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Translating Knowledge Into Practical Therapy

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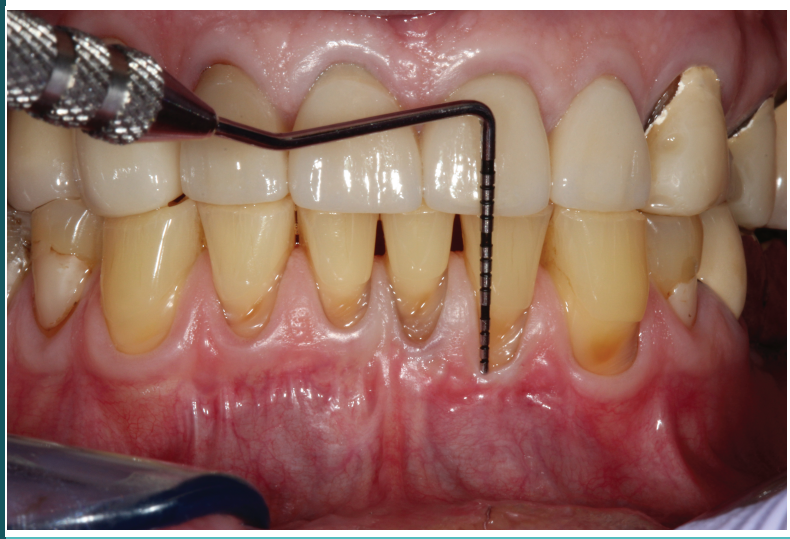

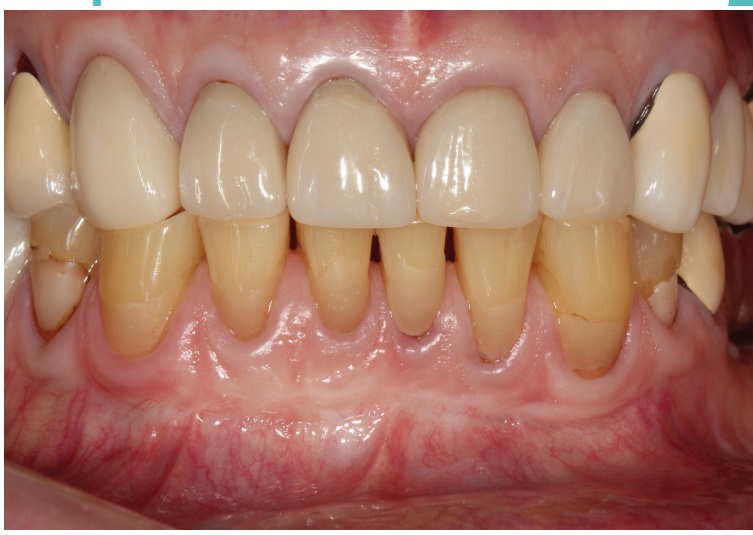

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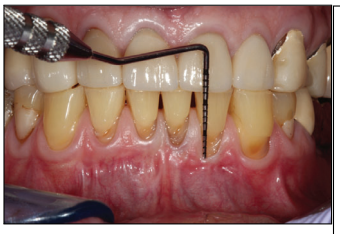
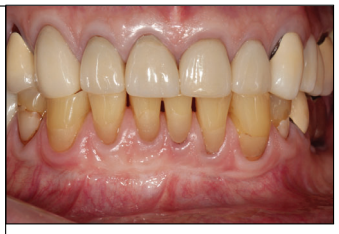


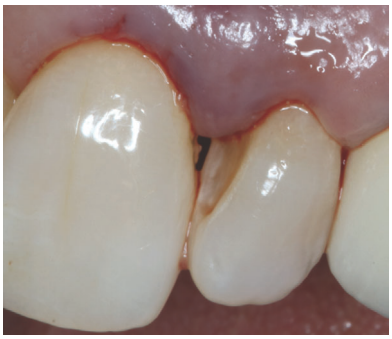
ON THE COVER:
Preoperative view of mandibular incisors with inadequate zone of keratinized mucosa (KM), shallow vestibule, and aberrant frenum attachments (left). 4.5 years postoperative showing stable gingival margins with adequate width of KM, and tissue esthetics (right).
(Ghadri et al.)

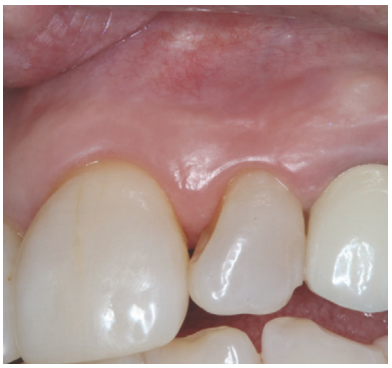


CLINICAL DECISION MAKING

Subperiosteal Papilla Augmentation With a Non–Animal-Derived Hyaluronic Acid Overlay Technique

Stephen J. Spano,[*] Romanita Ghilzon,[*] David K. Lam,[†] Michael B. Goldberg[*‡] and Howard C. Tenenbaum[*‡§‖]





Introduction: Loss of the interdental papilla, leading to the formation of black triangular spaces just below the contact area of adjacent teeth, is one of the most challenging periodontal conditions to treat and often requires an interdisciplinary approach by the periodontist, restorative dentist, and orthodontist. Although these "black triangles" may appear quite small from a clinician's standpoint, they can have a significant impact on oral health satisfaction for patients. This case series illustrates a novel minimally invasive approach to restore interdental papilla deficiencies.

Case Presentation: Four interdental papilla defects were treated in three females. No patients were lost to follow-up over 6 months. The surgery consisted of a horizontal incision placed apical to the area of papillary loss in the alveolar mucosa just beyond the mucogingival junction. An interdental subperiosteal tissue space was then created by tunneling toward and under the dental papilla. Once adequate release was achieved, dermal filler was administered into and underneath the deficient papilla. The papillary margins were then sealed with cyanoacrylate and additional dermal filler was injected as needed to achieve ideal papillary fill. Six months after treatment there was an improvement in patient-satisfaction regarding papilla fill demonstrated by a mean increase in visual analogue scale (VAS) measurements of 62.46%. Mean papilla fill was 1.75 mm.

Conclusion: This surgical technique demonstrates the restoration of deficient interdental papillae between teeth and implants, and perhaps as importantly, a considerable improvement in patient-based outcomes quantified through VASs. *Clin Adv Periodontics* 2020;10:4–9.

Key Words: Dental papilla; dermal fillers; hyaluronic acid; reconstructive surgical procedures; visual analog scale.

Background

"Black triangles" associated with papilla defects are a significantly displeasing aesthetic factor for patients, ranked only behind visible caries or exposed crown margins.[1] More than 90% of patients show interdental papillae when smiling and almost half of patients have papillary recession.[2,3] The interdental papillae surrounding >60% of implant-supported crowns lack complete fill.[4,5] Loss of interdental papilla can also lead to caries, food or plaque accumulation, and altered word pronunciation.[2–4] Thus, interdental papillary loss is not strictly an aesthetic issue. Yet, no predictable treatment is available.[4,6] The aim of this clinical trial was to develop a novel and minimally invasive surgery to reconstruct lost interdental papillae using a hyaluronic acid (HA) dermal filler. HA derivatives are biodegradable fillers composed of a natural glycosaminoglycan called HA found in human skin. The

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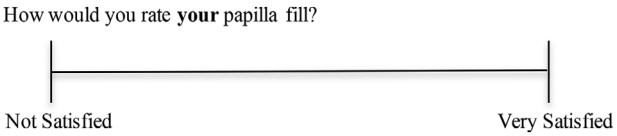

FIGURE 1 The visual analog scale assessment used for patient-based outcomes based on preoperative and postoperative clinical photographs of the deficient interdental papilla. These were continuous 100 mm scales anchored by particular descriptors that are considered to be opposites of one another. Patients were instructed on how to use these scales, allowing us to quantify subjective parameters involving patient perceptions.

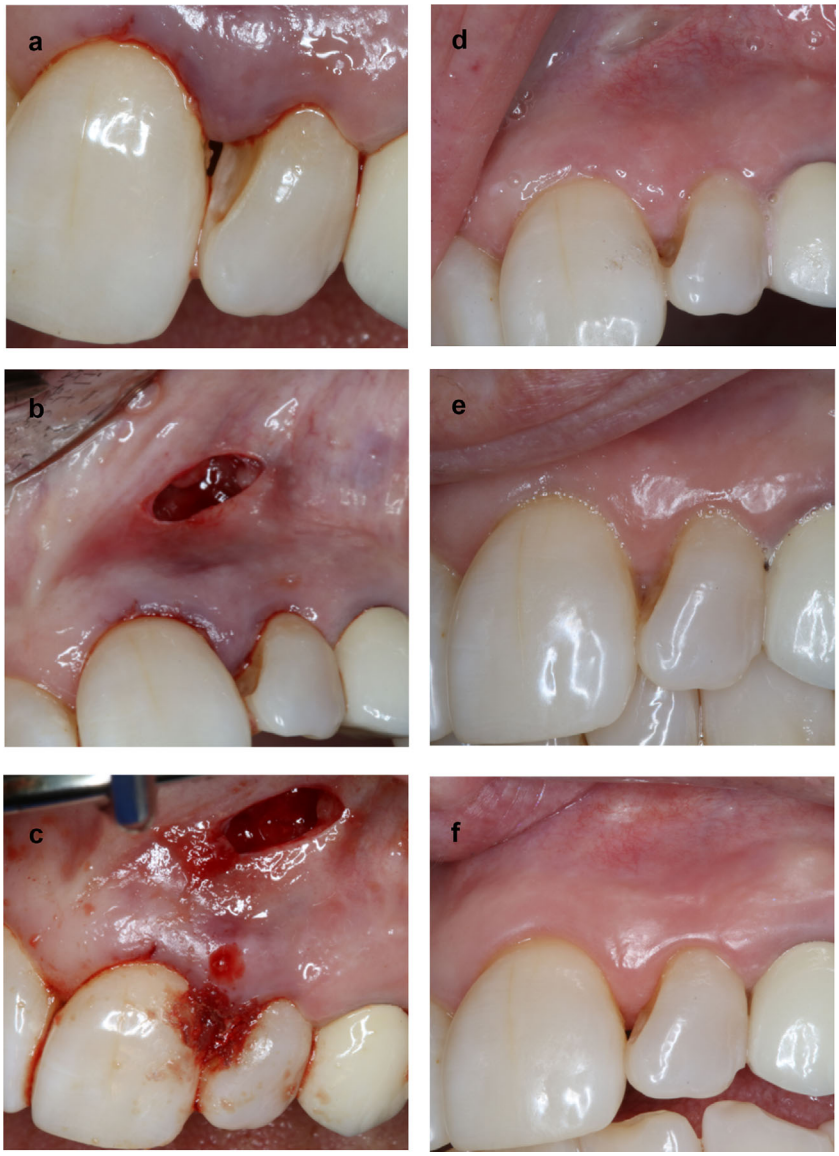

FIGURE 2 Treatment of a papillary defect between teeth 9 and 10 (Case 1). **2a** Preoperative presentation of a 3 mm papilla defect. **2b** A horizontal incision is made in the alveolar mucosa above the deficient papilla. Through the horizontal access incision, a subperiosteal tissue space is made by tunneling toward and under the deficient papilla while leaving the interdental and marginal tissue intact. **2c** Hyaluronic acid (dermal filler) is administered into the deficient papilla and the tissue space underneath to achieve ideal papillary fill. Then cyanoacrylate is used to seal the free gingival margins surrounding the papilla and additional dermal filler was administered as needed. **2d** One-week postoperative healing. Note the complete papillary fill obtained between teeth 9 and 10 as well as the closure of the incision wound without the need for sutures. **2e** Six-week postoperative healing. **2f** Six-month postoperative healing.

dermal filler[¶] used in this study is cross-linked HA gel synthesized from *Streptococcus species* fermentation.[7]

Clinical Presentation

This clinical study received approval for scientific merit and ethics from the University of Toronto's Faculty of Dentistry and Research Ethics Board. Written consent was obtained for all patients for both the examination and surgery. All treatment was performed in the Graduate Periodontics Clinic at the Faculty of Dentistry, University of Toronto. Patients who presented were dissatisfied with their papillary esthetics and were screened and treated from December 2015 to November 2017. Individuals with clinical signs of active periodontitis or gingivitis were excluded. Patients were American Society of Anesthesiologists' physical status classification 1 or 2, not pregnant, and non-smokers.[8] Four maxillary interdental papilla deficiencies in three females (mean, 51.7 ± 12.7 years old) were selected for treatment. The distance from the deficient papilla tip to the base of the interdental contact point was measured with a UNC15 probe and classified using Nordland and Tarnow's classification system.[9] Patients also completed preoperative practice VAS measurements of subjective data. Once familiarized with VAS-based assessments, the patients' own papilla defect was displayed as a photograph and they were asked to rate the esthetics (**Figure 1**). This initial VAS score provided a presurgical assessment performed by the patient of their own papillary esthetics and a baseline for posttreatment comparisons. All measurements, photographs, VAS assessments and surgeries were performed by the same clinician (SS).

Case Management

After obtaining informed consent, local anesthetic was administered at the surgical site and scaling of the interdental space and adjacent teeth was performed with hand curettes (**Figs. 2 and 3**). A 3 to 5 mm horizontal incision was made with a 15C blade in the alveolar mucosa 2 mm apical to the mucogingival junction. A

[¶]Juvéderm, Allergan, Markham, Ontario, Canada.

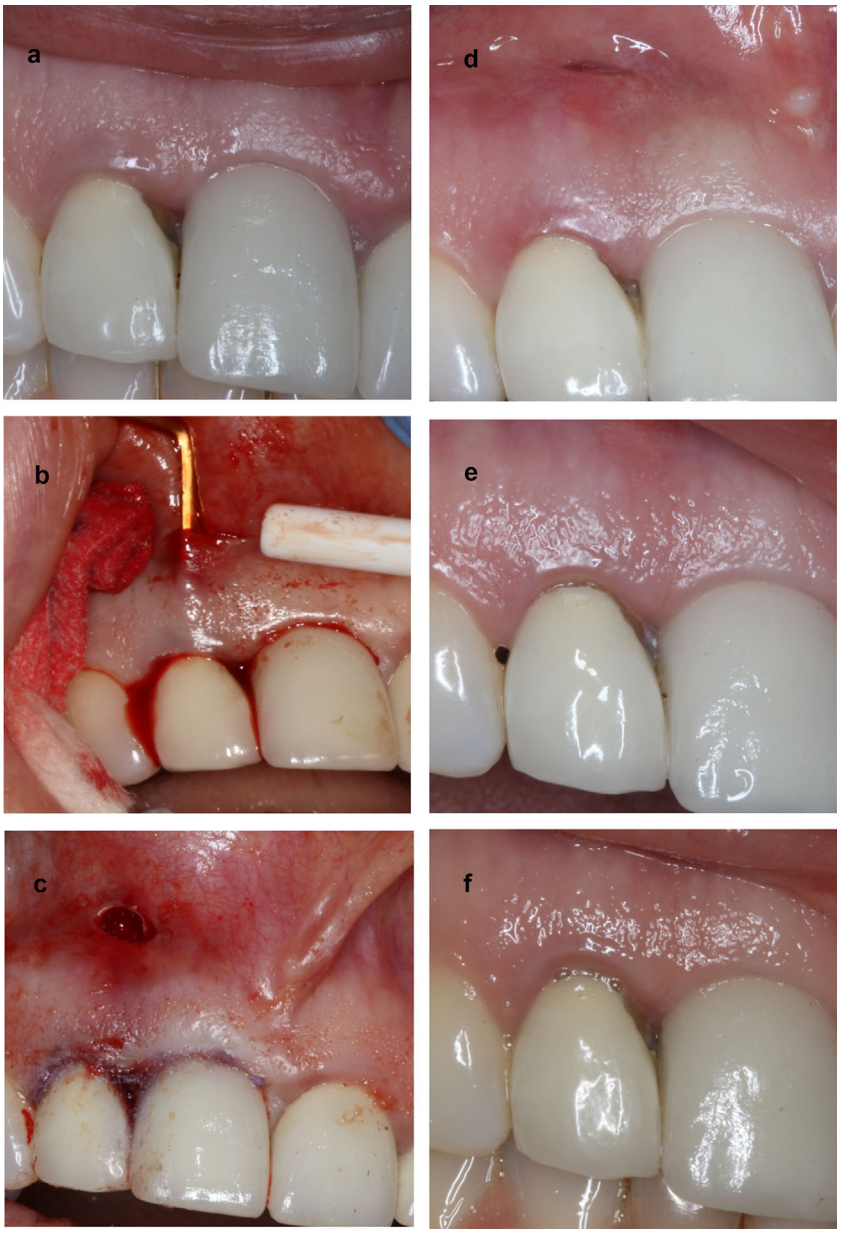

FIGURE 3 Treatment of a papillary defect between tooth 7 and the implant-supported crown at site 8 (Case 2). **3a** Preoperative presentation of a 4 mm papilla defect. **3b** A horizontal incision is made in the alveolar mucosa above the deficient papilla. Through the horizontal access incision, a subperiosteal tissue space is made by tunneling toward and under the deficient papilla while leaving the interdental and marginal tissue intact. **3c** Hyaluronic acid (dermal filler) is administered into the deficient papilla and the tissue space underneath to achieve ideal papillary fill. Then cyanoacrylate is used to seal the free gingival margins surrounding the papilla and additional dermal filler was administered as needed. **3d** One-week postoperative healing. Note the substantial papillary fill obtained and closure of the incision wound without the need for sutures. **3e** Six-week postoperative healing. **3f** Six-month postoperative healing.

subperiosteal tunnel was created through this access incision toward and under the deficient interdental papilla with an end-cutting intrasulcular knife. Dermal filler (HA)* was administered with a 27-gauge needle into the deficient papilla and subperiosteal tissue space. Cyanoacrylate[#] was then used to seal the free gingival margins surrounding the papilla. Subsequently, additional dermal filler was administered for a total of 0.2 to 0.6 mL per papilla. No sutures were placed. Postoperative instructions were reviewed. The patient was prescribed 0.12% chlorhexidine mouth rinse and instructed to take ibuprofen as needed.

[#]Histoacryl, B. Braun of Canada, Mississauga, Ontario, Canada.

Clinical Outcomes

Four papilla defects were treated and no patients were lost to follow-up. At 6 months, there was a mean papilla fill of 1.75 mm (**Table 1 and Figs. 2 through 5**). The VAS used to assess treatment success was the preoperative and postoperative response to the question: "How would you rate your papilla fill?" (**Table 2 and Figure 1**). There was a mean 59.76% and 62.46% improvement in patients' perceptions of papilla fill when comparing preoperative versus postoperative VAS scores of interdental papillary appearance at 6 weeks and 6 months after treatment, respectively.

Discussion

To the best of our knowledge, this is the first clinical study evaluating a subperiosteal papilla augmentation technique with this material. The substantial improvement in patient satisfaction relating to their papilla appearance after treatment correlates well with quantitative postoperative measurements of papilla fill, suggesting VASs measuring subjective outcomes may be reliable assessments of treatment success.[10] As the main concern of these patients is papillary esthetics, quantifying their subjective assessments of improvement and satisfaction is centrally important.

The amount of papilla fill achieved with our technique appears superior to other studies. Through the simple injection of dermal filler into papillae, Becker et al.[11] showed "modest" improvements in papillary fill. Similarly, Awartani and Tatakis[12] treated Tarnow class 1 and 2 papillae and reported a mean 6-month increase in papillary fill of 0.5 mm. In comparison, the average amount of papilla fill obtained in our investigation was 1.75 mm; more than a three-fold improvement obtained regardless if the papilla defect

TABLE 1 **Papilla defect at baseline, 6 weeks after treatment, and 6 months after treatment measured with a UNC15 periodontal probe from the tip of the papilla directly to the base of the interdental contact point**

Case	Papilla between teeth	Papilla defect pretreatment (mm)	Papilla defect 6 weeks posttreatment (mm)	Papilla defect 6 months posttreatment (mm)
01*	9/10	3	1	1
02†	7/8§	4	1.5	2
03‡	9/10	5.5	4	3.5
04*	8/9	2	1	1
Mean papilla fill and standard deviation			1.75 mm ± 0.65 mm	1.75 mm ± 0.5 mm

*Tarnow class 1 defect.
†Tarnow class 2 defect.
‡Tarnow class 3 defect.[9]
§Implant-supported crown.

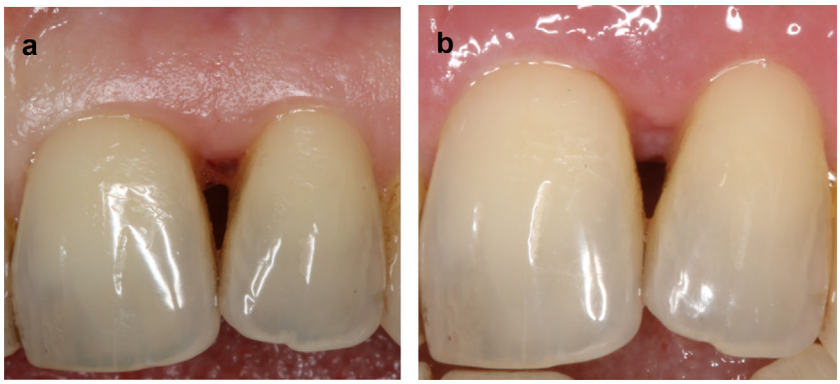

FIGURE 4 Treatment of a papillary defect between teeth 9 and 10 (Case 3). **4a** Preoperative presentation of a 5.5 mm papilla defect. **4b** One-week postoperative healing.

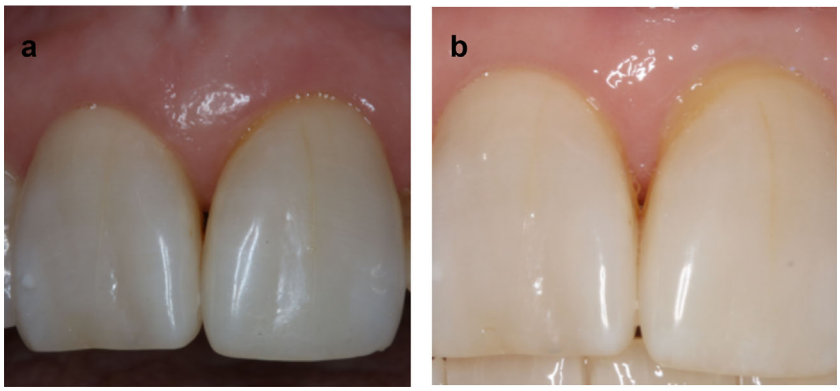

FIGURE 5 Treatment of a papillary defect between teeth 8 and 9 (Case 4). **5a** Preoperative presentation of a 2 mm papilla defect. **6b** Six-month postoperative healing.

was adjacent to a tooth or a dental implant. Considering the differences in gingival composition and attachment around teeth and dental implants, we believe this result re-emphasizes the effectiveness of our technique.

When HA is "merely" injected into deficient papillae, a randomized controlled trial showed no significant improvements in papilla fill compared to control (saline) injections.[13] Detaching the gingiva by tunneling, as was done in our technique, creates a subperiosteal space that could provide for more mobilization of the papilla before injection. Previous studies have relied on the ability of HA to absorb water over time along with the use of up to five separate injections to obtain meaningful papilla expansion.[11–14] By using our approach, papilla fill was obtained in one surgical appointment. The addition of cyanoacrylate also sealed the free gingival margins preventing any "leakage" during dermal filler injection.

Long-term stability of papillary fill is unknown. However, papilla augmentation with direct injection of HA has demonstrated stability 2 years postoperatively.[11] Further, HA may impact collagen remodeling by increasing the production of procollagens 1 and 3 as well as modulating of matrix metalloproteinase-1 secretion by fibroblasts.[15] Thus, we hope that in developing this novel surgical treatment, as well as our approach to evaluating treatment outcomes, we have laid the foundation for longer term, more comprehensive and randomized clinical trials, to improve our ability to treat interdental gingival problems.

