aspect of the palatal root of the maxillary first molar as far anteriorly as needed for the appropriate amount of donor tissue required. A second incision is made parallel to the underlying bone so that a thin split-thickness flap is created to separate the underlying connective tissue from the superficial flap. When the desired volume of SCTG has been identified, the blade is directed towards the bone at the edges of the graft so that the SCTG is free except for its periosteal attachment. A Woodson elevator is slid under the partial-thickness flap to separate the graft from the underlying bone. The procured graft is kept in saline-soaked gauzes until used. The palatal flap can be closed with either single interrupted sutures, sling sutures around the maxillary teeth, or a combination of the above. It is important that the clinician be familiar with the anatomy of the palate in order to minimize the risk of hemorrhage associated with traumatizing the major palatine artery during harvesting of the graft. The arterial vascular trunk is typically located ~12–17 mm from the CEJ of the posterior teeth in patients with an average or high palatal vault while the artery is usually within 7 mm of the CEJ in patients with a shallow palatal vault [28].

7.3. Harvesting from the Superficial Palatal Tissue. This technique is used for the harvesting of both the FGG and the SCTG. This technique utilizes a very similar method to that of a FGG to harvest the SCTG, with the only difference being that the epithelium is removed after harvesting. The rationale for using this technique is that sounding reveals a limited amount of connective tissue beneath the palatal mucosa. In contrast to the tuberosity area where connective tissue occupies the whole tissue volume underneath the epithelium, here a limited amount of connective tissue exists between the epithelium (superficial) and adipose tissue (deep). Consequently, use of the deep palatal harvest technique in patients with thin palatal mucosa as described before would not procure an adequate thickness/volume of graft after removal of the adipose tissue.

The superficial palatal harvest technique places a horizontal anterior/posterior incision 3 mm away from the maxillary teeth, as described in the deep palatal harvest technique, as a partial-thickness incision of only 1.5–2 mm in thickness and leaves the periosteum intact. A second anterior/posterior horizontal partial-thickness incision is traced parallel to the first incision at a position closer to the midline. The distance between these two incisions is based upon the estimated amount of tissue graft required for grafting. The two horizontal incisions are connected via anterior and posterior vertical partial-thickness incisions on the mesial and distal aspect of the graft. Either a sharpened gingivectomy knife (Kirkland knife) or a blade (15c) is utilized to separate the graft from the underlying tissue for an ideal thickness of 1.5 mm to 2 mm. Then the graft is placed on a moist, sterile surface whereby the superficial epithelium is removed by sharp dissection. Adipose tissue is removed from the periosteal side of the graft with the aid of a fresh blade or LaGrange scissors until the harvested graft consists of only connective tissue or/and epithelium. The tissue graft is used as a template to trim a collagen biomaterial in the proper dimensions to cover the donor site wound. After adequate hemostasis has been achieved at the denuded donor site by application of gauze with digital pressure for 5–10 minutes, the collagen biomaterial is placed over the wound and secured by the application of cyanoacrylate via pipette. Periodontal dressing may be utilized depending on the surgeon's preference to improve patient comfort.

Step 3: Preparation of the Recipient Site. The flap is designed to retain a band of keratinized mucosa on the buccal aspect of the flap whenever possible. Consequently, it may be advisable to place the initial incision slightly palatal rather than midcrestal. The crestal incision is extended as sulcular incisions onto the adjacent teeth or as papillae sparing vertical releasing incisions passing to the level of the mucogingival junction. The length of each incision depends on the individualized treatment plan. A full-thickness flap is raised to allow access for surgical placement of the implant(s). The successful incorporation of a tissue graft does not depend on the thickness of the incision since the combination of a tissue graft with either a full- or partial-thickness flap yields similar clinical results [29]. The recipient bed should be kept well-hydrated with frequent irrigation throughout the procedure.

In order to create a partial-thickness flap, the dissection should occur beyond the mucogingival junction, leaving a layer of approximately 2 to 3 mm of connective tissue and periosteum intact.

Step 4: Adaptation of the Soft Tissue Graft. Following placement of the implant(s), the procured graft is adapted to the area. The dimensions of the graft should be adequate to provide soft tissue bulk at the level of the neck of the implant to ensure an esthetic emergence profile for the restoration as well as simulate a root prominence for the missing tooth. The tissue graft should be trimmed to resemble a semicircular cone so that the apical aspect does not span to the proximal surfaces of adjacent teeth. Such excessive soft tissue will create a bulky visual effect rather than that resembling the natural gingival contours of adjacent teeth. There is no significant clinical difference in regard to the orientation of the SCTG during its placement into the recipient site. Based on studies on root coverage procedures, when the periosteal side of the graft opposes the flap rather than the recipient bed, the success of the outcome will not be compromised [30].