Conclusion

An interdental subperiosteal tissue space created by tunneling toward and under the interdental papilla followed by the placement of a non-animal-derived HA dermal filler to restore interdental papilla deficiencies demonstrates clinical improvements in papilla fill and substantial improvements in patient satisfaction.■

TABLE 2 Visual analog scale (VAS) scores at baseline as well as 6 weeks and 6 months after treatment

Case	Pretreatment: How would you rate your papilla fill?	6 weeks posttreatment: How would you rate your papilla fill?	6 months posttreatment: How would you rate your papilla fill?	ΔVAS scores 6 weeks after treatment	ΔVAS scores 6 months after treatment
01*	6.93%	59.41%	83.16%	52.48%	76.23%
02†	0%	60.4%	52.41%	60.4%	52.41%
03‡	10.78%	74.26%	60.4%	63.48%	49.62%
04*	28.43%	91.09%	100%	62.66%	71.57%
Mean VAS scores and standard deviation	11.54% ± 12.11%	71.29% ± 14.84%	73.99% ± 21.69%	59.76% ± 5.02%	62.46% ± 13.40%

*Tarnow class 1 defect.
†Tarnow class 2 defect.
‡Tarnow class 3 defect.[9]

Summary

Why are these cases new information?

- This clinical case series presents a novel, minimally invasive surgical technique that uses a non–animal-derived HA dermal filler to restore interdental papilla deficiencies.
- Substantial improvements in both clinical and patient-reported outcomes were obtained.
- Demonstrates the value of considering patient-reported outcomes when determining treatment success.

What are the keys to successful management of these cases?

- Correct diagnosis of papilla deficiencies (e.g., Tarnow class 1 papilla defects showed the most favorable response).
- Absence of active periodontal disease at initial consultation.
- Following a very technique sensitive and minimally invasive surgical protocol.

What are the primary limitations to success in these cases?

- The extent of subperiosteal tissue space that can be created to receive the dermal filler.
- Unknown long-term stability and variability in treatment response. This technique requires more comprehensive clinical trials to study and improve on the treatment approach.

Acknowledgments

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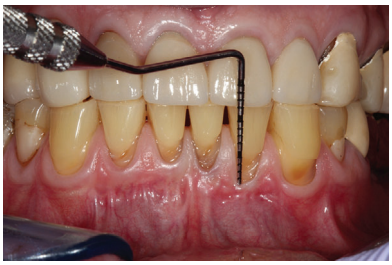
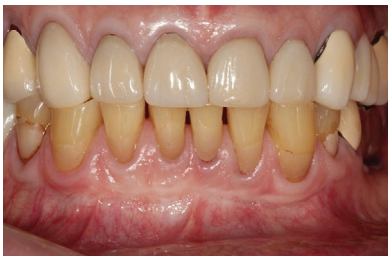
indicates key references.

Use of Collagen Matrix Scaffolds as a Substitute for Soft Tissue Augmentation: Case Series

Najib Ghadri,[*†] Rania Livada,[‡] Vrushali Abhyankar,[*] Les H. Binkley Jr.,[*] Paul S. Bland[*§] and Jacob Shiloah[*]





Introduction: The presence of keratinized mucosa (KM) around natural teeth is believed to be beneficial in certain restorative, prosthetic, and orthodontic situations. Lack of adequate KM is common and predictably treated by autogenous gingival grafts (AGGs); however, AGGs have the disadvantages of harvest site morbidity, limited donor site availability, and compromised esthetics.

Case Presentation: This case series presents the use of the xenogeneic porcine bilayer collagen matrix (BCM) in increasing the width of attached KM around natural teeth. Patients with a limited amount of KM, shallow vestibule, and aberrant frenum attachment were treated using this graft material. The patients were followed up to 4.5 years postoperatively and were evaluated regarding the amount of KM, gingival margin stability, and tissue esthetics.

Conclusions: Within the limitations of the sample size of patients in this report, the BCM appears to be a viable alternative option to AGG for increasing the width of KM gingiva around teeth. This method resulted in gain of KM, gingival margin stability, vestibular deepening, aberrant frenum elimination, and favorable esthetics in terms of color matching, texture, and contour blending. This xenogeneic graft material could be used in cases where the autogenous graft supply is limited or in highly esthetically demanding cases. Additionally, it could be an alternative option when a second surgical site is not desired by the patient or a less invasive procedure is preferred by the clinician in certain medical conditions. Well-controlled long-term studies are required to validate our limited clinical observations. *Clin Adv Periodontics* 2020;10:10–15.

Key Words: Collagen matrix; gingiva; gingival recession; grafts.

Background

The presence of adequate zone of attached gingiva has been historically considered superior to areas lacking it.[1] The attached gingiva plays an important role in maintaining the periodontium in health.[1] It provides a physical barrier to bacterial biofilm, dissipates masticatory forces, and protects the periodontium from injury,[2] mitigates forces from frenum pull[3] and maintains the vestibular depth. Therefore, it provides a better environment for home care and plaque control measures,[4] prevents gingival recession, unesthetic root exposures, and root caries.[5]

The autogenous gingival grafts (AGGs) obtained from the palate and adapted to the recipient site have long been recommended to increase the zone of attached gingiva.[6] While this procedure provides predictable clinical outcomes, it is frequently associated with some limitations and complications; such as limited quantity of donor tissue, patient discomfort, postoperative bleeding, and compromised esthetics. An alternative to AGG, is the use of a xenogeneic porcine bilayer collagen matrix (BCM)[‖] which has been used in the last decade[7,8] and continues to provide promising results around teeth and dental implants.[9,10]

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[‖]Geistlich Mucograft, Geistlich Pharma, Wolhusen, Switzerland.

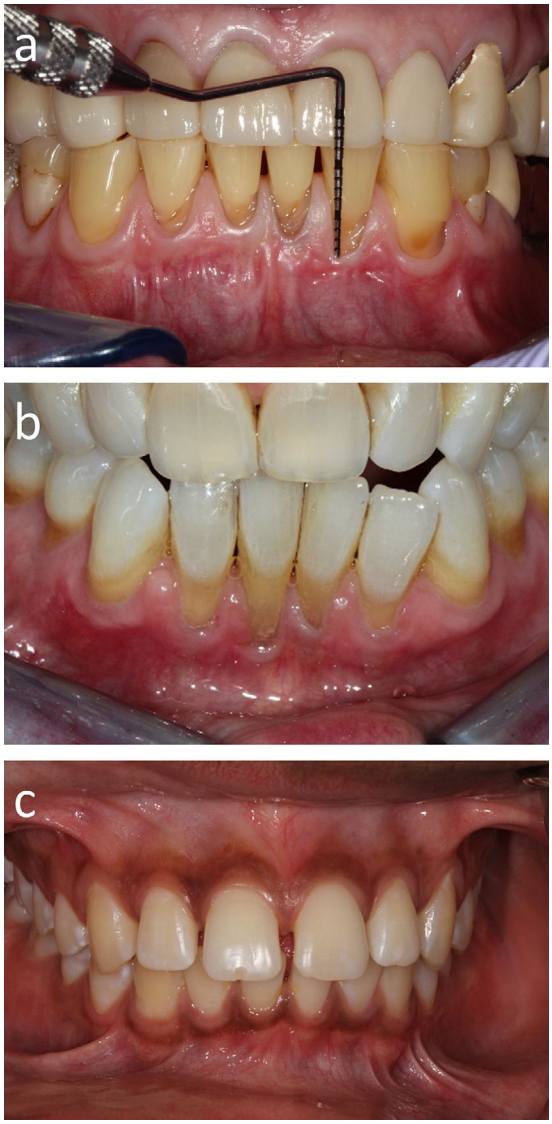


FIGURE 1 Preoperative view of the facial aspect of the involved teeth. Note the inadequate zone of keratinized mucosa, shallow vestibule, and aberrant frenum attachment. **1a** Case 1: Mandibular incisors present with non-carious cervical lesions. **1b** Case 2: Mandibular incisors present with gingival recession. **1c** Case 3: Canines and incisors present with anterior spacing.

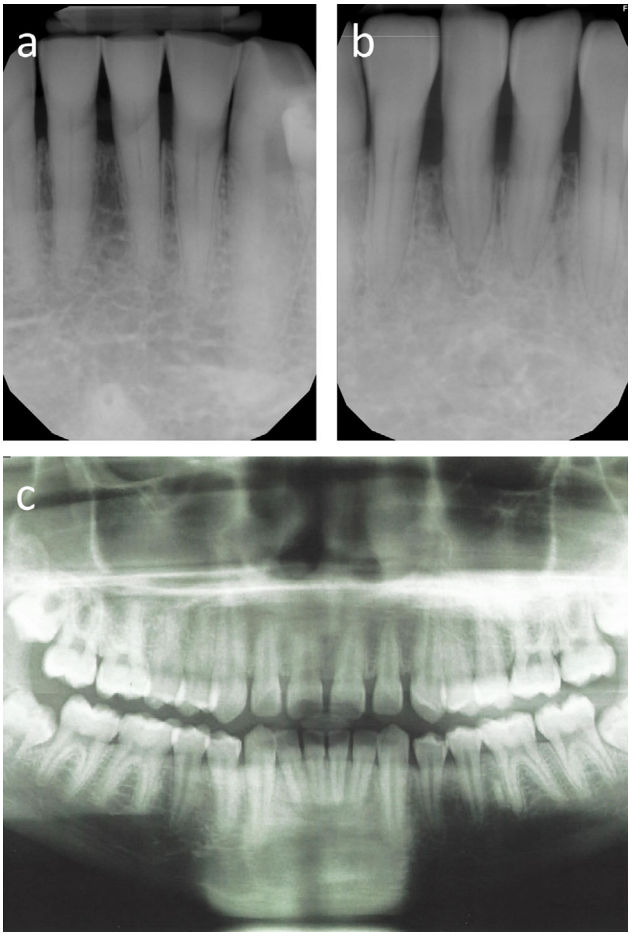


FIGURE 3 Preoperative periapical and panoramic radiographs: **3a** Case 1. **3b** Case 2. **3c** Case 3.

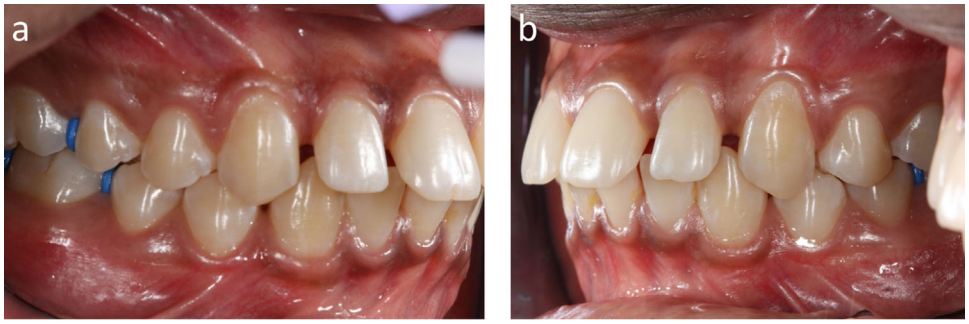


FIGURE 2 Preoperative facial views of the canines in case 3. **2a** Right side. **2b** Left side.

BCM is composed of pure Type I and III collagen that is ≈3.0-mm thick obtained with standardized, controlled manufacturing processes without cross-linking or chemical treatment.[11] The matrix consists of two layers; a cell occlusive layer consisting of collagen fibers in a compact arrangement that is placed facing the oral cavity and allows suturing and graft protection in open healing situations, and a thick porous spongy layer that favors the formation of a blood clot and the ingrowth of tissue from adjacent sites.[11] The BCM grafts act as a scaffold to allow ingrowth and repopulation of fibroblasts, blood vessels, and epithelium from the surrounding tissues and eventually transform into keratinized tissue. When Schmitt et al.[12] compared free gingival grafts and BCM obtained biopsies for histologic analyses, comparable healing was noted with the presence of specific keratinized tissue markers in the collagen matrix grafted areas. The aim of this case series is to present a long-term follow-up of the use of BCM around natural teeth and discuss its advantages and limitations.

Clinical Presentation

Three patients (two males and one female) aged 16 to 67 years underwent mucogingival surgeries using BCM

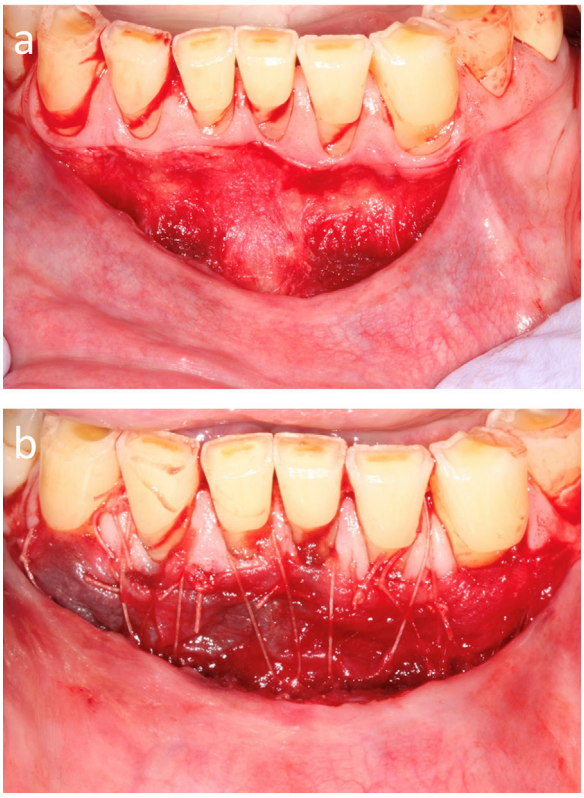


FIGURE 4 Intraoperative surgical photos of case 1. **4a** Partial thickness flap was reflected. **4b** BCM graft was tailored to site and secured with simple interrupted and vertical periosteal 4/0 Vicryl sutures. Note the overlap area between the trimmed BCM graft pieces on the facial mesial line angle of #26.

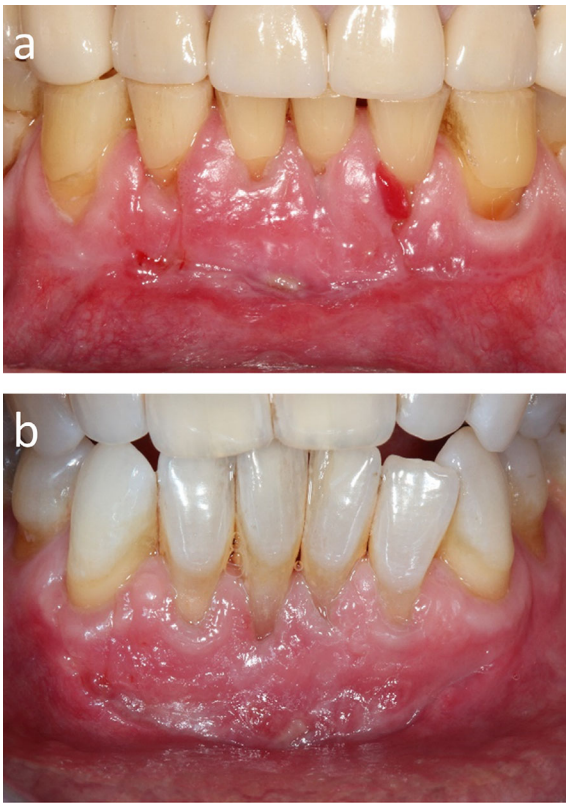


FIGURE 5 Initial postoperative clinical appearance (facial view). Week 3: Wide zone of augmented soft tissue, deepening of the vestibule, and elimination of the frenum attachment. **5a** Case 1. Note the line of gingival tissues at the facial mesial line angle of #26 that is consistent with the aforementioned overlap area between the trimmed BCM graft pieces. **5b** Case 2.

at the Graduate Periodontal Clinic at the University of Tennessee between March and August 2014. Both verbal and written informed consent forms were obtained from all patients. They all presented with a narrow zone of keratinized gingiva, high frenum attachment, and reduced vestibule (Figs. 1 and 2). Additionally, shallow probing depths were noted along with gingival recessions (Figs. 1a and 1b). Horizontal bone loss was present interproximally in cases 1 and 2 (Figs. 3a and 3b), while no evidence of bone loss was noted radiographically in case 3 (Fig. 3c). Before the surgeries, customized oral hygiene instructions were given as well as different alternative treatment options were discussed (non-surgical periodontal treatment only or use of autogenous graft). Following periodontal healing, restorative (case 1) and orthodontic treatment (case 3) was completed.

Case Management

Following administration of local anesthesia, supragingival scaling of the treated teeth was performed. Horizontal incisions were performed at the mucogingival junction and a partial thickness flap was reflected (Fig. 4a). BCM was trimmed to fit the area and care was taken not to crush or compress its matrix structure. It was placed dry (not pre-wet), and blood was allowed to soak into the matrix to form an initial, stable clot. It was sutured in a

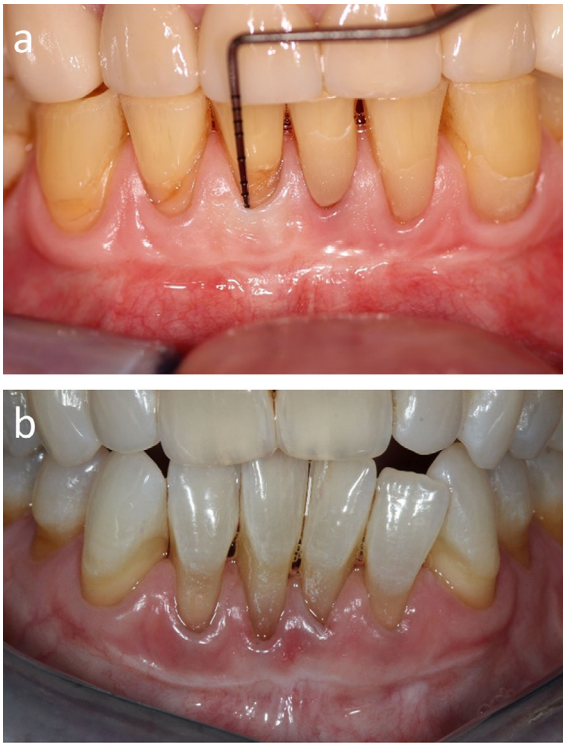


FIGURE 6 Early postoperative clinical appearance (facial view). Favorable graft color matching, texture, and contour blending. Shrinkage of augmented soft tissue. **6a** Case 1. Month 5: Note restoration of non-carious cervical lesions on #22, #23, and #24. **6b** Case 2. Month 10.

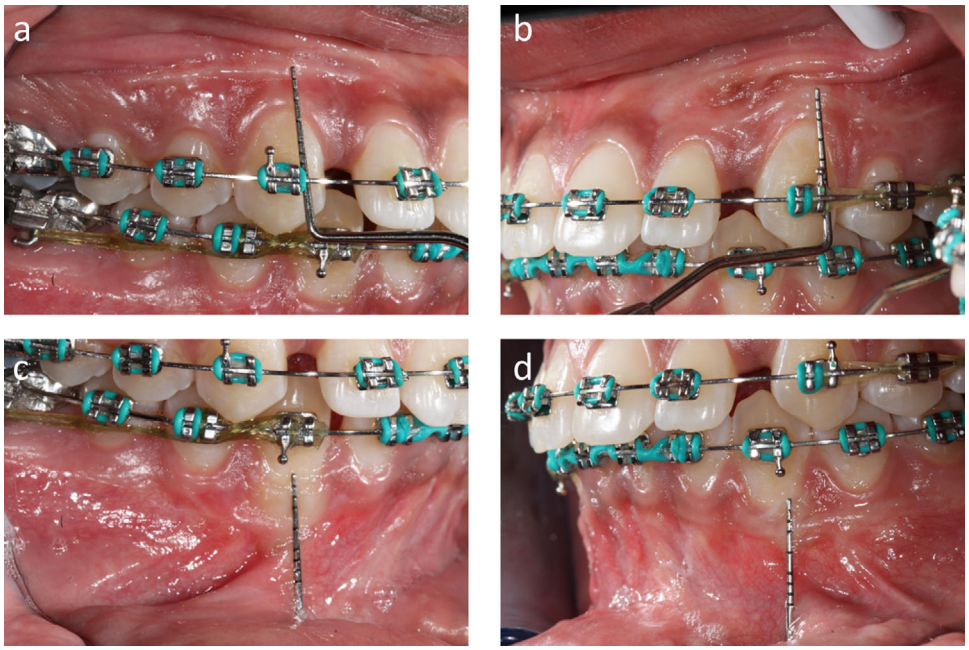


FIGURE 7 Early postoperative lateral views of case 3. **7a** Seven months for the upper right. **7b** Six months for the upper left. **7c** Six months for the lower right. **7d** Two months for the lower right site lower left. Patient is receiving orthodontic treatment.

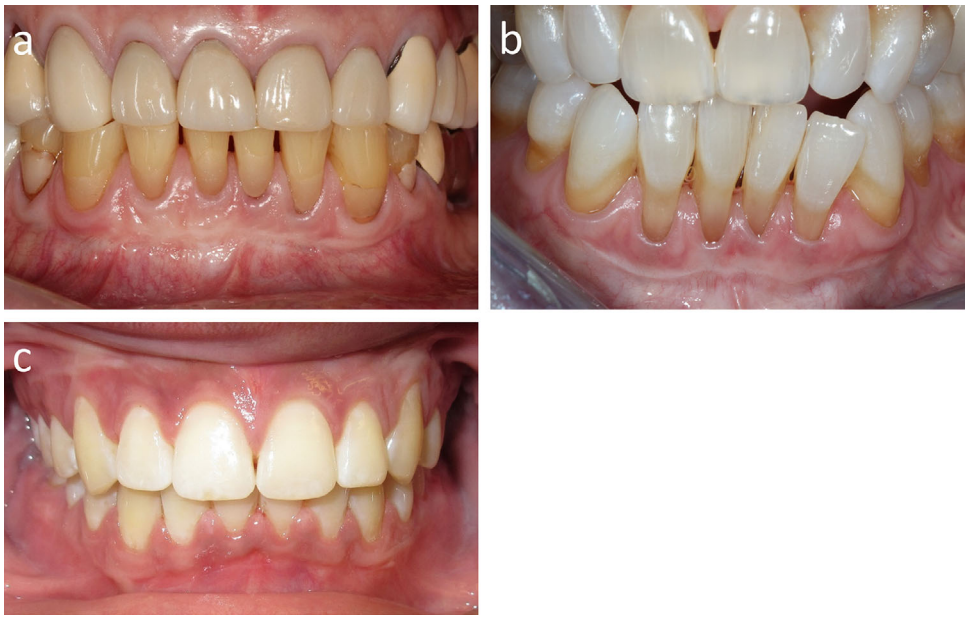


FIGURE 8 Long-term postoperative clinical appearance (facial view). Stability of the gingival margin with adequate width of keratinized mucosa. **8a** Case 1: Year 4.5. Non-carious cervical lesions are completely restored. **8b** Case 2: Year 4 and month 2. **8c** Case 3: Year 1 and 9 months for the upper right site, year 1 and 8 months for the upper and lower left sites, and year 1 and 3 months for the lower right site. Patient completed orthodontic treatment.

tension-free manner to the surrounding tissue with interrupted and vertical periosteal Vicryl 4-0 sutures (Fig. 4b). The sites were covered with periodontal dressing for the first week. Systemic antibiotics were prescribed in cases 2 and 3. Patients were instructed to use chlorhexidine (0.12%) mouth rinse for 30 seconds twice daily and to avoid aggressive rinsing for the first 4 weeks. Patients were also instructed not to brush the grafted area for the first 2 weeks and to avoid disruptive foods for the first month following surgery. After 2 weeks, patients were instructed in a brushing technique creating minimal trauma to the soft tissue of the treated teeth. At 4 weeks, patients resumed normal toothbrushing.

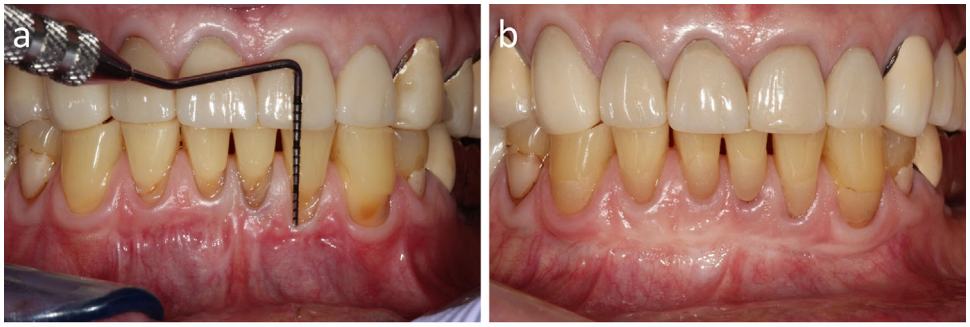
Clinical Outcomes

Healing in all cases was uneventful and without complications. During the initial follow-up appointments, new soft tissue formation at the facial aspect was noted as well as increased vestibular depth and elimination of the frenum attachment (Fig. 5). The noted increase in the width of keratinized mucosa (KM) and favorable blend of tissue color and texture were significant during the later follow-ups (Figs. 6 and 7). Although some post-surgical shrinkage was noted during the early follow-ups (Figs. 6 and 7), adequate width of KM was maintained at 1.25- to 4.5-year time point postoperatively (Fig. 8). Baseline and long-term postoperative appearance and chartings are presented in Figures 9 through 11.

Discussion

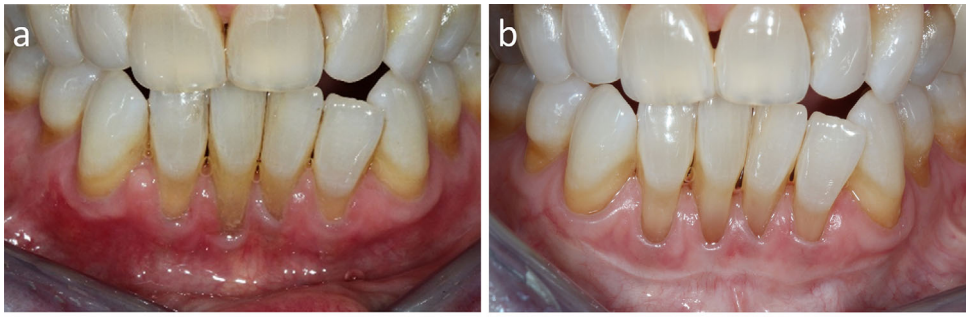
In this case series, xenogeneic porcine BCM grafts were utilized to increase the KM around natural teeth. A wider zone of KM as well as deepening of the vestibule and elimination of the frenum attachment were obtained. The overall integration of the graft with the surrounding tissues was favorable in terms of color matching, texture, and contour blending. This confirms previously published reports of using BCM around natural teeth[7–9,13] and dental implants.[10,14,15]

The main concern in using BCM is the amount of postoperative volume shrinkage. Maiorana et al.[14] observed tissue shrinkage at a percentage of 37% at 6 months, 48% after 1 year, and 59% after 5 years, while Sanz et al.[7] reported a 67% of shrinkage at 6 months postoperatively.



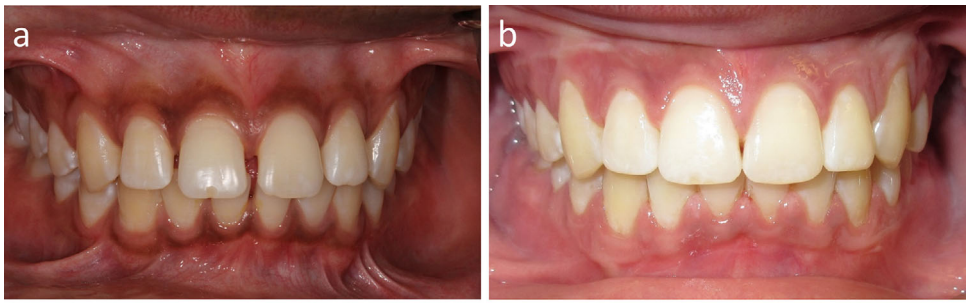
Baseline Presentation					4.5-Year Postoperative Presentation				
Tooth #	26 (mm)	25 (mm)	24 (mm)	23 (mm)	Tooth #	26 (mm)	25 (mm)	24 (mm)	23 (mm)
GR	3	3	4	5	GR	3	3	4	5
KM	2	2	0	1	KM	4	5	4	3

FIGURE 9 Case 1. Clinical appearance and parameters. **9a** Baseline. **9b** 4.5-years postoperatively. GR = deepest facial gingival recession; KM = apicocoronal width of keratinized mucosa.



Baseline Presentation					4-Year Postoperative Presentation				
Tooth #	26 (mm)	25 (mm)	24 (mm)	23 (mm)	Tooth #	26 (mm)	25 (mm)	24 (mm)	23 (mm)
GR	4	6	5	3	GR	6	6	5	3
KM	2	1	1	1	KM	4	3	4	4

FIGURE 10 Case 2. Clinical appearance and parameters. **10a** Baseline. **10b** 4-years postoperatively. GR = deepest facial gingival recession; KM = apicocoronal width of keratinized mucosa.



Baseline Presentation					1.25-1.75-Year Postoperative Presentation				
Tooth #	6 (mm)	11 (mm)	27 (mm)	22 (mm)	Tooth #	6 (mm)	11 (mm)	27 (mm)	22 (mm)
GR	0	0	0	0	GR	0	1	0	0
KM	2	1	2	2	KM	4	3	3	3

FIGURE 11 Case 3. Clinical appearance and parameters. **11a** Baseline. **11b** 1.25- to 1.75-years postoperatively. GR = deepest facial gingival recession; KM = apicocoronal width of keratinized mucosa.

However, when compared with the gold standard (AGG), the post-surgical tissue loss was comparable (60% shrinkage for the AGG and 67% for the BCM[7] and 40.65% for the AGG versus BCM group of 52.89%).[15] In our cases, the collagen grafts exhibited postoperative shrinkage of almost half the width that was gained initially. However, the gingival margin position remained stable and the final width of KM was adequate in all cases.

Conclusions

Within the limitations of the small number of patients, the BCM appears to be a viable alternative option to AGGs for increasing the width of attached KM around teeth with good esthetic results and patient acceptance while eliminating the need for a second surgical site in the palate. However, further long-term controlled, randomized, multi-centered studies are needed to confirm our observations.■

Summary

Why are these cases new information?	■ Although previous studies used BCM to extend the vestibule around dental implants with long-term follow-up (5 years),[14,15] only short-term results have been published using BCM around natural teeth.[7–9] To the best of the authors' knowledge, this case series provides a long-term follow-up (4.5 years) of the results achieved with this material around natural teeth.
What are the keys to successful management of these cases?	■ The key to successful management of these cases is to secure the matrix with intimate contact at the recipient site to limit micromovements or formation of voids underneath the graft.
What are the primary limitations to success in these cases?	■ The primary limitation to success in these cases is the postoperative shrinkage and subsequent reduction of the width of the augmented keratinized mucosa.

Acknowledgment

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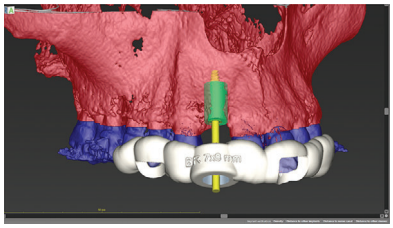
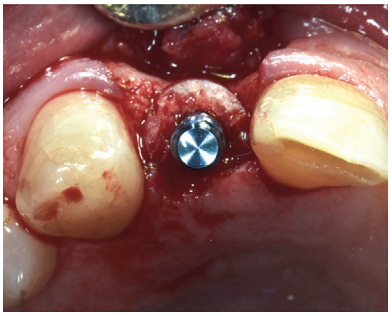
indicates key references.

Computer-Guided Surgery Using Human Allogenic Bone Ring With Simultaneous Implant Placement: A Case Report

Kerri Thomas Simpson,* Matthew Bryington,† Michele Agusto,* Matthew Harper,† Arif Salman* and Gian Pietro Schincaglia*‡





Introduction: The allogenic bone ring technique allows for horizontal and vertical bone augmentation with simultaneous implant placement in severely compromised sites. The aim of this report is to present a modified protocol for simultaneous placement of implant and allogenic bone ring graft using a computer-guided surgery technique.

Case Presentation: Patient's chief complaint was to replace a missing lateral incisor. The implant site presented both vertical and horizontal tissue deficiencies. Study models and wax-ups were digitally scanned to stl files and merged with the existing CBCT data in the implant planning software. A 3D representation of an allogenic bone ring was developed, and two digitally designed guides were created: a 5 mm sleeve guide for the implant site and a 7 mm sleeve guide for the allogenic bone ring trephine. Both the implant site and the allogenic bone ring recipient site were prepared using the computer-generated guides. Once the ring was adapted into the recipient site, the implant was inserted through the allogenic bone ring. The healing was monitored and the implant was restored at 12 months. The accuracy of implant placement was measured and the difference in the final positioning was as follows: 0.6 mm at entry point, 0.55 mm vertical displacement, 1.94 mm at the apex, and angle discrepancy 6.1°.

Conclusion: The use of computer-guided technology for planning and placement of an allograft bone block with simultaneous implant insertion allows for a prosthetically driven team approach to compromised site grafting in addition to improving precision and accuracy when compared with non-guided techniques. *Clin Adv Periodontics* 2020;10:16–22.

Key Words: Bone graft(s); implantology; ridge augmentation.

Background

When dealing with an area of prior extraction, previously published classifications discuss the parameters to be considered before implant placement.[1] Edentulous sites that present with bone thickness >3 mm and adequate vertical height (Types I-III) can have an implant placed without bone augmentation, or augmentation that is concomitantly performed at implant placement. However, in sites with ⩽3 mm bone thickness with vertical bone deficiency, the horizontal and/or vertical bone has been altered to the point that implant placement may not be performed, and a staged approach is recommended. Several surgical techniques have been described for augmenting the vertical and horizontal dimension of the implant site including bone grafts, osseous distractions, segmental ostectomy, and guided bone regeneration.[2–6]

The allogenic bone ring[§] is a prefabricated hollow cylinder of human cancellous bone. The external dimensions of the ring are 10 mm in height, 7 mm in width, whereas the internal dimension of the hollow space is available with a diameter of 3.3 or 4.1 mm. The allogenic bone ring technique allows for horizontal and vertical bone augmentation with simultaneous implant placement.[7] The

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This article was modified on 2 April 2020, after first online publication: The article title was changed on page 16 ("allograft ring technique" was replaced with "human allogenic bone ring"). A second affiliation (Department of Implantology, University of Ferrara, Ferrara, Italy) was added for Gian Pietro Schincaglia on page 16. The term "allograft ring" was replaced with "allogenic bone ring" throughout the article on pages 16–21.

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§AlloGraft Ring, Straumann, Basel, Switzerland.

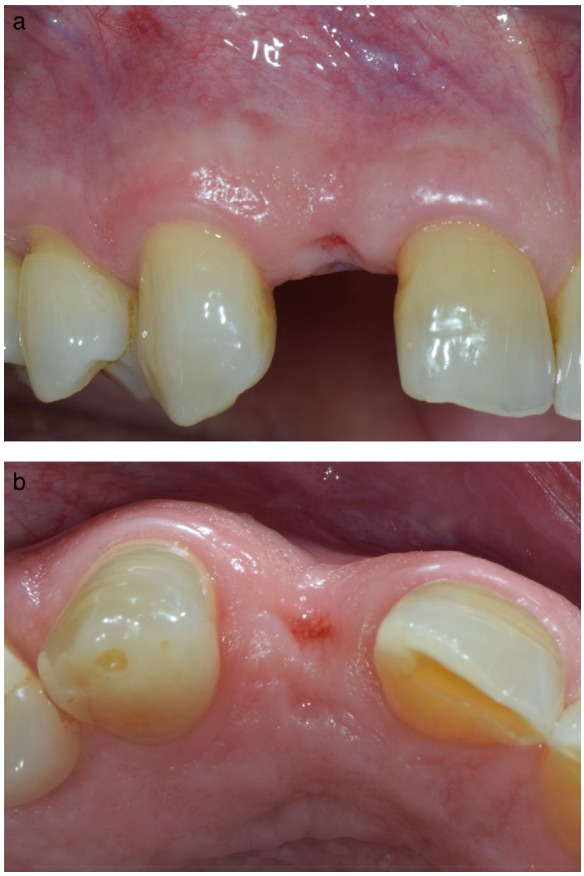

FIGURE 1 1a and 1b. Initial presentation, frontal and occlusal view of the edentulous site showing loss of vertical and horizontal soft and hard tissue dimension.

anatomical requirements for the use of the allogenic bone ring technique include a minimum width at the base of the ridge defect of at least 7 mm and an inter-radicular distance of 8 mm if the placement is planned between teeth. In addition, at least 3 mm of native bone must be available apical to the housing of the ring to stabilize the implant. One of the concerns by using this approach is to control the position of the ring in relation to the implant position during the preparation of the osteotomy. This becomes critical in the maxillary anterior area where the implant position dictates the esthetic outcome.[1,8] Computer-guided protocols have significantly improved accuracy of implant positioning.[9] The aim of this report is to present a modified protocol for simultaneous placement of implant and allogenic bone ring graft for three-dimensional (3D) ridge reconstruction using a computer-guided surgical technique.

Clinical Presentation

A 69-year-old, ASA II, male, non-smoker presented to WVU dental clinics in October 2017 with a chief complaint of wanting to replace his missing lateral incisor (#7) extracted 6 months prior due to vertical root fracture and recurring abscesses. Upon clinical and radiographic evaluation, patient was diagnosed with localized periodontitis, stage II, grade A and Siebert class 3 ridge defect at site #7 with both horizontal and vertical ridge volume

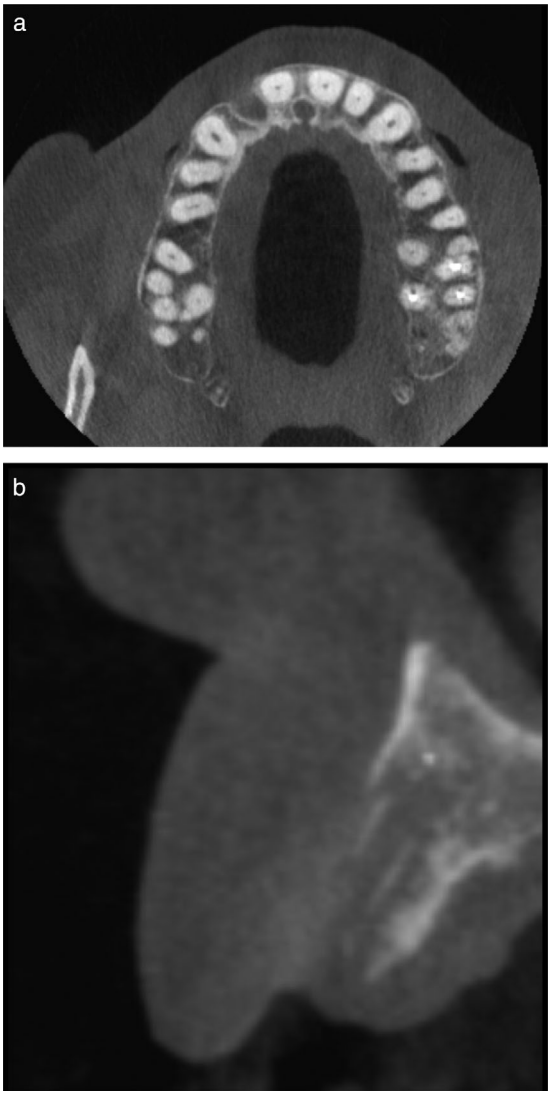

FIGURE 2 2a and 2b. Occlusal and sagittal view of CBCT scan exhibiting vertical and horizontal bone loss requiring three-dimensional bone augmentation to place implant in optimal position.

deficiency (Figs. 1a and 1b, 2a and 2b). Patient treatment plan consisted of oral hygiene instruction and scaling and root planing. After evaluating multiple reconstructive solutions, including a two-stage implant placement followed by GBR, and simultaneous implant placement with titanium-mesh or titanium reinforced Teflon membrane, an allogenic bone ring technique with simultaneous implant placement was considered as a therapeutic treatment option for site #7. A computer-guided approach was used for graft and implant planning and execution.

Case Preparation

The patient's CBCT study was uploaded to an implant planning software[‖]. A 3D representation of an allogenic bone ring was developed using CAD software[¶] and the stl files uploaded. A 3.3 mm × 14 mm implant[#] was

[‖]coDiagnostiX, Version 9.8, Dental Wings, Montreal, Canada.

[¶]Autodesk, San Rafael, CA.

[#]Straumann, Basel, Switzerland.

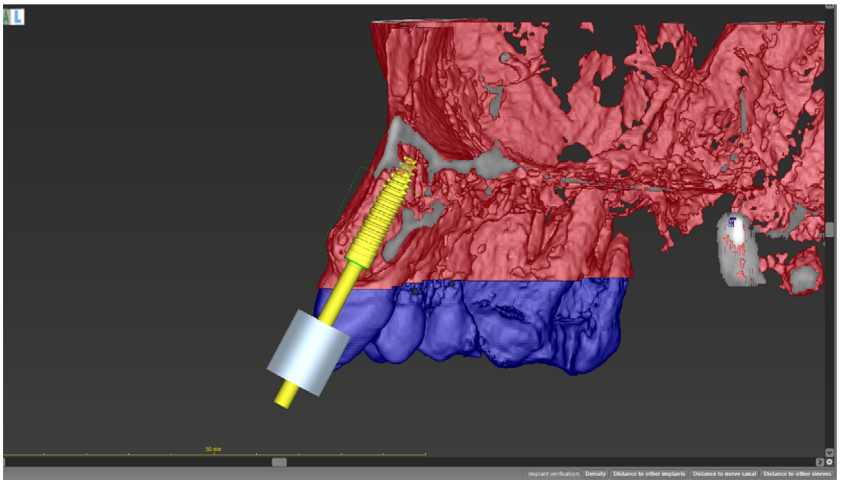

FIGURE 3 3D rendering of the sagittal view of the planned implant placement (represented in yellow).

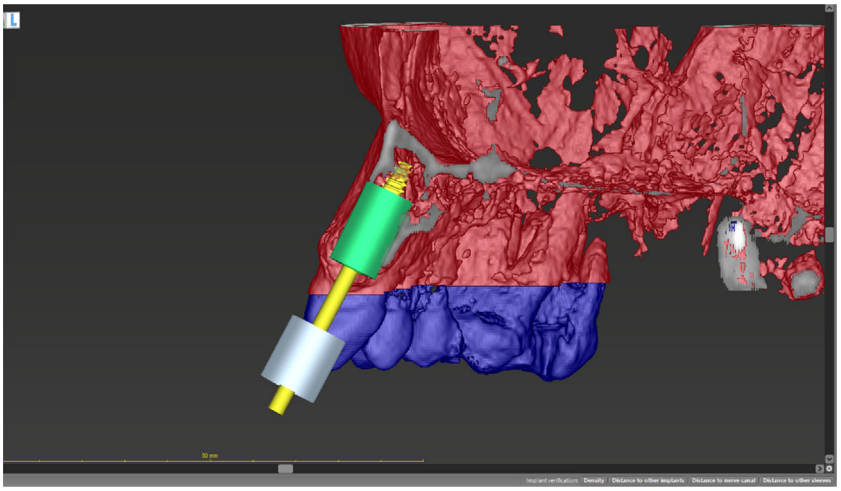

FIGURE 4 3D rendering of the sagittal view of the planned implant placement with 3D allogenic bone ring object (represented in green).

planned in relation to the final crown following previously reported guidelines.[1,8] The 3D allogenic bone ring object was virtually placed to assess inter-radicular clearance and amount of augmentation required (Figs. 3 and 4). Two digitally designed guides were created: a 5 mm sleeve guide for the preparation of the implant site (Fig. 5) and a 7 mm sleeve guide for the allogenic bone ring trephine preparation (Fig. 6). Stl files of the guides were generated and printed on a 3D printer using surgical-guide grade resin** following manufacturing recommendations.

Case Management

Patient provided written consent for treatment. After infiltration of 2% lidocaine with 1:100,000 epinephrine, a crestal incision with full thickness trapezoidal flap including the interdental papilla was elevated (Fig. 7). The 5 mm sleeve guide was used to prepare the implant osteotomy site following manufacturer surgical protocol.

**FormLabs, Somerville, MA.

After the implant osteotomy was prepared, the 7 mm sleeve guide was positioned and the housing for the allogenic bone ring was created (Fig. 8). The allogenic bone ring was then placed and leveled to the bone peaks on the adjacent teeth, according to the initial digital planning. Hence, the implant (3.3 mm × 14 mm) was manually inserted through the allogenic bone ring and the platform was positioned about 1 mm apical to the coronal border of the ring (Fig. 9). The provided graft cap screw was placed onto the implant to stabilize the graft (Fig. 10). Xenogenic bone graft material†† was then placed on the buccal aspect of the allogenic bone ring and covered by a resorbable xenogenic membrane‡‡ secured using 3 mm titanium tacks§§ (Fig. 11). A pedicle flap from the palate was displaced over the implant to aid in full coverage of the surgical site and the buccal flap was released for passivity.[10] Both flaps were secured with 5-0 e-PTFE‖‖ suture material (horizontal mattress/interrupted) and 6-0 monofilament¶¶ sutures (interrupted) (Fig. 12). A video of the surgical procedure is depicted in supplementary Video 1 in the online *Clinical Advances in Periodontics*. Patient was instructed to avoid brushing in the area for 30 days and to use 0.12% chlorhexidine gluconate (CHG) rinse twice a day for 4 weeks. Patient was given 500 mg amoxicillin to be taken 3 times a day for 7 days and ibuprofen 600 mg to be taken every 4 to 6 hours as needed.

Clinical Outcomes

Patient healing was uneventful. Sutures were removed at 14th day. Implant uncovery occurred at the 6-month post-operative appointment and at that time, a 5 mm healing abutment was connected to the implant. Three weeks later, a cement-retained metal ceramic crown restoration was delivered on a Zirconia patient specific abutment (Fig. 13). The radiographic bone level measured on the implant periapical radiographs comparing baseline (Fig. 14a) and 12 months post implant placement (Fig. 14b) showed no bone loss assessed from the implant shoulder. The clinical assessment of the peri-implant soft tissue showed probing depths ranging from 2 to 3 mm and no bleeding on probing.

††Straumann, Basel, Switzerland.

‡‡Geistlich Pharma, Wolhusen, Switzerland.

§§TruTACK, ACE surgical supplies, Brockton, MA.

‖‖Gore Tex, size 5-0, Gore Medical, Flagstaff, AZ.

¶¶Monosof clear 18" P-10 cutting, size 6-0, Covidien Sutures, Dublin, Ireland.