Step 5: Suturing at the Recipient Bed. After trimming the graft to the appropriate dimensions, the graft is secured in the recipient bed utilizing a palatal-locking suture technique. The suture needle initially penetrates the palatal keratinized tissue in a palatobuccal direction. The needle then passes through the mesial aspect of the graft employing a faciopalatal direction. The sequence is repeated for the distal portion of the graft, and as the needle exits the palatal flap a second time, a knot is placed on the palatal side. The apex of the graft is stabilized in the connective tissue at the base of the flap so that the graft is stretched and well adapted onto the recipient bed. It is emphasized that the graft should be uniformly adapted and well secured on the recipient bed to prevent disruption of plasmatic circulation and healing. The final adaptation should be verified with the aid of a periodontal probe. Pressure is applied with moist gauze for 5 minutes. The flap is closed with single interrupted sutures using a 4-0 or 5-0 suturing material. If passive closure cannot be achieved, then horizontal vestibular releasing incisions should be placed in the base of the labial flap with a fresh 15C blade until tension-free flap adaptation and closure can be accomplished.

8. Technique for Soft Tissue Grafting during 2nd Stage Implant Surgery

A broad variety of techniques have been proposed to augment the soft tissue profile of implants at second stage surgery. Ideally, second stage surgery should be a minimally invasive procedure whereby minor revisions in soft tissue architecture can be accomplished to create a natural emergence profile for the healing abutment and/or final restoration [31]. A rolled pedicle flap can be used to augment the connective tissue that covers the coronal portion of a submerged implant. Tissue sounding is utilized to locate the palatal shoulder of the cover screw followed by an arcing crestal incision around the palatal aspect of the cover screw. Papillae sparing mesial and distal vertical releasing incisions are placed, leaving the labial pedicle flap intact. A blade (15c) is used to deepithelize the superficial layer of the labial pedicle flap. The labial pedicle is elevated as a full-thickness mucoperiosteal flap and a Woodson elevator is used to create a small tunnel beneath the base of the labial pedicle. A horizontal mattress suture with absorbable suturing material (5-0 chromic gut or vicryl) is initially passed from the base of the tunnel horizontally through the coronal margin of the deepithelized pedicle flap and back through the base of the tunnel in order to invert the deepithelized pedicle beneath the labial marginal gingiva. A knot is tied to secure the rolled pedicle flap beneath the labial pouch and can be verified by slight blanching of the area. The patient is instructed to avoid mechanical trauma to the area for the next couple of weeks and to use only a chlorhexidine rinse while the deepithelized pedicle flap heals. As in all implant cases, the construction of a well-contoured restoration is critical to the maintenance of a desirable soft tissue profile and an acceptable esthetic outcome.

Other minimally invasive techniques for contour augmentation are also available. One such example is the use of a buccal "envelope" technique for sliding a connective tissue graft on the labial aspect of the implant, as was originally described by Raetzke for use around teeth with mucogingival defects [32]. In this technique, sharp dissection is employed to produce a partial-thickness "envelope" flap that extends beyond the mucogingival junction on the facial of the implant [33]. Subsequently, a SCTG is procured and slid in the buccal envelope at the implant site. Lastly, sling sutures are utilized to secure the graft and coronally advance the flap [33]. Eghbali et al. have shown that a mean increase of 0.8 mm of mucosal thickness can be achieved with the use of this technique, whose increase is stable for at least 9 months after surgery. Therefore this procedure could be also considered in cases where minor buccal contour enhancement is indicated [33].

9. Conclusions

Implant dentistry has been established as a predictable treatment modality with high clinical success rates. Esthetic considerations for implant restorations and the role of surgical procedures in the creation and maintenance of peri-implant soft tissue have been gaining interest over the years. Clinicians who practice implant dentistry should attain more than just implant osseointegration to achieve an esthetic, successful outcome. Knowledge of the variety of techniques available and proper planning enable clinicians to meet patients' increasing esthetic demands. However, the need for soft tissue augmentation procedures around dental implants in the anterior esthetic zone remains a controversial topic and lacks support from the literature. Long-term clinical trials are needed for better assessment of these surgical procedures.

Conflict of Interests

All of the authors declare that they have no conflict of interests regarding this paper.

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