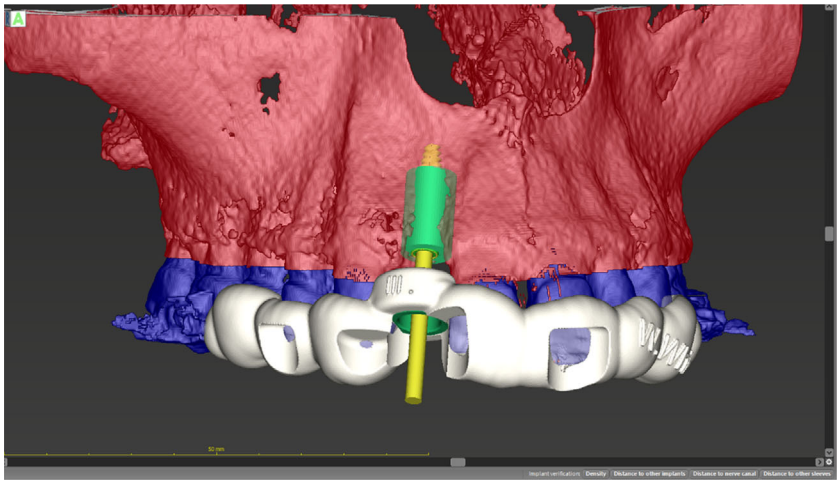

FIGURE 5 3D rendering of the designed implant surgical guide.

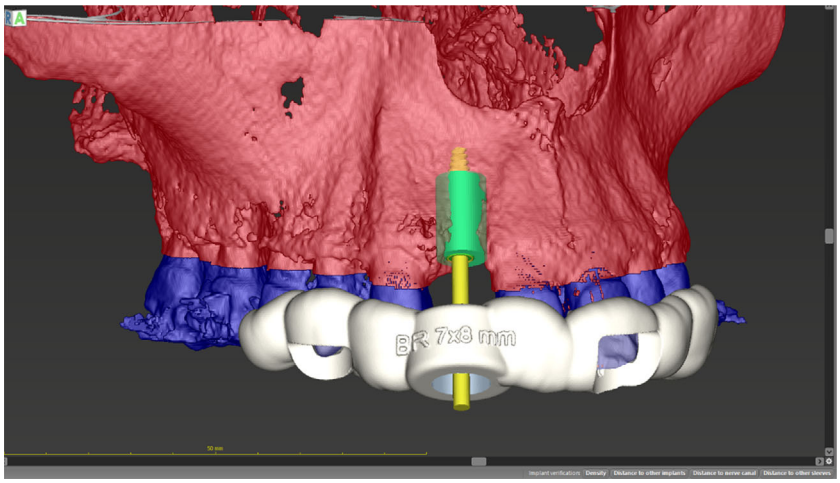

FIGURE 6 3D rendering of the designed allogenic bone ring surgical guide.

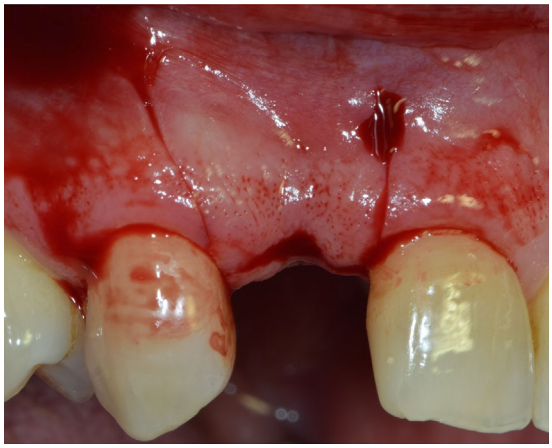

FIGURE 7 View of the full thickness trapezoidal flap with mesial and distal vertical releasing incision including the interdental papilla.

The accuracy of implant placement was measured using the implant software evaluation tool[##]. The difference in the final positioning was as follows: 0.65 mm at entry point, 0.55 mm vertical displacement, 1.94 mm at the apex, and angle discrepancy 6.1° (Figs. 15a and 15b).

Discussion

The use of the allogenic bone ring technique may provide some advantages compared with other regenerative procedures used in combination with implant placement. The allogenic bone ring offers a rigid bone scaffold and a predefined homogeneous dimension of graft volume around the implant surface; thus, simulating more closely the reconstruction of the original socket anatomy. In addition, the rigidity of the ring block may contribute to the implant primary stability. Thus, allowing simultaneous implant placement even in presence of a limited availability of basal bone. However, due to the novelty of this technique, more research is necessary to confirm these clinical considerations when compared to GBR techniques. In the presented case, we had the opportunity to verify the accuracy between the planned versus the actual implant position. The angular difference was reported as 6.1°, which was higher than the average 3.8° discrepancy as reported in systematic reviews, but well within the reported range of 0° to 24°.[9] The higher value in angular discrepancy reported in this case may be explained by the free hand implant placement instead of a fully guided insertion. Further investigation is needed to validate this approach.

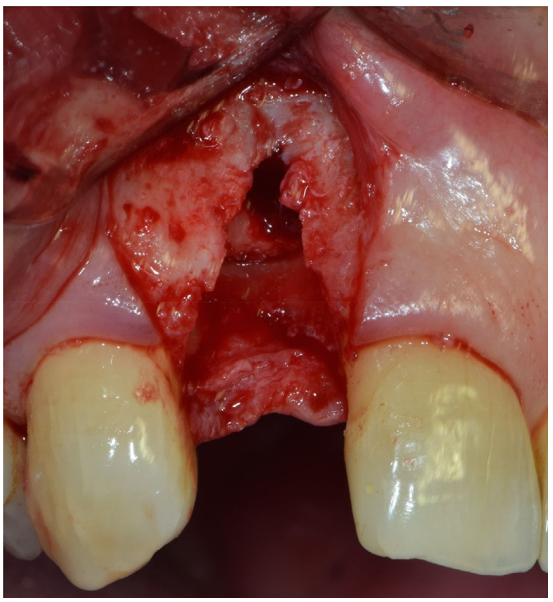

FIGURE 8 Use of trephine surgical guide for the allogenic bone ring housing preparation.

[##]coDiagnostiX, Version 9.8, Dental Wings, Montreal, Canada.

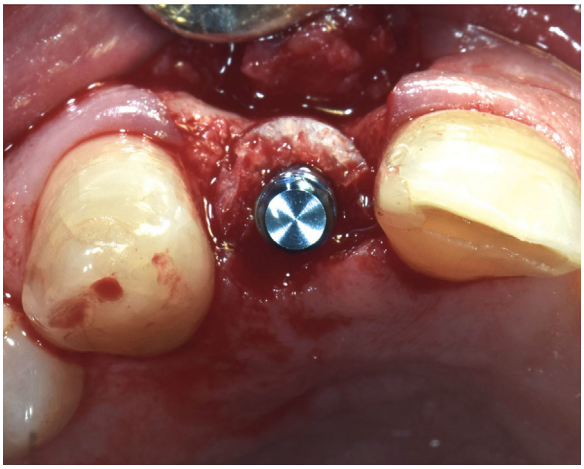

FIGURE 9 Occlusal view of implant placed through allogenic bone ring.

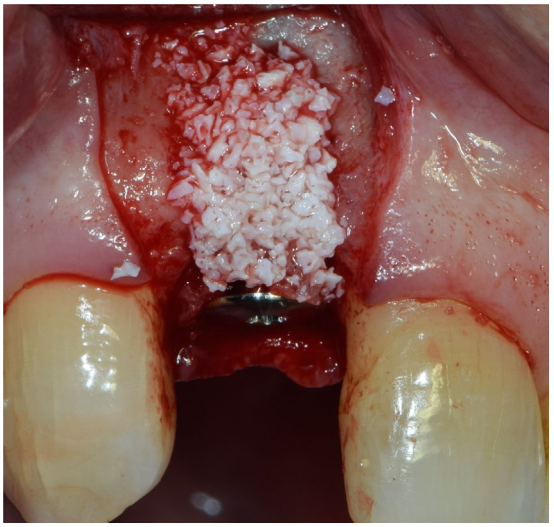

FIGURE 10 Frontal view of implant through allogenic bone ring with allogenic bone ring cap screw applied.

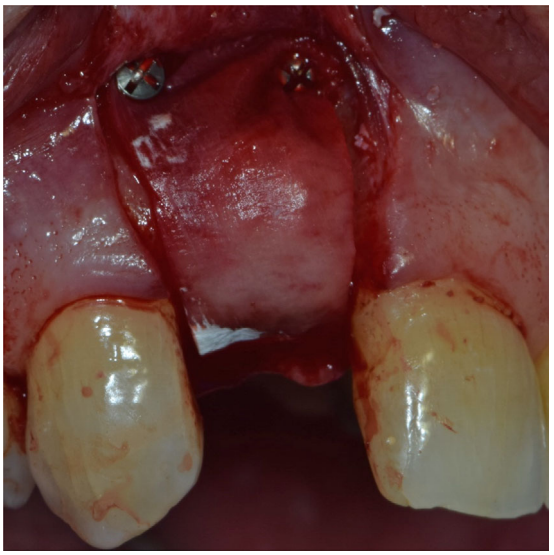

FIGURE 11 Frontal view of xenogenic membrane isolating the particulate graft and the allogenic bone ring.

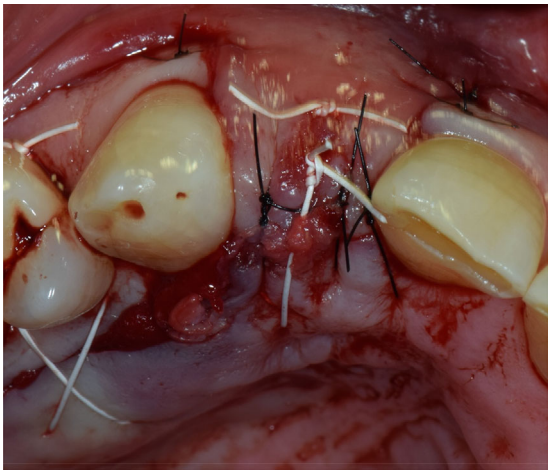

FIGURE 12 Occlusal view of closure with 5-0 e-PTFE suture material (horizontal mattress/interrupted) and 6-0 monofilament sutures (interrupted).

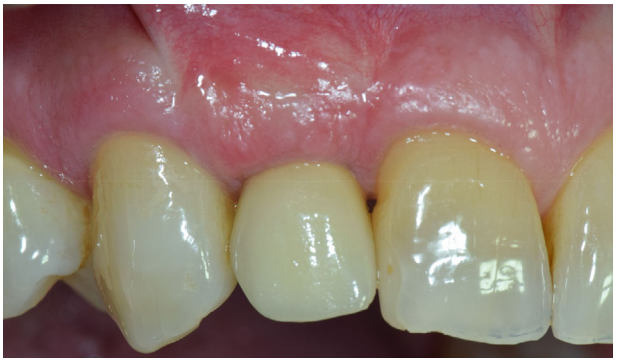

FIGURE 13 Frontal view of final restoration 6 months after delivery.

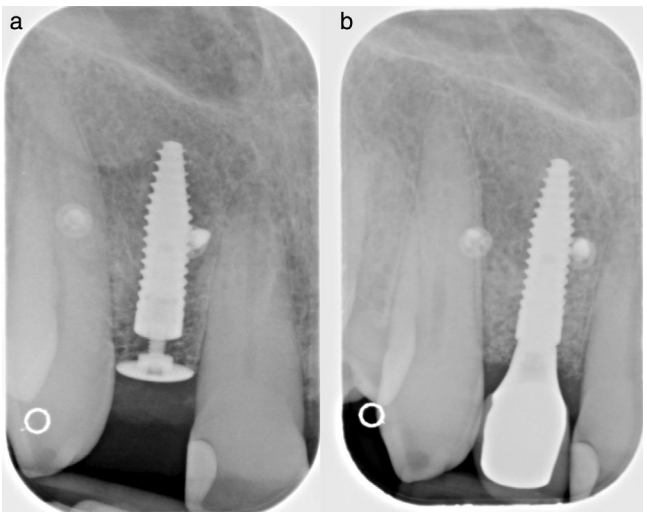

FIGURE 14 14a and 14b. Radiographic appearance of implant at baseline and 12 months after surgery.

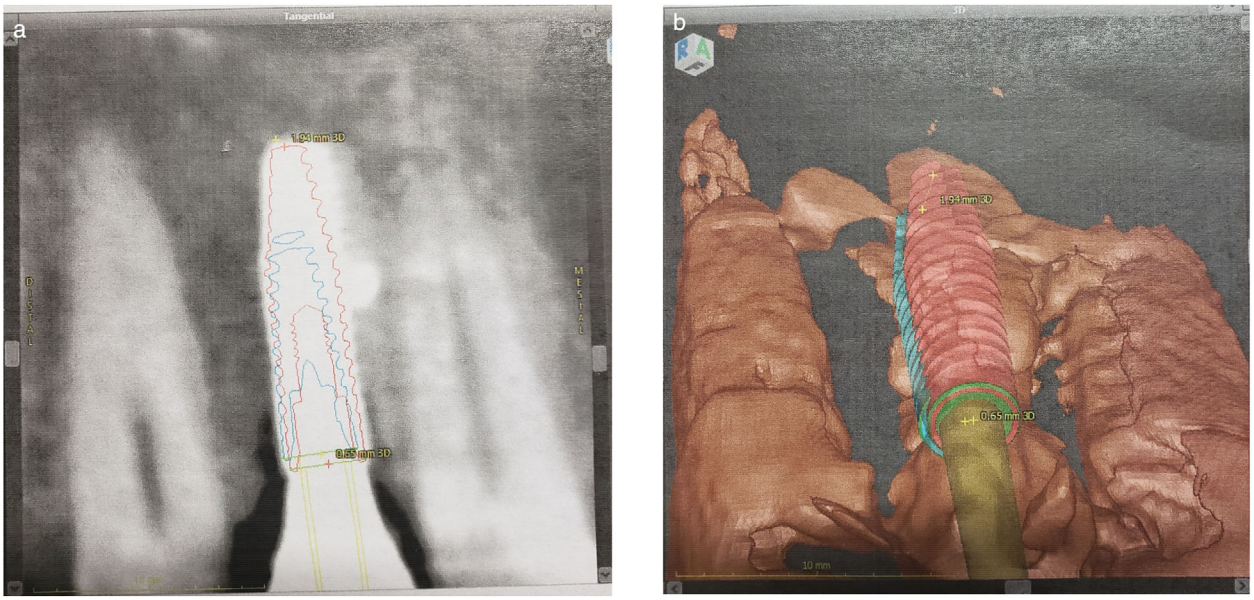

FIGURE 15 15a and 15b. Image obtained from software evaluation tool showing planned placement (blue color) and actual placement (red color) of the implant.

Summary

Why is this case new information?	■ This demonstrates a novel use of digital workflow principles applied to prosthetically plan, augment, and implant severely resorbed sites. ■ Healed sites of type IV and V do not allow placement of implants without a staged approach and augmentation. ■ A novel treatment concept is described to address this specific type of defect, providing a prosthetically driven horizontal and vertical augmentation concomitantly with implant placement.
What are the keys to successful management of this case?	■ 3-mm bone apical to implant and allogenic bone ring to stabilize the implant. ■ Mesio-distal distance >7 mm to allow trephine bur access. ■ Submerging of implant and allograft, with primary closure and no exposure. ■ Planning the proposed graft and implant in the most ideal position for both grafting, esthetics, and function.
What are the primary limitations to success in this case?	■ Insufficient mesio-distal space for allogenic bone ring. ■ Insufficient apical native bone height for implant to engage past allogenic bone ring. ■ Primary closure must be obtained. ■ Insufficient mesio-distal space to support trephine guide.

Acknowledgments

The authors reported no conflicts of interest related to this case report.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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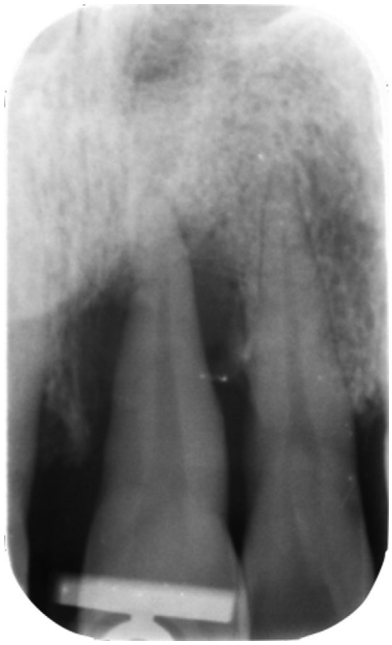
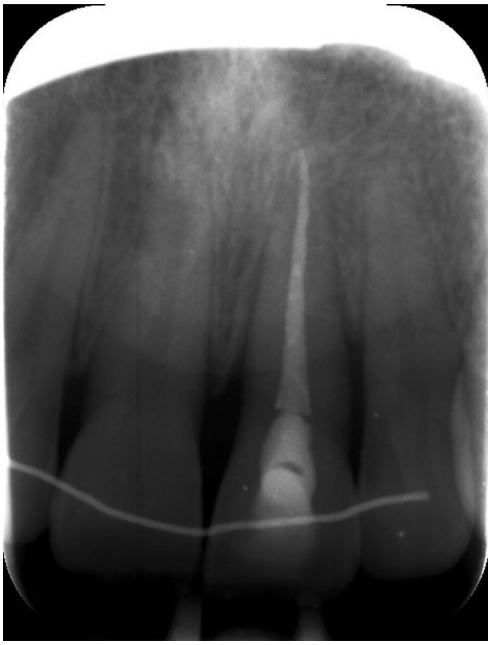
○ indicates key references.

Orthodontic Management of a Migrated Maxillary Central Incisor With a Secondary Occlusal Trauma

Laurent A.M. Thierens,*† Tommie Van de Velde† and Guy A.M. De Pauw*





Introduction: Normal or excessive occlusal forces exerted on teeth with a reduced periodontal support might result in a secondary occlusal trauma. This type of injury is diagnosed based on histological changes in the periodontium. Multiple clinical and radiographic indicators are, therefore, required as surrogates to assist the presumptive diagnosis of a (secondary) occlusal trauma.

Case Presentation: In this case report, the diagnosis, management, and the 1-year follow-up of a secondary occlusal trauma of a maxillary central incisor are described. The occlusal relationship was rehabilitated with fixed orthodontic appliances and was further stabilized with both fixed and removable retainers.

Conclusions: A combined periodontal-orthodontic approach for a secondary occlusal trauma allows the rehabilitation of periodontal, occlusal, and esthetic parameters. Twelve months after the end of the active orthodontic treatment, a combination of fixed and removable retainers showed to be effective in retaining the treatment outcome. *Clin Adv Periodontics* 2020;10:23–29.

Key Words: Chronic periodontitis; dental occlusion, traumatic; orthodontic appliances, fixed.

Background

Secondary occlusal trauma is injury resulting in tissue changes from normal or excessive occlusal forces applied to a tooth with reduced periodontal support.[1,2] It occurs in the presence of attachment loss, bone loss, and normal/excessive occlusal force(s); it is associated with stage IV periodontitis.[3,4]

Definitive diagnosis of occlusal trauma is not possible without block section biopsy. However, multiple clinical and radiographic indicators can support the presumptive diagnosis of this injury. These indicators include progressive tooth mobility, fremitus, occlusal discrepancy, wear facets (caused by tooth grinding), tooth migration, tooth fracture, thermal sensitivity, root resorption, cement tear, and widening of the periodontal ligament space upon radiographic examination.[4–6]

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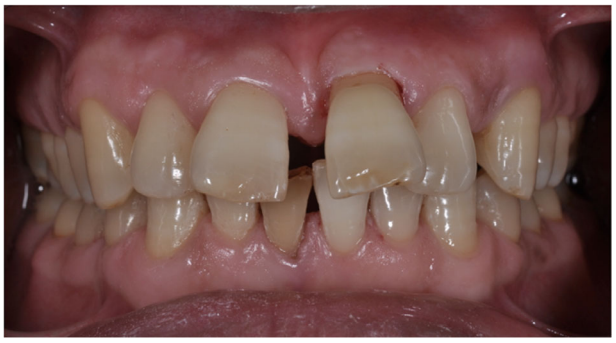

FIGURE 1 Frontal view of the clinical situation after initial periodontal therapy. Tooth #9 shows a labial recession of 3 mm and is severely proclined.

Elimination of occlusal trauma can be an important adjunct therapy in the comprehensive treatment of periodontal disease.[7] However, the evidence linking occlusal adjustment to the improvement in periodontal parameters is limited.[4] It might be presumed that orthodontic management can play a prominent role in this context by eliminating adverse occlusal interferences.[8] After all, teeth with a reduced but healthy periodontium can undergo successful tooth movement without compromising the supporting periodontal tissues.[9,10]

In this case report, the management of a secondary occlusal trauma of a maxillary incisor with fixed appliances (FA) exerting light forces is described.

Clinical Presentation

A 42-year-old male white patient with an unremarkable medical history was referred in December 2015 by the periodontist for orthodontic advice. His oral hygiene was good and all permanent teeth except the third molars were present. Since June 2015, the patient had successfully undergone initial therapy for generalized periodontitis, and he had quit smoking. All pockets were ⩽3 mm, except for the upper left central incisor (#9). This element still presented a localized pseudopocket of 6 mm, increased mobility (Grade 2), tenderness to percussion, fremitus, and pain on chewing. The vitality test was inconclusive and there was an increased thermal sensitivity. The clinical and radiographic conditions are presented in Figures 1 through 3.

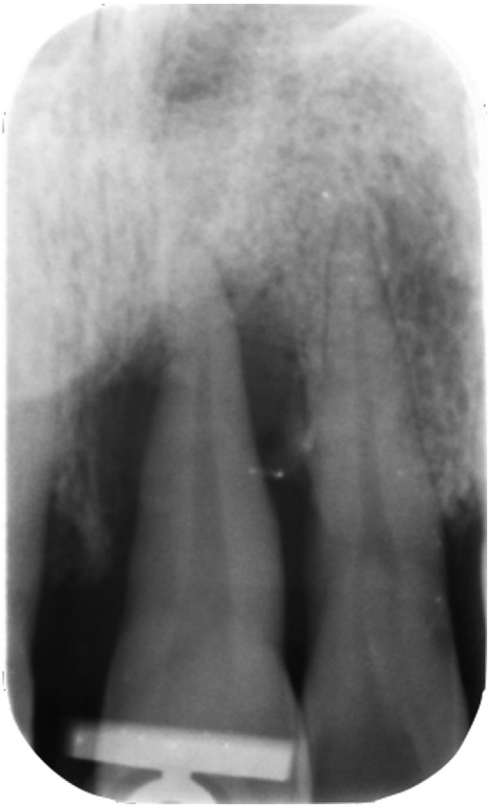

FIGURE 3 Radiographic view after initial periodontal therapy reveals a comprehensive radiolucent area without detectable lamina dura in the cervical and middle third of the root. In the apical third, the periodontal ligament space was increased, but the lamina dura was intact.

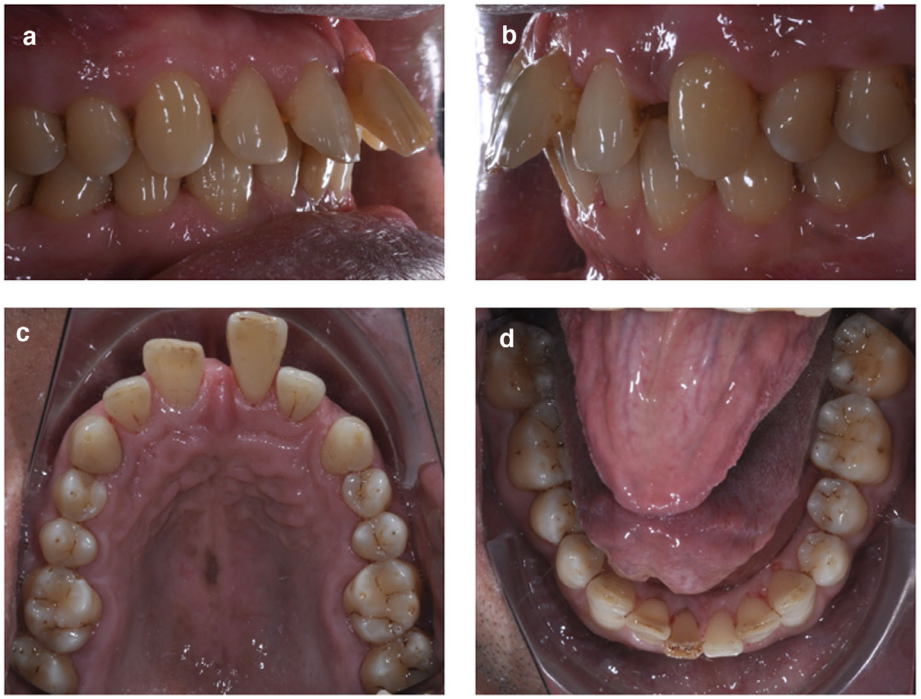

FIGURE 2 Lateral and occlusal views of the clinical situation after initial periodontal therapy. The lateral views (**2a** and **2b**) reveal a Class I relationship. The occlusal view of the upper arch (**2c**) reveals multiple diastemas, wear facets on teeth #8 and #9, and a palatal recession of 1 mm and severe proclination of tooth #8. The occlusal view of the lower arch (**2d**) shows minor incisor crowding of 3.5 mm.

Regarding the multiple clinical and radiographic indicators, the condition of tooth #9 was diagnosed as a localized, severe periodontal lesion with moderate progression due to secondary occlusal trauma.

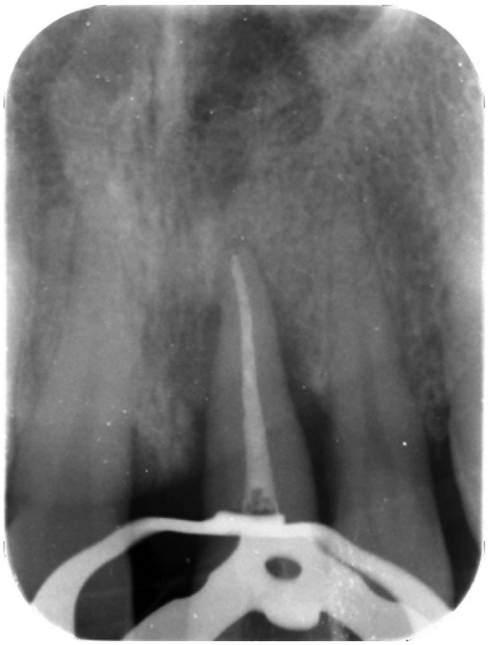

FIGURE 4 Radiographic view after the root canal treatment.

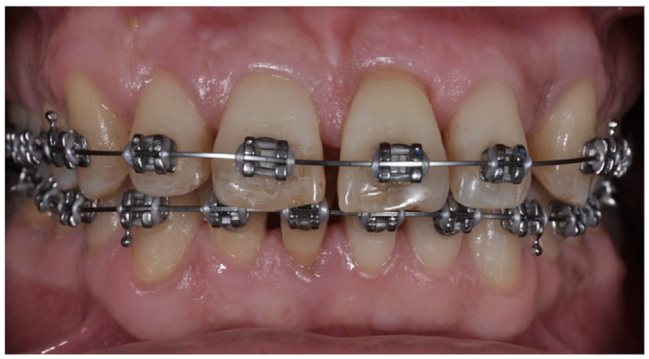

FIGURE 5 Frontal view of the clinical situation after insertion of 0.016 × 0.022 inch memory wires. Leveling and alignment are almost completed. The labial recession on tooth #9 has reduced in comparison with the initial situation.

Case Management

After an interdisciplinary consultation, a root canal treatment of tooth #9 was planned and subsequently performed in January 2016 (Fig. 4). Periodontal treatment consisted of frequent supragingival instrumentation, localized subgingival scaling and root planing around tooth #9, and the elevation of a mucoperiosteal flap to remove the periodontal pocket at the mesial side. Orthodontic treatment was started in March 2016. After 5 months, arch leveling and alignment were completed (Figs. 5 and 6) and a 0.016 × 0.016-inch stainless steel wire was inserted. Figure 7 shows the intermediate radiographic evaluation. Before the start of the space closure in the upper arch, the Curve of Spee in the lower arch was completely leveled to reduce the heavy incisal contacts.

Interproximal reduction of the lower incisors was performed to facilitate retraction, and to subsequently allow complete space closure in the upper arch. First, contact points were reduced using double-sided, aluminum oxide-coated separation strips with a 0.2-mm thickness.[‡] The triangular shape of the incisors was further reduced using a double-sided, diamond-coated stripping disk with a 0.3-mm thickness,[§] and finally the enamel was polished with fine and extra fine contouring and polishing disks.[‖] The interproximal spaces were closed with elastomeric chain (Fig. 8). Prophylaxis was performed at every orthodontic appointment. Additionally, the patient had an appointment with the periodontist every 3 months. The patient gave oral consent for all procedures.

Clinical Outcomes

After 22 months, the FA were removed. Complete alignment and space closure were accomplished. An adequate overbite and balanced incisor relationship were achieved. The labial recession of tooth #9 had decreased to 1 mm and the probing depth halved to 3 mm (Figs. 9 and 10). Radiographically, trabecular bone can be detected at the mesial and distal side of tooth #9. The periodontal ligament space is still widened (Fig. 11). A lingual retainer (CoAx 0.0195 inch) was bonded in the upper arch (#7 to #10) and the lower arch (#22 to #26) (Figs. 9 and 10). A vacuum formed retainer was also provided in both arches. The 1-year follow-up shows stable clinical and radiographic results (Figs. 12 through 14).

Discussion

Several other treatment strategies could be pursued to rehabilitate the dentition of this patient, such as an implant supported crown or a partial removable denture. However, the orthodontic approach was the only one rehabilitating the unbalanced incisor relationship. The notable compliance and motivation of our patient, essential for an intensive orthodontic treatment, were ultimately decisive.

Melsen and coworkers[11] and Cardaropoli and coworkers[12] concluded that low forces between 5 and 15 g per tooth are sufficient to achieve successful tooth movement in periodontal compromised patients, especially when performing intrusion of incisors. They observed radiographically that the total amount of alveolar support was unaltered or even increased after orthodontic therapy.[11,12] Cardaropoli and coworkers also observed a reduction of the probing depth and clinical crown length, and absence of bleeding after a combined periodontal-orthodontic approach.[12] The evolution of the periodontal parameters and the alveolar bone surrounding tooth #9 in this case is in line with their conclusions.

[‡]Horico Dental, Berlin, Germany.
[§]Komet Dental, Lemgo, Germany.
[‖]Sof-Lex, 3M Oral Care, St. Paul, MN.

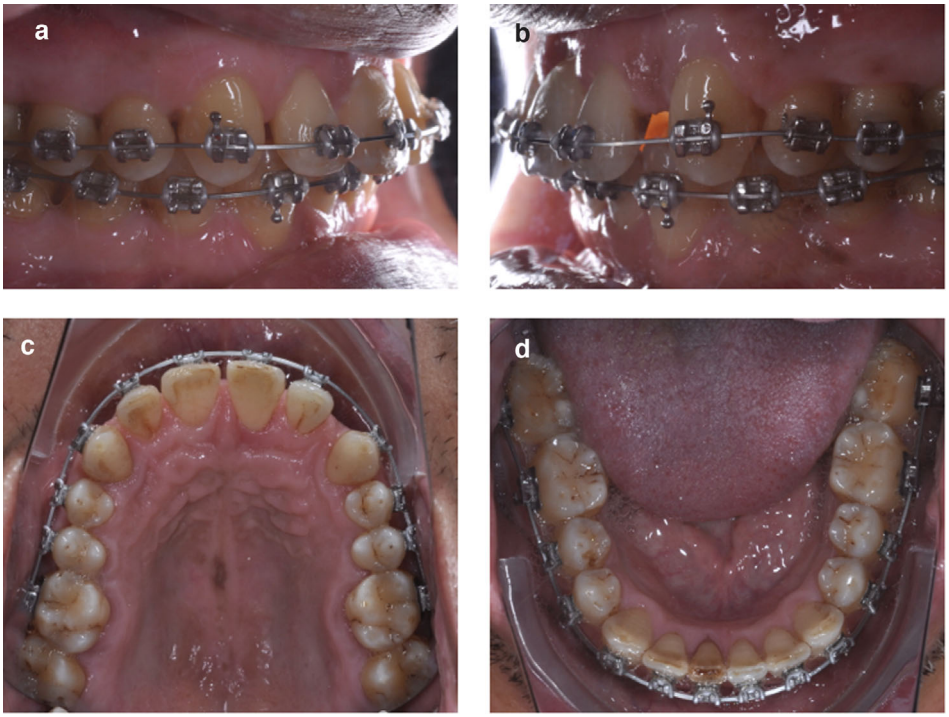

FIGURE 6 Lateral (**6a** and **6b**) and occlusal (**6c** and **6d**) views of the clinical situation after insertion of 0.016 × 0.022 inch memory wires. The severe proclination of tooth #9 has been reduced.

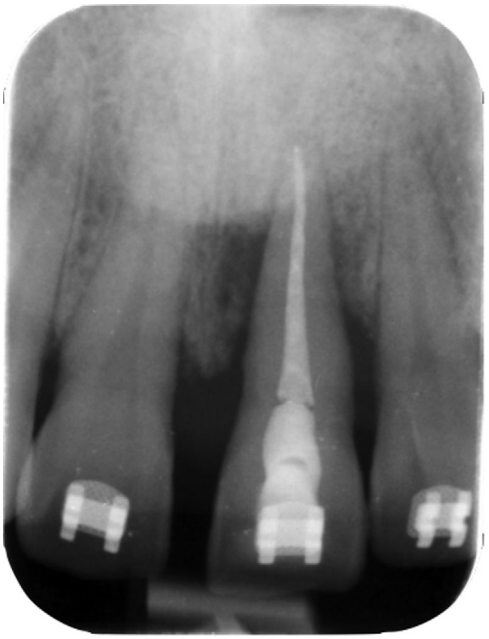

FIGURE 7 Radiographic view before insertion of 0.016 × 0.022 inch memory wires. Formation of trabecular alveolar bone at the distal side of tooth #9 can be observed.

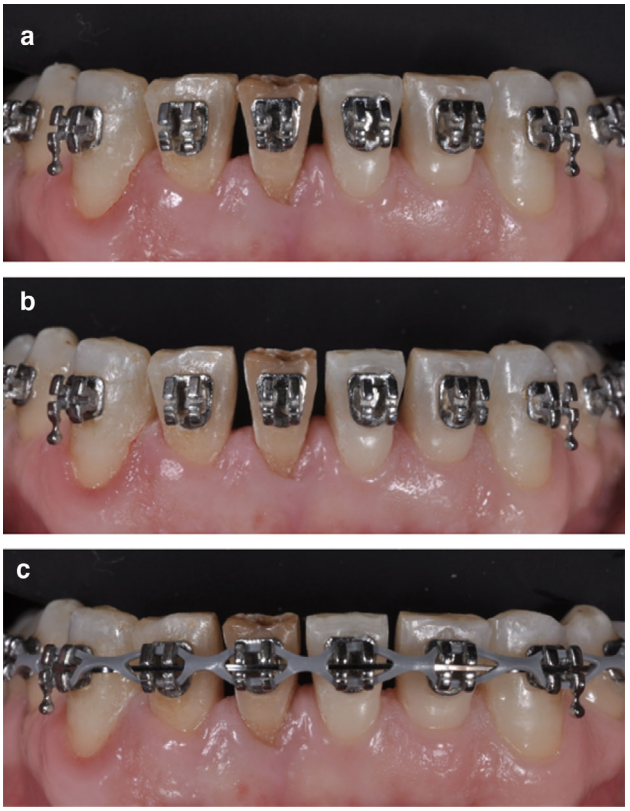

FIGURE 8 Frontal clinical view of the lower incisors before interproximal reduction (**8a**), after interproximal reduction (**8b**), and after application of an elastomeric chain (**8c**).

Intrusion of maxillary incisors that have migrated due to periodontal disease is still controversial. Periodontally involved teeth show bacterial infiltration in dentin tubuli as well as the dental pulp.[13] These teeth can act as bacterial reservoirs from which decolonization of mechanically treated root surfaces can occur. This can possibly cause more periodontal problems when intruding these teeth apically. Notwithstanding, histologic studies have also shown that the intrusion of periodontally involved teeth may lead to a noticeable gain in connective tissue attachment with adequate oral hygiene and supportive periodontal therapy.[14]

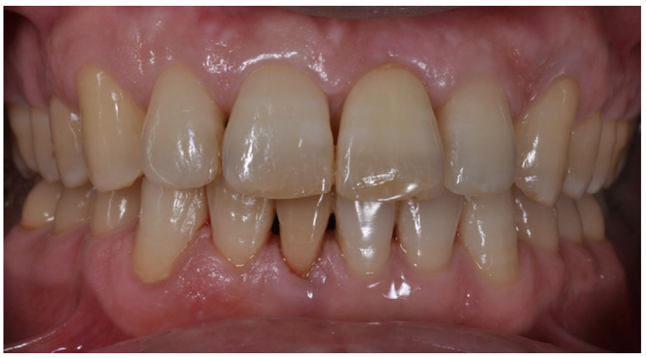

FIGURE 9 Frontal view of the clinical situation after bracket removal. The labial recession on tooth #9 is gone and an adequate vertical incisor relationship can be observed.

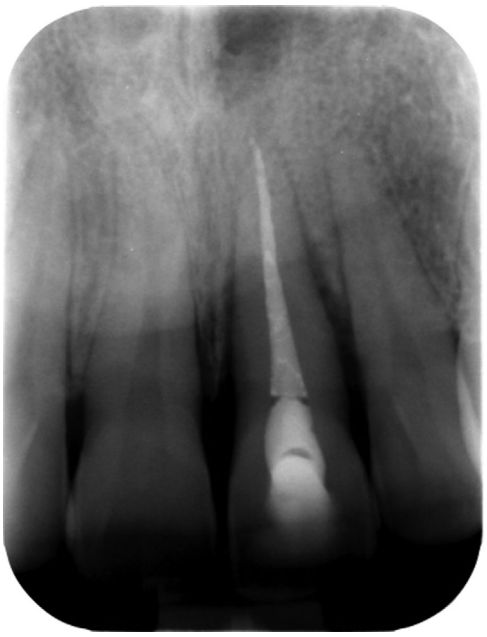

FIGURE 11 Radiographic view after bracket removal. Trabecular bone can be observed at both the mesial and distal side of tooth #9. The periodontal ligament space is still enlarged.

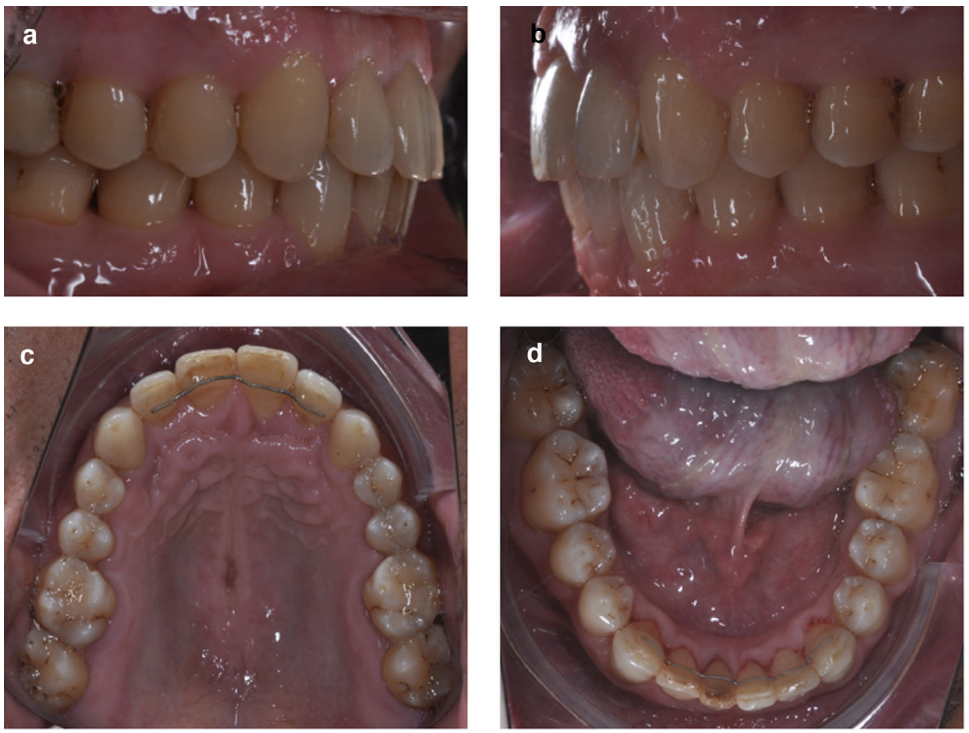

FIGURE 10 Lateral (**10a** and **10b**) and occlusal (**10c** and **10d**) views of the clinical situation after bracket removal. The incisors in the mandible and maxilla are retained using a bonded 0.0195 inch CoAx wire. The palatal recession is still present.

Conclusions

A combined periodontal-orthodontic approach for a secondary occlusal trauma allows the rehabilitation of periodontal, occlusal, and esthetic parameters. Twelve months after the end of the active orthodontic treatment, a combination of fixed and removable retainers showed to be effective in retaining the treatment outcome. ■

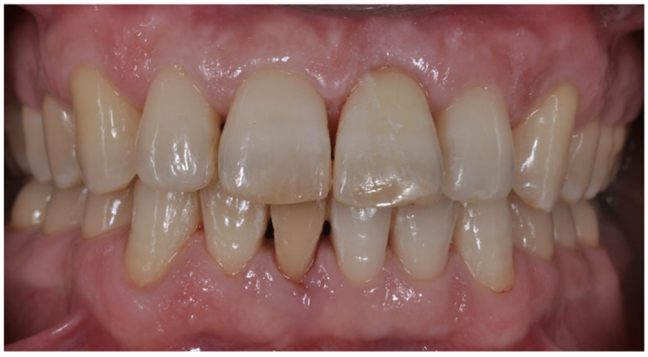

FIGURE 12 Frontal view of the clinical situation 1 year after bracket removal. The occlusion and esthetic parameters are stable.

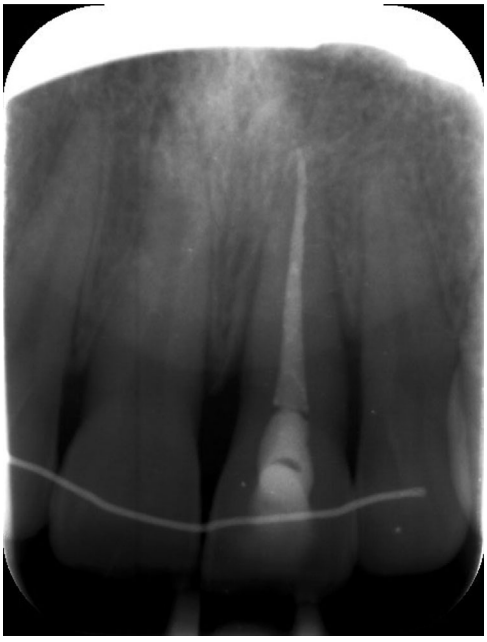

FIGURE 14 Radiographic view 1 year after bracket removal. The periodontal ligament space has reduced in comparison with **Fig. 11**.

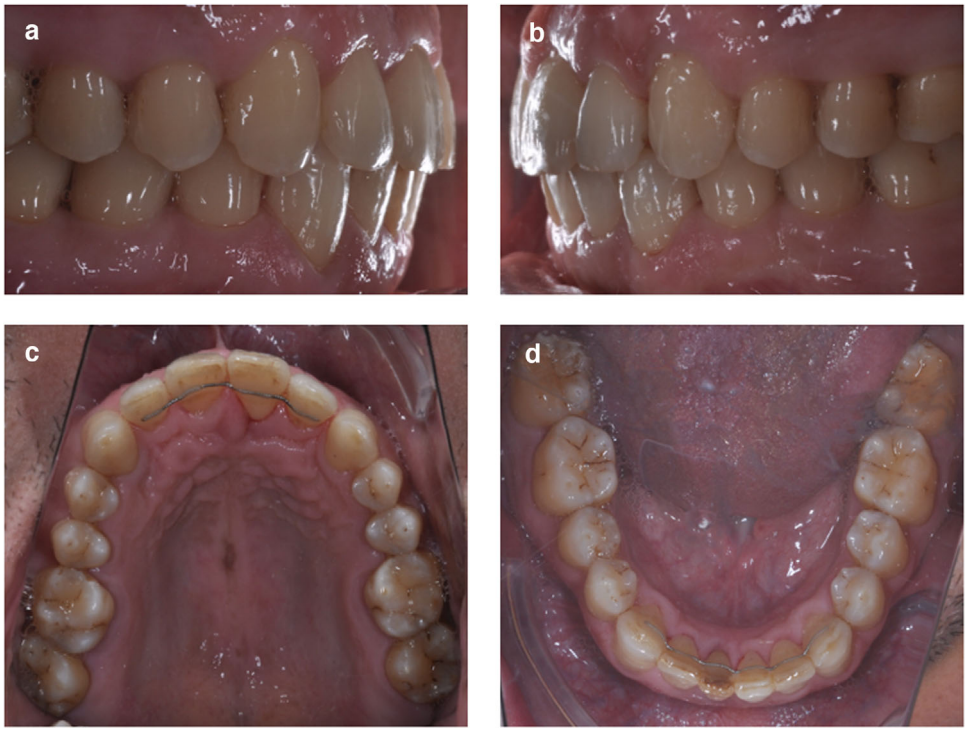

FIGURE 13 Lateral (**13a** and **13b**) and occlusal (**13c** and **13d**) views of the clinical situation 1 year after bracket removal. The occlusion and periodontal condition are stable.

Summary

Why is this case new information?	■ To our knowledge, this case report is presumably the first to describe this type of pathology with a substantive follow-up period.
What are the keys to successful management of this case?	■ Interdisciplinary consultations are essential to perform adequate diagnostics and to set up a feasible treatment plan.
What are the primary limitations to success in this case?	■ A combined periodontal-orthodontic approach is not an instant solution and requires profound patient motivation.

Acknowledgments

The authors would like to thank Helene Van kerkhoven (private dental office MOND, Antwerp, Belgium) for her advice and the performance of the endodontic treatment. No funding was obtained for this study. Laurent Thierens, Guy De Pauw, and Tommie Van de Velde report no conflicts of interest related to this case report.

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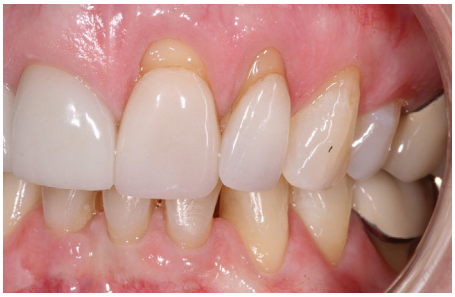
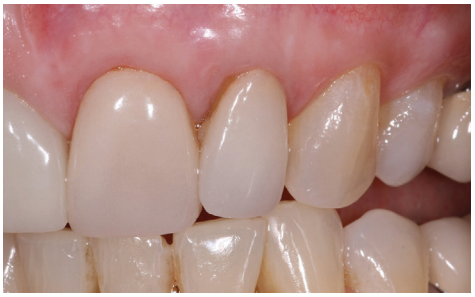
○ indicates key references.

Treatment of Recession Defects With Mucosal Access and Use of Soft Tissue Allograft: A Case Report of a Simplified Protocol

Ryan Clagett,* Dorothy Ogdon,† Miyoung Kim‡ and Maria L. Geisinger§





Introduction: Esthetic and functional root coverage procedures using a variety of techniques and materials allow for predictable outcomes in Miller Class I and II defects, but may be accompanied by high levels of postoperative discomfort and lengthy intrasurgical time. Current techniques may also require a steep practitioner learning curve, cumbersome intrasurgical steps, and their use in challenging clinical situations, e.g. multiple adjacent recession defects, limited vestibular depth, and anatomical limitations can prove difficult. This report introduces the side access mucosal releasing incision (SAMRI) technique as an innovative and simplified method to perform mucosal-access root coverage procedures.

Case Presentation: A 42-year-old female presents with 3 to 4 mm of gingival recession at #9-11 and opts for treatment with a vestibular approach and acellular dermal matrix graft to avoid a secondary surgical site.

Conclusion: SAMRI procedure allows for optimal root coverage and esthetic results while limiting intrasurgical time and postoperative patient morbidity. *Clin Adv Periodontics* 2020;10:30–37.

Key Words: Acellular dermis; gingival recession; periodontal; surgery; therapy.

Background

Root coverage procedures using periodontal plastic surgical techniques have been employed to treat gingival recession defects around teeth and implants.[1,2] These therapies are indicated to improve esthetics, dentinal hypersensitivity, progressive recession, inadequate keratinized tissues, and for the prevention of tooth structure loss through caries and non-carious cervical lesions (NCCLs).[1–5] For these reasons, complete root coverage is the optimal outcome for root coverage procedures,[5,6] but this outcome may be influenced by the initial defect dimensions,[7] the surgical treatment modality,[4–6] the postsurgical position of the gingival margin,[8] and patient characteristics, such as smoking.[9] Miller Class I and II[10] defects have been shown to have a high success rate, with mean root coverage of 80.9% (50% to 97.3%) and complete root coverage achieved in 46.6% (7.7% to 91.6%) of cases.[1,2,5]

In addition to individual recession defect morphology that may limit success of surgical treatment, the presence of multiple gingival recession defects also presents challenges. In these cases, a larger surgical field may result in a greater amount of anatomic variability and the size of the area to be treated may limit treatment options because of the quantity of autogenous donor tissue available for use.[11] Multiple techniques have been developed to obtain predictable root coverage in challenging clinical situations. The aim of these evolving techniques is to increase predictability of treatment, reduce patient morbidity and discomfort, minimize surgical visits, and improve esthetic success including color variability and continuity of the gingival margin.[12,13] Distant incisions in the vestibule have been employed to improve access and patient treatment acceptance at multiple recession defects.[13,14] This approach may allow for improved access with less risk of papillary displacement and better esthetic

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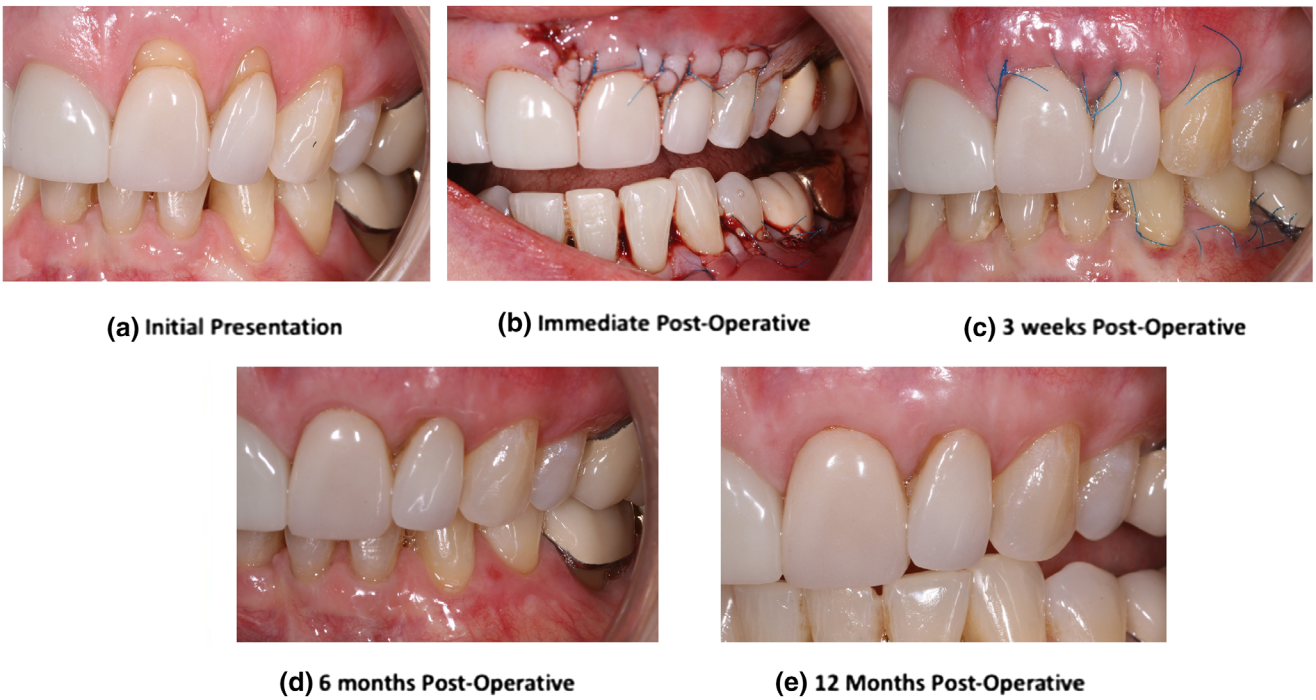

FIGURE 1 Presentation of 42-year-old female with gingival recession at #9-11 who opted to be treated with the SAMRI technique. Photographs demonstrate **1a** initial presentation of gingival recession defects, **1b** postoperative coronal advancement of tissues, and postoperative healing at **1c** 3 weeks, **1d** 6 months, and **1e** 12 months.

and patient-centered outcomes postoperatively.[13] However, the vestibular incision subperiosteal tunnel access (VISTA) includes a cumbersome suturing technique and uses a resorbable collagen matrix, which may limit applicability in all clinical situations and requires increased surgical time.

The adjunctive use of growth factors in soft tissue grafting protocols has been employed to improve root coverage, gingival tissue quantity and quality, and postoperative patient comfort.[6,15–17] The addition of growth factors has been shown to improve clinical outcomes with acellular dermal matrix (ADM) grafts and less predictable defects, such as Miller Class III gingival recession defects.[17–19] Given the challenges to achieve optimal outcomes in challenging patients and recession defects and the limitations of soft tissue graft materials, the addition of growth factors when grafting in suboptimal clinical scenarios may be warranted.[17]

Clinical Presentation

A 42-year-old female presents with a chief complaint of "gum recession and sensitivity on the teeth on my upper front left." Examination reveals 3 to 4 mm gingival recession defects at teeth #9-11 without radiographic interproximal bone loss or interproximal tissue loss. All recession defects in the upper left quadrant (ULQ) are classified as Miller Class I and II. The patient's medical history is non-contributory and a comprehensive oral examination reveals no other dental or periodontal diagnoses. The patient has expressed concern about postoperative discomfort and postsurgical esthetics of the gingival graft and states that she would prefer to avoid a secondary surgical site, if acceptable results can be achieved (Fig. 1).

Case Management

After initial examination and discussion of treatment options and risks and benefits of therapy, a mucosal incision approach to allow coronal advancement of the gingival flap and use of an allogeneic ADM graft[‖] was used to treat the recession defects in the ULQ. The patient provided verbal and written informed consent before any procedures were performed.

Recipient Site Preparation

Before surgical access, all exposed root surfaces were thoroughly scaled and root planed with hand and ultrasonic curettes. A medialized vertical mucosal incision of 8 to 12 mm in length penetrating to the underlying bony tissue was made with a 15c blade extending from the mucosal tissue to the mucogingival junction (MGJ). This was performed to allow release at the teeth to be treated and 1 to 2 teeth medial and lateral (offset) to the treatment area. Full thickness mucoperiosteal elevation of a pouch from the incision to the gingival margins of affected teeth was prepared with a Molt Periosteal elevator. Elevation of the lateral extent of the recipient site was performed initially and the pouch then extended coronally and apically to allow for gingival margin mobility for coronal

[‖]Alloderm Regenerative Tissue Matrix; BioHorizons IPH, Inc. Birmingham, AL.

advancement of tissues. Interproximal papilla were then elevated using a 7/8 Younger-Good curette.

Graft Preparation and Insertion

ADM material was washed and hydrated per manufacturer's instructions and trimmed to cover the treatment area and one tooth lateral on each side. The length and thickness of the material should be adequate to allow for coronal advancement and increase in tissue thickness at the treatment site(s). The ADM graft was then inserted through the vertical incision and moved coronally and laterally into position. The graft and flap was positioned so that the gingival margin of the flap is concordant with the coronal edge of the graft and the flap and graft unit can be advanced together.

Suturing

ADM graft and overlying tissues were sutured using a sling suture. 6-0 polypropylene[¶] sutures were used and the overlying tissue and graft pierced with the same pass in a bucco-lingual direction at each buccal line angle. Sutures were tied on the buccal and both graft and overlying tissue were coronally advanced and positioned at or above the cemento-enamel junction (CEJ). The graft was completely covered by the overlying tissues at the treatment site and the vertical access incision was closed using 5-0 chromic gut sutures.[†]

Postoperative Management

The patient was postoperatively prescribed amoxicillin 875 mg bid or azithromycin 250 mg for 10 days postoperatively. The patient was also prescribed ibuprofen 800 mg tid for analgesia as needed, methylprednisone (Medrol dose pack) to be used as directed, and a topical antioxidant gel[#] applied twice daily until suture removal. Postoperative instructions included light activity restrictions for 72 hours postoperatively and avoidance of toothbrushing and interdental cleaning until suture removal at 6-weeks postoperatively. The patient was seen for postoperative visits at 3- and 6-week intervals and sutures were removed at the 6-week visit.

Surgical Approach

Schematic diagrams of the surgical approach include: initial presentation (Fig. 2), incision design (Fig. 3), flap dissection with Molt periosteal elevator (Fig. 4), papillary elevation (Figs. 5 and 6), ADM insertion (Figs. 7 and 8), ADM in position in the released pouch preparation (Fig. 9), suturing technique (Figs. 10 through 16), and final postoperative sutured surgical site (Fig. 17).

[¶]SuriPoint Suture; Salvin Dental Specialties, Inc.; Charlotte, NC.

[#]AO ProVantage; Periosciences; Dallas, TX.

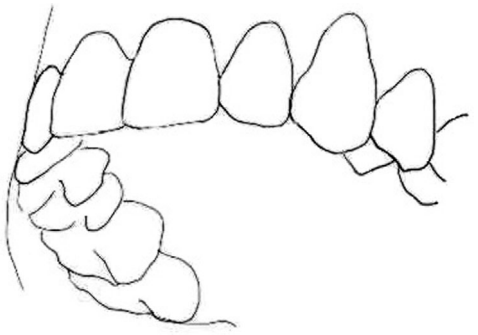

FIGURE 2 Schematic of initial presentation of a gingival recession defect at #11 to be treated with the SAMRI technique.

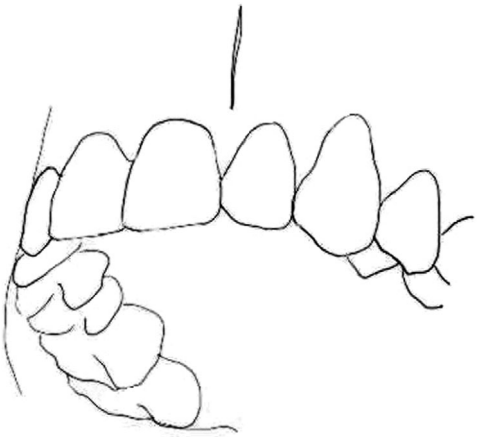

FIGURE 3 Schematic of the offset vertical vestibular access incision design for the SAMRI technique to address gingival recession at tooth #11.

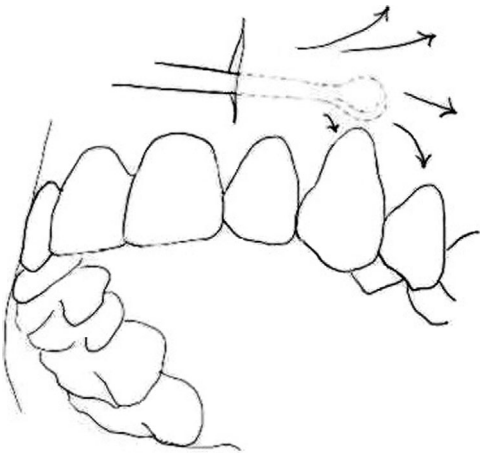

FIGURE 4 Schematic of subperiosteal flap dissection with Molt periosteal elevator to create graft recipient bed at teeth #10-12.

Clinical Outcomes

At 6-months posttreatment, complete root coverage of treated areas can be seen with intact and non-blunted papillae at the treatment site. Both practitioner (RC) and patient judged the esthetic result to be superior with a root coverage esthetic score (RES)[20] on all teeth treated

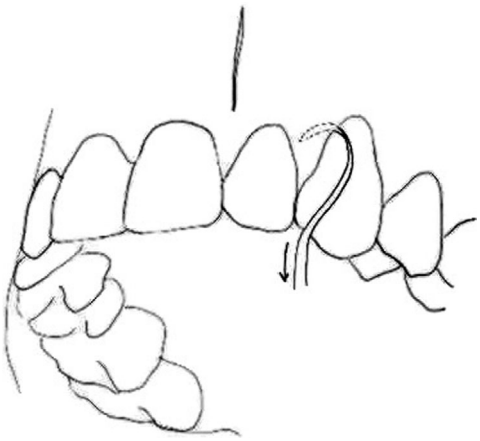

FIGURE 5 Schematic of papillary elevation with a 7/8 Younger-Good curette.

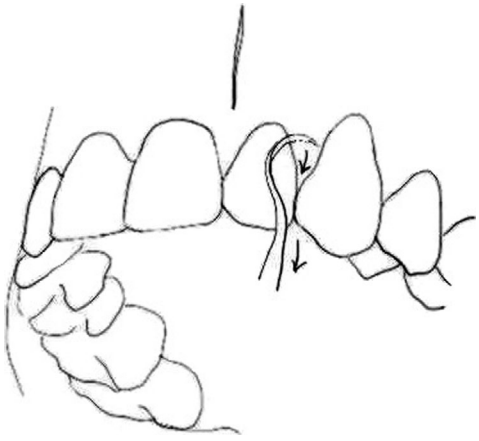

FIGURE 6 Schematic of papillary elevation with a 7/8 Younger-Good curette.

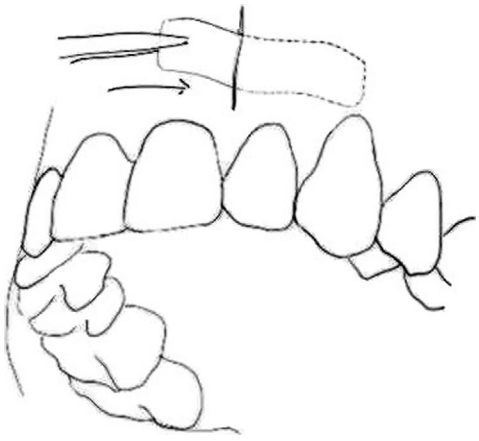

FIGURE 7 Schematic of ADM insertion through vestibular access incision.

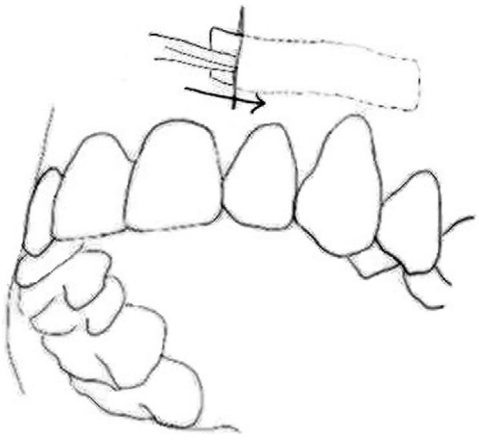

FIGURE 8 Schematic of ADM insertion through vestibular access incision.

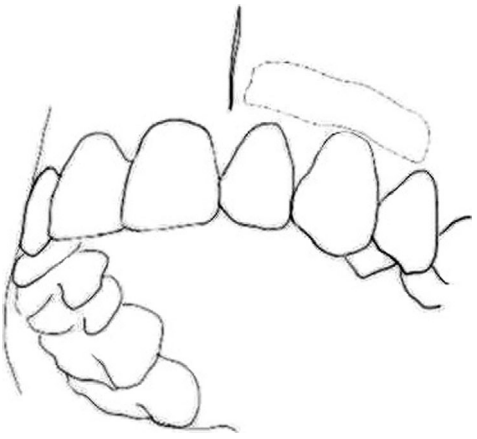

FIGURE 9 Schematic of ADM in position in the released pouch preparation prior to final coronal advancement of graft and flap with suturing.

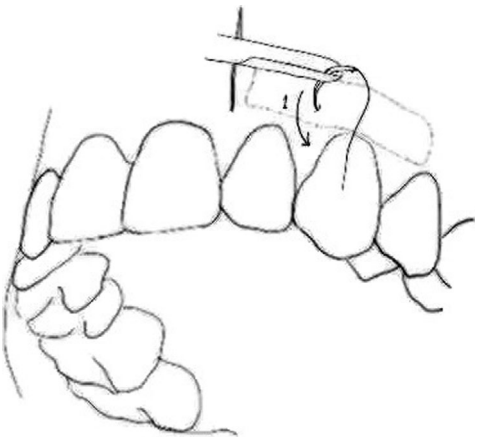

FIGURE 10 Schematic of initial suture engaging ADM graft and overlying mucoperiosteal graft within the mucosa at the mesial of #11.

of 9 to 10. The gingival thickness was such that a periodontal probe did not produce gingival color change when inserted into the gingival sulcus and was deemed of adequate thickness by the practitioner (RC). The patient reported minimal discomfort and reported no restrictions to her daily activities after 24 hours postoperatively. The patient reported that her radicular sensitivity had been eliminated after this procedure. In postprocedural interview with the patient, the patient reported high levels of satisfaction. She stated her expectations were exceeded in

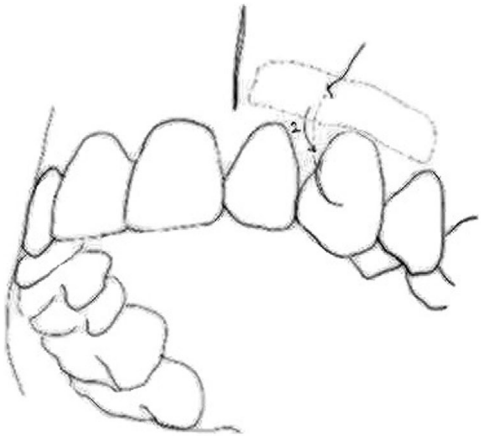

FIGURE 11 Schematic of suture exit from gingival tissue allowing tacking of ADM graft to overlying mucoperiosteal flap on the mesial of #11.

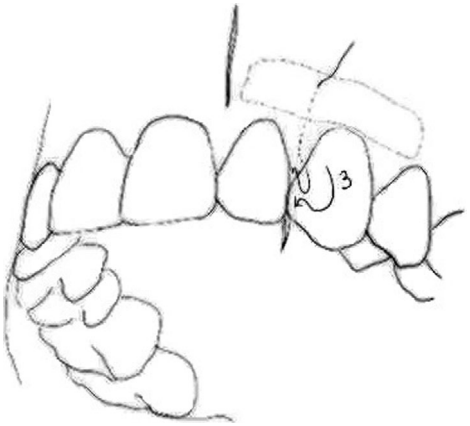

FIGURE 12 Schematic of suture passing below the mesial interdental contact to allow a mesio-distal sling suture position on the palatal of #11.

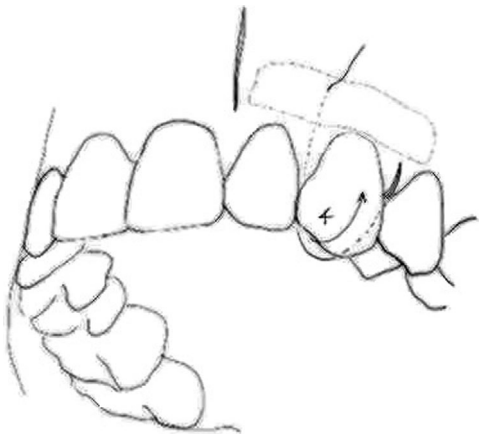

FIGURE 13 Schematic of suture passing below the distal interdental contact after a mesio-distal sling suture position on the palatal of #11.

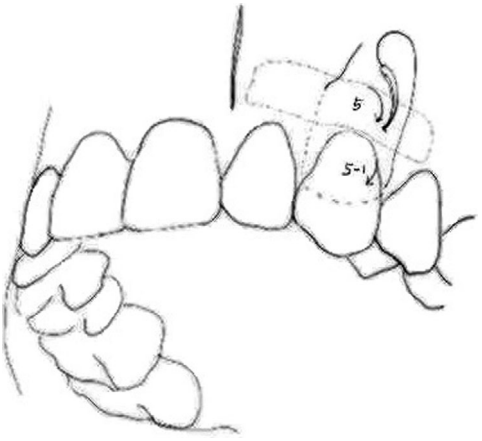

FIGURE 14 Schematic of suture engaging the ADM graft and overlying mucoperiosteal from from the external flap surface within the mucosa on the distal of #11.

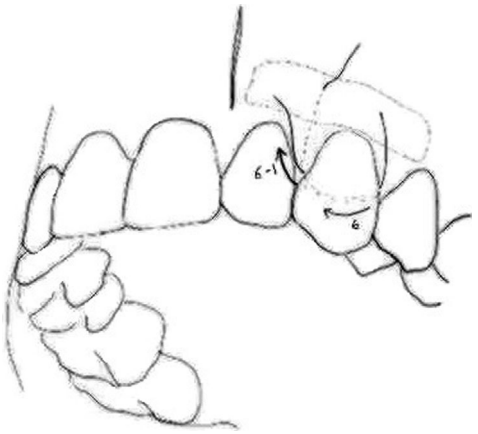

FIGURE 15 Schematic of suture passing below the contact points and being slung from distal to mesial to facilitate coronal flap and ADM graft advancement.

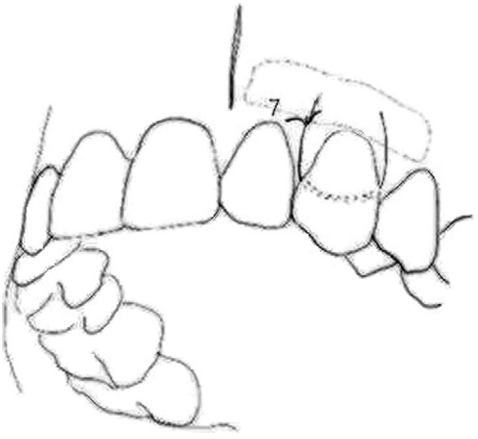

FIGURE 16 Schematic of suture tie to secure flap and graft in a coronal position at #11.

areas of (1) intrasurgical time, (2) postoperative discomfort, and (3) final esthetic results. The surgeon (RC), a periodontist with over 15 years of experience, estimates that intrasurgical time was decreased by 25% to 30% using this technique when compared with other soft tissue grafting techniques and that esthetic and root coverage outcomes are similar to other techniques used. Additionally, although the materials cost and patient surgical fee

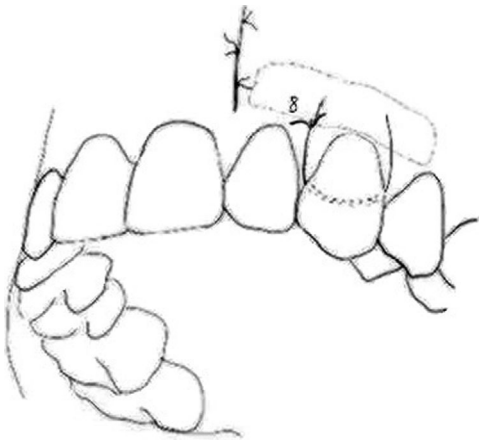

FIGURE 17 Schematic of final postoperative sutured surgical site after SAMRI technique used to address gingival recession at tooth #11.

are similar to other soft tissue grafting procedures, a decreased intrasurgical time reduces overhead expenses and may allow practitioners to see additional patients and increase profitability in their practice.

Discussion

The treatment of gingival recession defects is performed for esthetic and functional reasons and final esthetic outcomes as well as patient-centered outcomes regarding postoperative discomfort and patient satisfaction are critical to patient acceptance of therapies. Techniques to reduce postoperative discomfort and improve esthetic outcomes have been described in the literature,[1,2,16] but remain technique-sensitive, time-consuming, and may not consistently deliver ideal outcomes. The technique presented in this report allows for full-thickness recipient site preparation, which has been demonstrated to be less time consuming than partial-thickness flap elevation and may result in decreased intrasurgical time.[20] The present case report uses a simplified access and recipient site preparation as well as soft tissue allograft that may decrease intrasurgical time, and thus, secondary surgical site morbidity and allow for graft and flap advancement to improve root coverage and esthetic outcomes compared to other techniques to achieve root coverage. This step-by-step approach to the technique can be abbreviated as the side access mucosal releasing incision (SAMRI) technique, which allows a blueprint of the approach.

Although other approaches to achieve root coverage using a vestibular approach have been described, these approaches differ slightly from the technique described in this report.[13,14,21,22] The VISTA technique has been described to include root conditioning with 24% buffered ethylenediaminetetraacetic acid gel,** positioning of a collagen membrane soaked in recombinant human platelet-derived growth factor (rhPDGF-BB) over the exposed root surfaces, a suturing technique that uses suture fixation on coronal tooth surfaces with composite to insure coronal positioning, and postsuturing placement of β-tricalcium phosphate (β-TCP) and rhPDGF-BB over root dehiscences.[14] Many of these components are omitted in the SAMRI technique, which may allow for significant reduction of intrasurgical time. In the procedure presented in this report, the simplified flap elevation, graft placement, and suturing technique described here can reduce surgical time. There is also data to suggest that no statistically significant difference in root coverage can be noted based on differing suturing protocols,[23] so simplification of suturing should be undertaken if it can reduce surgical time while still achieving optimal results. Additionally, the use of ADM in the SAMRI technique allows for avoidance of a second surgical site when compared with autogenous grafting. In this manner, ADM may serve as a soft tissue substitute with outcomes most similar to those achieved with subepithelial connective tissue grafts (SCTGs) without the additional morbidity associated with a SCTG harvest.[2]

Mean root coverage for CAF with ADM at Miller Class I and II gingival recession defects has been reported in systemic reviews as ranging from 83% to 99%.[1,24–26] It has also been estimated that the addition of ADM with CAF improved root coverage outcomes 15.6% over CAF alone.[1] Further, consistently achieving complete root coverage at all affected sites can be limited by multiple adjacent recession defects, pre-operative width of keratinized tissue, initial recession depth, exposed root surface area, and surgical technique.[27,28]

Many factors may be associated with patient acceptance of this technique, including postoperative analgesic and anti-inflammatory and corticosteroid therapy, decreased intrasurgical time, and gingival suture location. Given the emphasis on patient acceptance, patient-centered outcomes, and esthetic success, the technique presented here may allow practitioners to provide improved esthetic and functional root coverage for patients while limiting postoperative morbidity and esthetic compromise at buccal recession defects. Future comparative research studies may be undertaken to identify optimal clinical scenarios for the SAMRI technique and to quantify clinical, esthetic, and patient-centered treatment outcomes.

Conclusions

Within the limitations of this case report, it can be concluded that the novel SAMRI technique is a simple protocol that may allow for decreased intrasurgical time and is capable of achieving optimal clinical and esthetic outcomes for patients with recession defects.

**Prefgel; Straumann, Basel, Switzerland.

Summary

Why is this case new information?	■ By using an offset vertical vestibular incision subperiosteal tunnel access, improved release and extension of the flap laterally may be achieved without interruption of gingival and papillary architecture even in the presence of prominent anatomical structures and with a decreased risk of disrupting blood supply to tissues that are overlying the ADM graft. ■ This case describes a less invasive surgical approach with improved patient morbidity and acceptance using acellular dermal matrix, growth factors if deemed necessary because of clinical presentation, and vestibular incisions resulting in complete root coverage and high levels of patient satisfaction.
What are the keys to successful management of this case?	■ Adequate soft tissue release must be achieved to allow for placement of the soft tissue graft within a passive tunnel created by the surgeon. ■ The graft and overlying full thickness flap must be coronally advanced without tension to a position at or above the cemento-enamel junction. ■ Graft immobility is critical for success and the graft tissue must be adherent to the underlying bone, root surfaces, and periosteum without space that may allow for accumulation of blood during the healing phase.
What are the primary limitations to success in this case?	■ Patient compliance with postoperative instructions is critical to the successful outcome in this case. Patients should be instructed not to manipulate the surgical tissues with eating or brushing, minimal rigorous physical activity should be observed to allow for stabilization of the blood clot during initial healing, and behavior modification to remove initiating factors, including factitious habits and vigorous toothbrushing should be advised. ■ Sutures must remain in place and intact for the initial 6 weeks of healing. ■ Interproximal bone height is critical to ultimate outcomes and complete root coverage cannot be anticipated at Miller Class III and IV defects.

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○ indicates key references.

Decision Making for Soft and Hard Tissue Augmentation in Surgically Facilitated Orthodontics

Thanos Dounis* and Lillie M. Pitman*

Introduction: The purpose of this article is to present a decision-making algorithm for soft and hard tissue augmentation in surgically facilitated orthodontics (SFOT).

Focused clinical question: What type of hard and soft tissue augmentation is recommended in surgically facilitated orthodontics (SFOT)?

Summary: In cases where there is adequate hard and soft tissue envelope, selective corticotomies may be adequate. In cases where the existing hard and soft tissue anatomy is inadequate, hard and soft tissue augmentation is recommended. Also, hard and soft tissue augmentation is recommended to avoid teeth extractions during orthodontics.

Conclusion: This decision-making process allows the clinician to select between hard and soft tissue augmentation protocols based on projected tooth movement as well as existing soft and hard tissue architecture in SFOT cases. *Clin Adv Periodontics* 2020;10:38–41.

Key Words: Orthodontics; surgically facilitated orthodontics; tissue grafts.

Background

Seibert and Lindhe classified periodontal biotypes based on the appearance of gingiva as thick-flat versus thin scalloped,[1] whereas Mandelaris et al. classified dentoalveolar bone phenotypes based on the thickness of the crestal and radicular zones using CBCT imaging data, respectively.[2] For the purposes of this article, the gingival phenotype and the presence of dehiscence and fenestrations will be taken into account for our decision-making process. Selective corticotomies have been reported as adjuncts to traditional orthodontics by Bryan.[3] The technique was introduced by Kole in 1959[4] and was streamlined by Wilcko et al. in 2001.[3] Kole described as corticotomies to allow for en block movement of the teeth. Wilcko et al. described a protocol that consists of buccal and lingual or palatal corticotomies after full-thickness flaps were elevated. Additional onlay grafting was described to increase the existing envelope in which teeth can move and avoid bone dehiscence or fenestrations that may compromise the long-term periodontal stability.[2,3] The rationale for corticotomies is based on the production of a regional acceleratory phenomenon (RAP) that was initially described by Frost.[5] Transient osteopenia around roots induces a more rapid tooth movement.[3,5,6] Literature suggests an accelerated rate of tooth movement three to four times compared to the normal rate without corticotomies.[7] The purpose of this article is to present a decision-making algorithm for soft and hard tissue augmentation in surgically facilitated orthodontics (SFOT) based on existing hard and soft tissue architecture and projected root movement. Augmentation of soft and hard tissue in conjunction with corticotomies allows for an increase of periodontal tissues and counteracts potential deleterious effects of orthodontic forces. Deleterious effects include postorthodontic alveolar dehiscence and fenestrations as well as gingival recession. Additionally, by taking advantage of the RAP effect, the duration of orthodontic treatment is reduced. In certain cases, periodontal augmentation can make it possible to avoid extractions during expansive orthodontic movement.[3]

Decision Process

A decision tree that summarizes the augmentation strategy is described (Figure 1). This decision-making tree for hard and soft tissue augmentation is based on existing anatomy and projected tooth movement. Existing anatomy and determination of dehiscence and/or fenestrations present is accomplished by means of pre-operative cone beam computed tomography (CBCT) while projected tooth movement is determined by the orthodontist based on occlusal and facial esthetic outcome goals. Communication with the orthodontist to determine projected tooth movement is imperative for success. That communication can potentially be further enhanced by use of digital technology that allows visualization of the projected movement of not only crowns but also roots of teeth in the existing alveolus. Such visual information can be shared with the surgeon in order to provide specific information on where to perform corticotomies to facilitate and enable

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This article was modified on 2 April 2020, after first online publication: "SFOT" was replaced with "Corticotomies" in the far left blue panel in Figure 1 on page 39. Legends were added to Figures 2, 3, and 4 on page 40.

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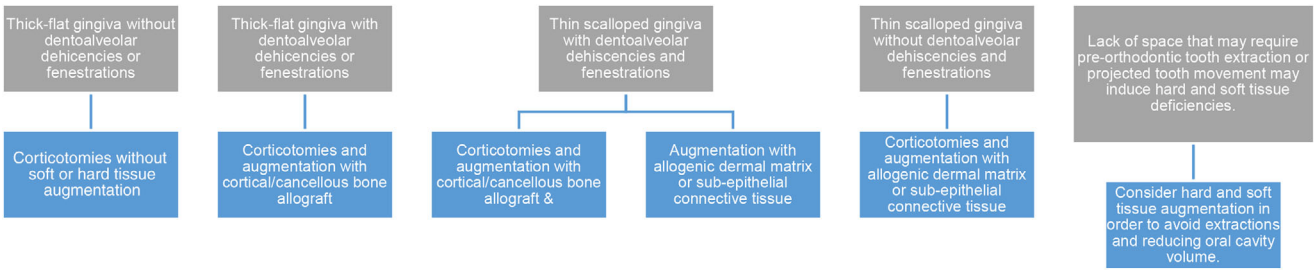

FIGURE 1 Decision tree diagram.

tooth movement without exceeded orthodontic boundary conditions detrimental to the periodontium.

In patients that present with a flat-thick gingiva as well as no apparent dehiscences and fenestrations from pre-operative CBCT, no augmentation may be needed if the existing envelope of planned orthodontic therapy can sustain the limits of tooth movement. In this situation, it is unlikely that extractions would be necessary to achieve the desired results. In these cases, non-augmentative SFOT can be considered to accelerate orthodontic movement. Non-augmentative SFOT consisted of techniques such as micro-osteoperforations and Piezocision. On patients that present with either dento-alveolar dehiscence or fenestrations or thin scalloped gingival biotype, hard and soft tissue augmentation should be considered to provide long-term periodontal stability and avoid postorthodontic gingival recession. In cases where the existing osseous envelope cannot accommodate ideal tooth movement and position, gingival recession and bone loss may occur.[8] Most importantly, there is emerging evidence that reducing oral cavity volume by retraction with or without extractions may have long-lasting deleterious effects such as trending patients towards sleep disordered breathing conditions.[9] Increasing the envelope of orthodontic tooth movement facilitated by SFOT may allow for anterior tongue posturing which may optimize conditions to improve apnea-hypopnea indices (AHI) in some patients which can positively influence systemic health parameters such as heart rate during sleep. In such cases, hard and soft tissue augmentation should strongly be considered in the context of a treatment plan that allow for expansion to occur safely and predictably.

Clinical Scenarios

All patients provided verbal and written informed consent prior to any procedures performed.

Case 1

Flat-thick gingival biotype and no apparent dento-alveolar dehiscence or fenestration. Eighteen-year-old Asian male presents at the authors' private clinic in March 2018. Patient presents with flat-thick gingival biotype and no apparent dento-alveolar dehiscence or fenestrations based on preoperative cone-beam CT. Procedure took place under intravenous moderate conscious sedation using midazolam and fentanyl. Vitals monitoring, capnography, and electrocardiography were recorded throughout the procedure. Anesthesia was achieved using block injections with articaine HCI 4% with epinephrine 1:100,000 injection and bupivacaine HCl 0.5% and epinephrine 1:200,000 injection, USP. Intrasulcular incisions took place on the buccal of all teeth. Full-thickness flaps were elevated beyond the muco-gingival junction. Corticotomies took place under irrigation using a carbide bone cutter with a 1 mm diameter.[†] Corticotomies penetrated the entire depth of the cortical plate between the tooth roots. All necessary precautions were taken to avoid injuring the roots. No hard or soft tissue grafting took place and flaps were replaced and secured with dPTFE 5.0 and 3.0 sutures in individual sling fashion.[‡] Care was taken to avoid gingival impingement by adjusting orthodontic trays (**Figures 2a through 2e**). Postoperative medication included ibuprofen and acetaminophen, amoxicillin 500 mg/tid and chlorhexidine 0.12% w/v mouthwash. Patients (cases 1, 2, and 3) were instructed to follow a soft diet for 1 week. Active movement using trays started within 7 to 10 days. Orthodontic movement consisted mainly of expansion.

Case 2

Thin scalloped gingival biotype with gingival recession and dento-alveolar dehiscence and fenestrations. Patient presents at authors' private clinic in February 2018. Clinical steps took place as in Case 1, although cortical-cancellous freeze-dried bone allograft[§] was used as a first layer over corticotomies followed by acellular allogenic dermal matrix.[‖] In this case, autogenous blood harvesting took place and following Choukroun's protocol, A- PRF and i-PRF was created.[10] A-PRF membranes were cut into small pieces and mixed with the allograft and injectable PRF was also used to on the bone allograft. The layers of ADMA were placed as an onlay on the bone graft layer. Several mattress sling periosteal sutures were used to secure the dermal matrix just below the CEJ of the teeth, proving stability on the underlying bone graft layer. Flaps were coronally advanced and secured with dPTFE 5.0 and 3.0 sutures in individual sling fashion. See **Figures 3a through 3f**. Active movement using trays started within

[†]H141, Komet USA, Rock Hill, SC.

[‡]Cytoplast, Osteogenics Biomedical, Inc., Lubbock, TX.

[§]MinerOss, BioHorizons, Birmingham, AL.

[‖]OrAcell, LifeNet Health, Virginia Beach, VA.

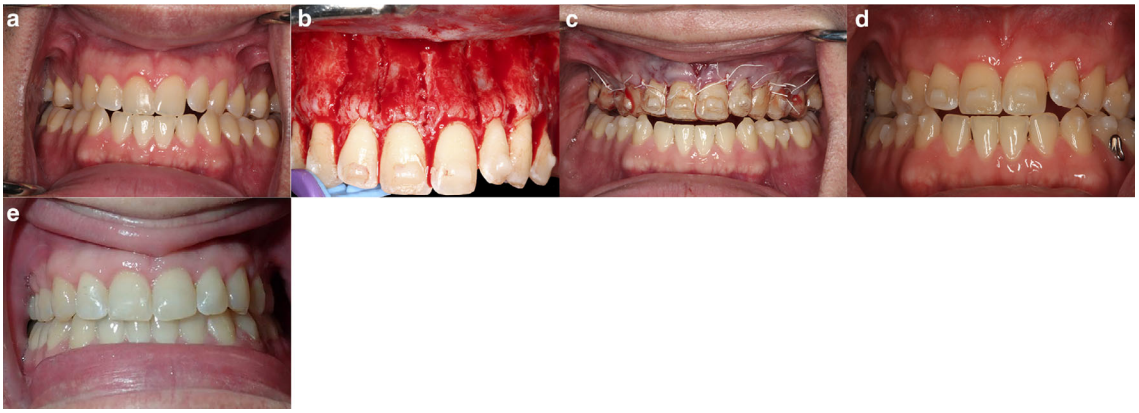

FIGURE 2 a-e Case 1. Flat-thick gingival biotype and no apparent dentoalveolar dehiscences or fenestrations. Projected tooth movement will not induce soft and hard tissue deficiencies. Selective corticotomies between teeth are noted. No grafting took place, and trays were adjusted. Healing at 2 weeks (**2d**) and 1 year (**2e**) showing robust periodontal architecture.

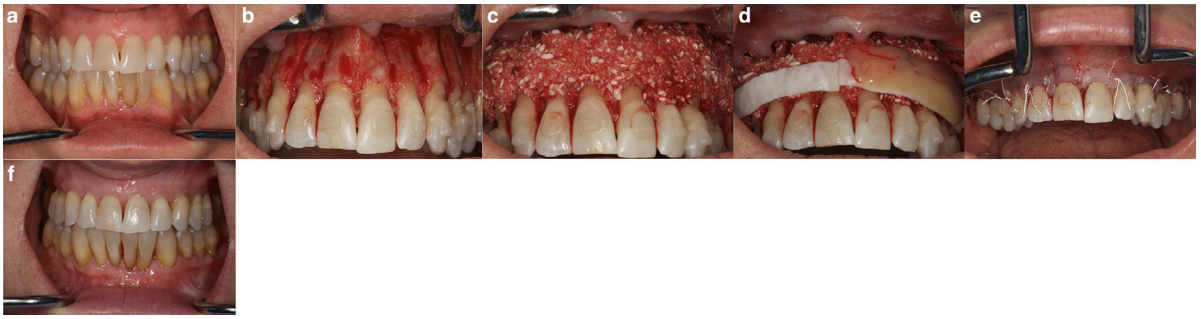

FIGURE 3 a-f Case 2. Thin scalloped gingival biotype with recession. Dentoalveolar dehiscences and fenestrations are present. Platelet-rich fibrin–infused cortical cancellous allograft placed on crestal and radicular dentoalveolar zones. Also, allogenic dermal matrices placed above the particulate graft. In Figure 3d, a PRF membrane is placed on top of dermal matrix. Figure 3f presents condition at 1 year.

FIGURE 4 a-f Case 3. Lack of space and projected tooth movement have the potential to induce hard and soft tissue deficiencies. Cortical cancellous allograft followed by allogenic dermal matrix was used, and flaps were coronally advanced. Figure 4f presents condition at 1 year. Patient is still under active treatment.

7 to 10 days. Orthodontic movement consisted mainly of expansion and alignment.

Case 3

A 25-year-old Caucasian male presented in our clinic in May 2018. Lack of space and projected tooth movement has the potential to induce hard and soft tissue deficiencies. Clinical steps took place as before with hard and soft tissue augmentation without the use of platelet rich-fibrin. See **Figures 4a through 4f**. Active movement using trays started within 7 to 10 days. Orthodontic movement consists mainly of expansion of both arches and alignment of the maxillary arch to reduce overbite and overjet.

Discussion

Several studies have examined the incidence of dehiscence or fenestrations around teeth.[11–13] A dry skull study reported that in 146 dentate skulls, dehiscences were present in 40%, whereas fenestrations were present in 62%.[11] A CBCT study indicated dehiscence prevalence ranging from 6.5% to 8.5% depending on vertical growth pattern whereas fenestrations were present in 2.8% to 3.6% of examined subjects.[12] This significant discrepancy in reported prevalence maybe a function of the study design in which dehiscence and fenestrations are more readily identifiable on dry sculls versus CBCTs. Thus, many times intrasurgically the clinician may

identify dehiscence and fenestrations that were not visible in the preoperative CBCT. A CBCT study by Januario et al. indicated that 50% of anterior maxilla sites had a mean labial bone thickness of <0.5 mm.[13] Traditional orthodontics may be limited by the existing osseous architecture especially in cases in which significant crowding is present.[8] Mandelaris classified crestal and radicular bone phenotypes according to thickness in an effort to predict the need for preorthodontic periodontal augmentation.[2] In cases in which the existing osseous envelope cannot accommodate ideal tooth movement and position, gingival recession and bone loss may occur.[8] Richman showed a direct association between significant recession and alveolar bone dehiscence.[14] SFOT is a multidisciplinary approach that allows enhancement of the existing soft and hard tissue architecture by enlarging the available envelope of orthodontic movement and reducing the chance for unfavorable iatrogenic sequalae such as recession. Selective corticotomies induce transient osteopenia and a RAP that has been shown to accelerate tooth movement by three to four times whereas they have been shown to have favorable blood supply effects on guided bone regeneration in humans.[6,7,15]

Conclusion

This decision-making process allows the clinician to select between hard and soft tissue augmentation protocols based on projected tooth movement as well as existing soft and hard tissue architecture in surgically facilitated orthodontics (SFOT) cases. On patients who present with robust gingiva and osseous support, no augmentation is needed if the existing envelope can support the required tooth movement. On patients who present with dentoalveolar dehiscence or fenestrations or thin gingiva, hard and soft tissue augmentation should be considered to provide long-term periodontal stability. Communication with the orthodontist to determine projected tooth movement is imperative for success. That communication can potentially be further enhanced by use of digital technology that allows visualization of the projected movement of not only crowns but also roots of teeth in the existing alveolus. Such visual information can be shared with the surgeon to provide specific information on where to perform corticotomies to enable movement as well as where hard and soft tissue grafting is needed. The proposed decision-making matrix is based on clinical impression and requires further validation as new data and evidence becomes available.■

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Rational Prophylactic Antibiotic Selection for Sinus Elevation Surgery

Joshua A. Akers,* Thomas M. Johnson,* Richard B. Hill* and Sachiyo Kawaguchi†

Focused Clinical Question

For a generally healthy patient with no risk indicators for postoperative infection, what is the most appropriate perioperative antibiotic regimen for sinus elevation surgery in terms of reducing postoperative infection risk and minimizing untoward effects?

Clinical Scenario

A 38-year-old female patient in good general and periodontal health presents missing tooth #14 (Fig. 1). She reports no systemic conditions, no history of sinusitis, and no allergies. Medications include acetaminophen and ibuprofen as needed for pain. The patient's dentition is minimally restored, with no active caries. Cone-beam computed tomography reveals a clear, pneumatized left maxillary sinus and inadequate bone volume to support dental implant placement (Fig. 2). No septa or pathologic lesions are present, the ostium appears patent, and no thickening of the Schneiderian membrane is appreciable. The patient states that she wants to replace her missing molar without restoring adjacent teeth (Figs. 3 and 4). *Clin Adv Periodontics* 2020;10:42–55.

Key Words: Antibiotic prophylaxis; amoxicillin-potassium clavulanate combination; doxycycline; maxillary sinus; maxillary sinusitis; surgical wound infection.

Background

Infection-related complications such as sinusitis, graft infection, abscess, and dehiscence with drainage occur in the early postsurgical period following sinus elevation surgery (SES) with reported incidences varying from 0% to 27%,[1–7] most reports falling on the lower end of this range.[2–7] Physicians recognize dental procedures and sinus surgery as predisposing factors for acute bacterial rhinosinusitis (ABRS).[8] Even so, patients are not uniformly susceptible to postoperative sinus infection.[6,9–13] Factors that have been associated with increased risk of acute infection following SES include smoking, immunocompromised status, uncontrolled diabetes, chronic sinusitis, and alcohol abuse.[6,9,13] Additionally, lack of proper aseptic surgical technique, unfavorable osteomeatal anatomy, and impaired sinus drainage may also increase postsurgical infection risk[1,8,11–13] and jeopardize therapeutic outcomes.[14] Infrequently, severe acute sinus infections can extend to adjacent vital structures, with pansinusitis, osteomyelitis, blindness, and neurologic morbidity identified as rare outcomes.[15–17] One severe complication is estimated to occur for every 95,000 hospital admissions for sinusitis.[15]

If preoperative screening reliably distinguished high- from low-risk patients, prophylactic antibiotics could be reserved for only those individuals most likely to experience postoperative infection. Unfortunately, postoperative sinus infection risk assessment criteria have not been defined and validated. Accordingly, studies investigating SES outcomes predominantly report use of a perioperative antibiotic (**Table 1**).[3,4,6,7,10,16] However, practitioners have not achieved consensus on the most appropriate perioperative SES antibiotic regimen, and widely accepted guidelines do not exist.

Search Strategy

A comprehensive literature search of the PubMed database was conducted in April 2019 with the following terms forming the basis of the search strategy (mh indicates MeSH heading, tw indicates text word, and ∗ indicates root word search): "sinus augmentation" (mh) OR "maxillary sinus/surgery" (mh) OR "sinus elevation surgery" [tw] OR "sinus lift" [tw] AND ("antibacterial agents" (mh) OR "antibiotic prophylaxis" (mh) OR "anti-infective agents" (mh) OR amoxicillin∗ [tw] OR β-lactam∗ [tw] OR fluoroquinolone∗ [tw] OR

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This article was modified on 2 April 2020, after first online publication: The "before" and "after" images on page 42 were removed, as these types of images are not used on the first page of Best-Evidence Topic articles. These two images are depicted as Figures 1 and 4 on page 43.

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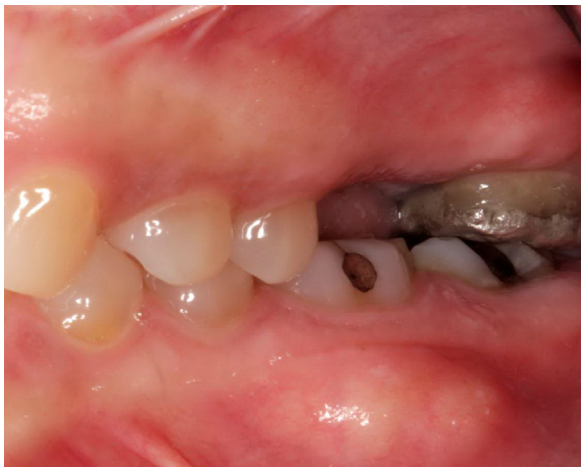

FIGURE 1 Baseline clinical appearance (example sinus elevation case). The patient is a healthy 38-year-old female missing tooth #14. Inadequate bone volume is present for dental implant placement due to pneumatization of the left maxillary sinus.

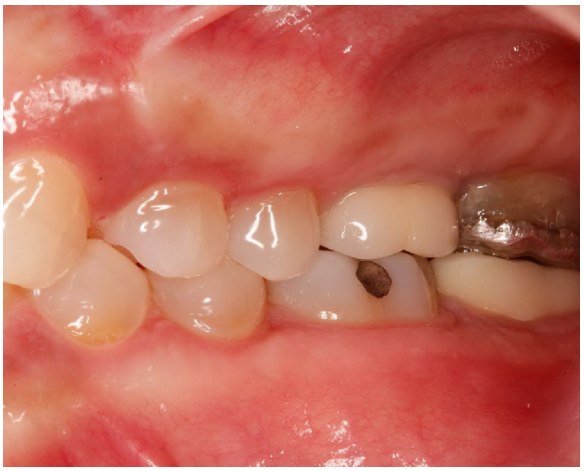

FIGURE 4 Definitive implant-supported restoration, tooth #14.

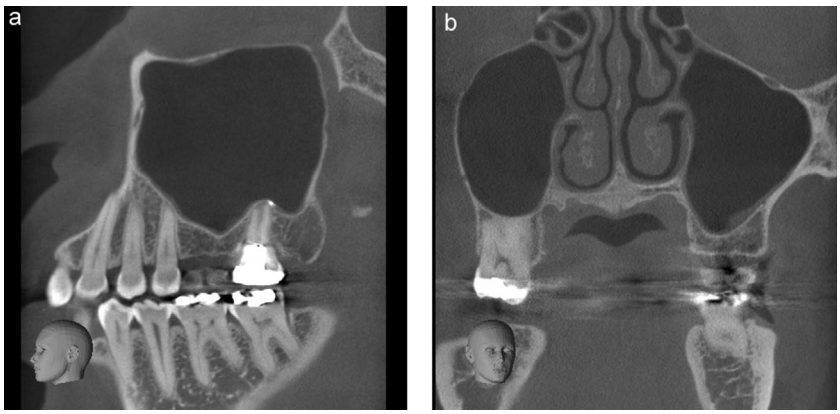

FIGURE 2 Preoperative cone-beam computed tomography images. **2a** Sagittal view. **2b** Coronal view.

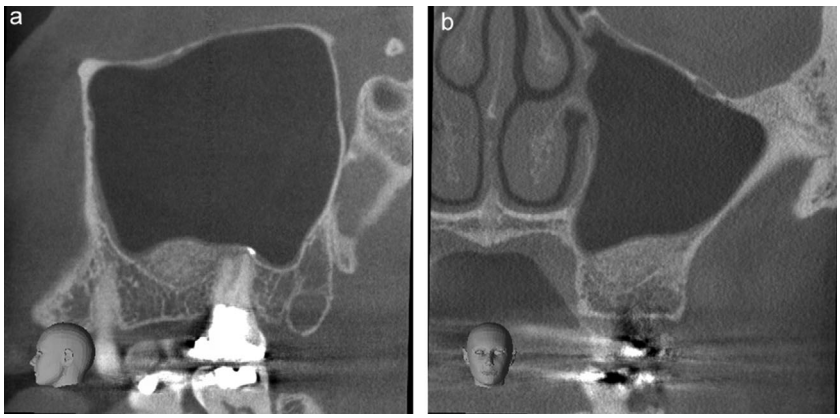

FIGURE 3 Cone-beam computed tomography images at postoperative month 6. **3a** Sagittal view. **3b** Coronal view.

cephalosporin*[tw] OR macrolide* [tw] OR clindamycin [tw] OR infection*[tw]).

Search Outcome

Twenty-one abstracts were manually reviewed, all of which were selected for full-text examination. Review of bibliographies within these articles, and subsequent recursive application of that protocol, led to the procurement of 37 additional articles for full-text review. Eighteen articles were included in this study. Given the absence of direct evidence for antibiotic prophylaxis before SES, inclusion criteria were expanded to incorporate papers of all levels of evidence, including expert opinion. Publications providing indirect evidence for appropriate prophylactic antibiotic regimens (e.g., studies testing antibiotic sensitivity in sinusitis patients) were also included (Table 2).[5,8,17–27,30–35] Studies that merely reported use of perioperative antibiotics for SES or associated postsurgical complications were excluded, as these reports neither provided rationale for antibiotic selection nor sought to specifically justify use of one antibiotic over another.[1–4,6,7,10–12,14,16,36–38]

Discussion

The search strategy described in this report identified no clinical trials in which SES patients were randomized by perioperative antibiotic, no controlled prospective studies, and no systematic reviews comparing treatment outcomes when various SES antibiotic regimens were used. Currently, practitioners must base perioperative antibiotic selection on indirect evidence and expert opinion. For a patient lacking factors that predispose toward postoperative infection, the best available evidence is consistent with a 7-day course of twice-daily amoxicillin/clavulanate 875/125 mg or doxycycline 100 mg as antibiotic prophylaxis, starting

TABLE 1 Representative Perioperative Antibiotic Regimens Reported for Sinus Elevation Surgery

Reference	Patient Group	Study Type (Level of Evidence)	Methods	Perioperative Antibiotic Regimen	Time to Onset of Symptoms (days)	Key Results / Conclusions	Comments
Urban et al. 2012[3]	n = 198 (274 sinus grafts).	Prospective analysis	Incidence of graft infection following SES was reported. Graft infection management and treatment outcomes were documented.	AMX 2 g, 1 hour prior, then 500 mg TID for 7 days or CLI 600 mg, 1 hour prior, then 300 mg QID for 7 days.	7 to 21	Sinus graft infection in 8 of 274 sinus grafts (2.3%).	Patients experiencing graft infection received surgical removal of the infected portion of the graft and locally applied DCN, then AMC 1 g BID for 7 days. All patients healed uneventfully.
Moreno Vazquez et al. 2014[4]	n = 127 (202 sinus grafts).	Retrospective analysis	Prevalence and types of SES complications were reported. Investigators also assessed effects of patient-, site-, and surgery-related factors on complication prevalence.	Preoperative: AMC (IV), dose not specified. Postoperative: AMC (PO) for 8 days, dose not specified.	Not reported.	Infection, abscess, dehiscence with drainage, or sinusitis in ≈12% of patients.	Study did not include microbiologic examination or antibiotic sensitivity testing.
Barone et al. 2006[6]	n = 70 (124 sinus grafts).	Prospective analysis	Therapeutic outcomes were assessed, and incidences of intraoperative and postoperative complications were reported.	Preoperative: CEPH 2 g (IV). Postoperative: CEPH 2 g (PO) daily for 5 days.	Not reported.	Infection with suppuration reported in ≈6% of patients 3 to 5 weeks after treatment.	Smoking and onlay bone grafting were associated with postoperative infection. Two of 7 patients with postoperative infection ultimately required endoscopic surgery.
Sakkas et al. 2016[7]	n = 99 (105 sinus grafts).	Retrospective analysis	Postoperative effects of Schneiderian membrane perforation during sinus augmentation were evaluated.	AMC 2.2 g (IV) or CLI 600 mg (IV) 30 minutes prior. Symptoms: AMC 3 g daily for 5 days.	7 to 21	Abscess or maxillary sinusitis in six of 99 patients (6.1%).	Study did not include microbiologic examination or antibiotic sensitivity testing.
Beltramini et al. 2013[10]	n = 1.	Case report	Microbiologic examination and case management were reported for a patient with infection following sinus elevation surgery.	Postoperative CLR 500 mg BID for 15 days. Symptoms: LVX 500 mg (IV) BID.	Not reported.	Authors recommended surgical intervention for acute postoperative sinusitis.	Infection was associated with *Gemella morbillorum*.
Chirilă et al. 2016[16]	n = 116 (151 sinus grafts with simultaneous implant placement).	Retrospective analysis	Acute sinusitis incidence following sinus elevation surgery was reported.	Postoperative CLI 300 mg TID for 5 days.	≈21 to 60	Sinusitis occurred in five patients (4.3%).	Management of postoperative sinusitis entailed sinus graft removal, irrigation of the sinus cavity with MTZ solution, and a 10-day course of MTZ and CLI (dosing not specified).

AMC = amoxicillin/clavulanate; AMX = amoxicillin; BID = twice daily; CEPH = cephalosporin (specific agent not specified); CLI = clindamycin; CLR = clarithromycin; DCN = doxycycline; IV = intravenous; MTZ = metronidazole; PO = per os (oral administration); QID = four times per day; SES = sinus elevation surgery; TID = three times per day.

TABLE 2 **Search Outcome: Indirect Evidence Relevant to Antibiotic Prophylaxis Before Sinus Elevation Surgery**

Reference	Patient/Sample Group	Study Type (Level of Evidence)	Methods	SES Perioperative Antibiotic Regimen/ABRS Treatment Protocol	Key Results	Comments
Testori et al. 2012[5]	Not applicable.	Expert opinion	Literature review and expert panel consensus on prevention of SES complications.	AMC 1 g BID starting 24 hours prior, followed by AMC 1 g TID for 7 days. or CLR 250 mg BID plus MTZ 500 mg TID for 7 days, starting 24 hours prior.	The authors proposed a 19-point list of recommendations for reducing incidence of complications following SES.	The panel included experts in anatomy, physiology, periodontology, otolaryngology, oral and maxillofacial surgery, and other disciplines.
Aring and Chan 2016[8]	Not applicable.	Expert opinion	Literature review and summary of practice guidelines for management of adult acute rhinosinusitis.	First-line: AMX 500 mg TID for 10 days. BLPOs: AMC 1 g BID for 5 to 10 days. Penicillin allergy or second line: DCN 100 mg BID for 5 to 10 days. or LVX 500 mg daily for 10 to 14 days.	*S. pneumoniae*, *H. influenzae*, and *M. catarrhalis* are most commonly associated with ABRS. Dental infections and procedures can predispose patients to ABRS. RFQ should be reserved for patients who lack other treatment options.	For treatment failure following initial antibiotic therapy, the authors recommend high-dose AMC (2g/125 mg BID for 10 days), a RFQ, or CLI plus third generation CEPH.
Patel and Hwang 2018[17]	Not applicable.	Expert opinion	Literature review and recommendations for treatment of uncomplicated ABRS.	No risk for pneumococcal resistance: AMX 500 mg TID or AMC 1g BID for 5 to 7 days. Risk for pneumococcal resistance: AMC 2 g/125 mg ER BID for 5 to 7 days. Penicillin allergy: DCN 100 mg BID for 5 to 7 days or LVX 500 mg daily for 5 to 7 days.	ABRS treatment recommendations.	The recommended algorithm involves four antibiotics: AMX, AMC, DCN, and LVX. Recommendations are consistent with prophylactic AMC or DCN before SES.
Carreño Carreño et al. 2018[18]	n = 174. Asymptomatic patients underwent SES with no prophylactic antibiotics.	In vitro microbial characterization and antibiotic sensitivity study	Microbial samples collected from the maxillary sinus floor during SES were cultured, characterized, and subjected to antibiogram analysis.	Not applicable.	Approximately 18% of cultures were positive for bacteria, with 45% belonging to the *Streptococcus* genus. The composite bacterial isolates were most resistant to macrolides and most susceptible to AMC, AMP, and CIP.	The authors conclude that AMC, AMP, and CIP should be considered as first-line prophylactic antibiotics for maxillary SES.

(Continued)

TABLE 2 (Continued)

Reference	Patient/Sample Group	Study Type (Level of Evidence)	Methods	SES Perioperative Antibiotic Regimen/ABRS Treatment Protocol	Key Results	Comments
Wald and DeMuri 2018[19]	Not applicable.	Expert opinion	Literature review and recommendation for empiric antibiotic selection in pediatric ABRS.	Children with ABRS: AMC 45 mg/kg/d in two divided doses of 400 mg/57 mg.	Given the increasing prevalence of BLPOs in ABRS, AMC was recommended over AMX for treatment of ABRS in children.	The authors call for a change in guidelines for initial empiric antibiotic management of ABRS in children based on updated microbiologic data. This publication presents revised recommendations from the lead author's 1986 study, which documented no difference in efficacy of AMX and AMC in the treatment of ABRS in children.[20]
Chow et al. 2012[21]	Not applicable.	Expert opinion	Literature review and expert panel consensus on ABRS treatment.	First line: AMC 1g BID for 5 to 7 days. β-lactam allergy: DCN 100 mg BID or 200 mg daily for 5 to 7 days. or LVX 500 mg daily or MXF 400 mg daily for 5 to 7 days.	IDSA clinical practice guidelines for treatment of ABRS. AMC and DCN are appropriate first-line antibiotics in treatment of ABRS.	Panel included experts in internal medicine, pediatrics, emergency medicine, otolaryngology, public health, epidemiology, and infectious disease. Recommendations are consistent with prophylactic AMC or DCN before SES.
Puglisi et al. 2011[22]	n = 59. Patients with chronic maxillary sinusitis.	In vitro microbial characterization and antibiotic sensitivity study	Specimens were aseptically acquired via antral puncture during endoscopic sinus surgery before antibiotic administration. Antibiogram analysis was performed on all bacterial cultures.	Not applicable.	Mixed aerobic/anaerobic cultures were identified in most cases. *S. aureus* and *S. pneumoniae* were the predominant aerobes. No Gram-negative isolates were resistant to AMC, but significant β-lactamase production and penicillin resistance was observed among Gram-negative isolates.	This study reported high in vitro activity of AMC against gram-negative anaerobic isolates in chronic sinusitis patients. MXF demonstrated favorable antibacterial activity against both anaerobes and aerobes.

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TABLE 2 (Continued)

Reference	Patient/Sample Group	Study Type (Level of Evidence)	Methods	SES Perioperative Antibiotic Regimen/ABRS Treatment Protocol	Key Results	Comments
Arrieta et al. 2007[23]	n = 459. Adult acute sinusitis patients (226 MXF, 233 AMC).	Randomized clinical trial	ABRS patients were randomized to receive either AMC or MXF to compare the safety and efficacy of the two antibiotic regimens. Microbial samples were collected from 234 patients via sinus puncture or endoscopy for microbiological analysis.	AMC 500/125 mg TID for 10 days. or MXF 400 mg daily for 7 days.	Similar high clinical success rates (≈93%) and bacterial eradication rates of pre-therapy pathogens (≈97%) were reported for both MXF and AMC. Similar incidence of adverse effects was documented for AMC (30%) and MXF (32%), with gastrointestinal disturbances being the primary drug-related adverse event.	This study was funded by Bayer.
Kim et al. 2006[24]	n = 81. Chronic sinusitis patients.	In vitro microbial characterization and antibiotic sensitivity study	Aseptic sinus aspirations were performed at the time of endoscopic sinus surgery. The resulting bacterial isolates were cultured, characterized, and subjected to antibiogram analysis.	Not applicable.	*S. aureus*, *H. influenzae*, and *S. pneumoniae* were the most prevalent aerobes, whereas *Prevotella* and *Peptostreptococcus* species were the predominant anaerobes. Penicillin-resistant rates of 93% and 25% were reported for *S. aureus* and *S. pneumoniae*, respectively, and 46% of *H. influenzae* isolates were resistant to AMP.	This study underscores the role of BLPOs in the etiology of chronic sinusitis. Study conclusions are consistent with prophylactic AMC or DCN for SES.
Borges Dinis et al. 2004[25]	n = 20.	Pharmacokinetic study	ABRS patients received MXF before endoscopic sinus surgery. Tissue samples were collected at specified sinonasal sites intraoperatively, and MXF concentration levels at these sites were assayed.	MXF 400 mg 3 or 4 hours before surgery.	MXF was distributed extensively throughout the sinuses and was particularly concentrated in sinus cysts. Tissue-to-blood levels exceeded 4:1 at most sites, with concentrations well above MIC_{90} for a wide range of microorganisms.	A single dose of MXF exhibited excellent distribution within maxillary sinus mucosa.

(Continued)

TABLE 2 (Continued)

Reference	Patient/Sample Group	Study Type (Level of Evidence)	Methods	SES Perioperative Antibiotic Regimen/ABRS Treatment Protocol	Key Results	Comments
Poole 2004[26]	Not applicable.	Expert opinion	Literature review and expert panel consensus on ABRS diagnosis and treatment.	Initial therapy (mild sinusitis): AMC (1.75 to 4 g/250 mg daily), AMX (1.5 to 4 g daily), CEF, CER, or CED. Moderate sinusitis without prior antibiotics or mild sinusitis with prior antibiotics: RFQ or high-dose AMC.	TMP/SMX, DCN, AZN, CLR, ERN, or TEL may be considered for patients with β-lactam allergies. However, bacteriologic failure rates of 20% to 25% are possible.	This report is an update to the 2000 SAHP guidelines for diagnosis and treatment of ABRS. Guidelines are consistent with prophylactic AMC for SES.
Williams et al. 2003[27]	Not applicable.	Systematic review and meta-analysis	Cochrane review to assess effects of antibiotics in adults with acute sinusitis.	Not applicable.	At the time of this publication, limited evidence supported a 7- to 14-day course of PCN or AMX for treatment of acute sinusitis confirmed radiographically or by aspiration.	Updates[28,29] to this 2003 review did not specifically support AMX for treatment of ABRS, possibly due to increase in bacterial resistance. In the most current update, no antibiotic was found to be superior to another, and antibiotics were determined to have only a minor impact on treatment outcome for most ABRS patients.[29]
Gehanno et al. 2002[30]	n = 48. Adult chronic sinusitis patients (42 received MXF, 6 non-infected controls).	Pharmacokinetic study	Patients in the treatment groups received oral MXF for 5 days and were then randomly allocated to sinus tissue sampling 2, 3, 4, 6, 12, 24, or 36 hours post-dose.	MXF 400 mg daily for 5 days.	Tissue/plasma ratios were ≈200% between 2 and 6 hours and up to 329% at 36 hours. Tissue levels exceeded the MIC_{90} for the pathogens typically associated with ABRS.	Results support use of MXF for treatment of sinusitis. Study was funded by Bayer-Pharma, France.

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TABLE 2 (Continued)

Reference	Patient/Sample Group	Study Type (Level of Evidence)	Methods	SES Perioperative Antibiotic Regimen/ABRS Treatment Protocol	Key Results	Comments
Passàli et al. 2001[31]	n = 24. Adult chronic sinusitis patients.	Pharmacokinetic study	Patients received AMC 875/125 mg 2, 4, or 6 hours before sinus surgery and were evaluated for serum and sinus tissue distributions of AMX and CA.	Not applicable.	Both AMX and CA were well distributed in the sinus mucosa. Highest serum and tissue concentrations occurred 2 hours after administration. Tissue levels of both drugs remained above the MIC_{90} for the most common sinusitis pathogens 2 to 6 hours after administration.	Authors conclude that AMC 1 g BID should be effective in the treatment of chronic rhinosinusitis. Favorable tissue concentrations of AMX and CA were present even in inflamed mucosa. Conclusions are consistent with prophylactic AMC for SES.
Sepp and Julge 2000[32]	Not applicable.	Expert opinion	Literature review and expert panel consensus on ABRS diagnosis and treatment.	Initial therapy (mild sinusitis): AMC, AMX (1.5 to 3.5 g daily), CEF, or CER. Moderate sinusitis without prior antibiotics or mild sinusitis with prior antibiotics: AMC, AMX (3 to 3.5 g daily), CEF, or CER. Moderate sinusitis with prior antibiotics: AMC, RFQ, or combination therapy.	SAHP guidelines for diagnosis and treatment of ABRS. TMP/SMX, DCN, AZN, CLR, or ERN may be considered for patients with β-lactam allergies. However, bacteriologic failure rates of 20% to 25% are possible. Potentially fatal toxic epidermal necrolysis has been associated with TMP/SMX use.	Panel consisted of members of the SAHP in consultation with representatives of the CDC, FDA, and experts in infectious disease, microbiology, and clinical pharmacology. Guidelines are consistent with prophylactic AMC for SES.
Borges Dinis et al. 2000[33]	n = 23. Adult CRS patients.	Randomized pharmacokinetic study	Patients were randomly selected to receive AMC 875/125 mg 2, 3, or 4 hours before endoscopic sinus surgery. Tissue samples of sinonasal mucosa were collected and assessed for AMX and CA concentrations.	Not applicable.	AMX was detected in 95% of tissue samples in concentrations $> MIC_{90}$ of most common susceptible pathogens. Only half of sinus tissue samples demonstrated detectable levels of CA.	Authors favored AMC as a first-line therapy for treatment of ABRS, given that AMX demonstrates the greatest efficacy of any β-lactam against *S. pneumoniae*, and CA possesses reasonable, albeit unpredictable, tissue pharmacokinetics. Study conclusions are consistent with prophylactic AMC for SES.

(Continued)

TABLE 2 (Continued)

Reference	Patient/Sample Group	Study Type (Level of Evidence)	Methods	SES Perioperative Antibiotic Regimen/ABRS Treatment Protocol	Key Results	Comments
Goldstein et al. 1999[34]	Adult sinusitis patients (unspecified sample size).	In vitro microbial characterization and antibiotic sensitivity study	Bacterial isolates were obtained from adult sinusitis patients by antral sinus puncture and subjected to antibiogram analysis.	Not applicable.	69% of *Prevotella* isolates and 100% of *H. influenzae* isolates were β-lactamase producers. All *H. influenzae* strains were resistant to AMX, but susceptible to AMC. LVX demonstrated activity against most isolates with the exception of some peptostreptococci. Macrolide antibiotics exhibited variable activity against *H. influenzae* and *S. aureus.*	AMC exhibited the greatest activity against the spectrum of aerobic and anaerobic bacteria examined. This study was partially funded by Smith-Kline Beecham Corporation.
Brook et al. 1996[35]	n = 23. (10 individuals with acute sinusitis, 13 individuals with chronic sinusitis).	In vitro microbial characterization study	Sinus aspirates were acquired from patients undergoing Caldwell-Luc procedures for treatment of sinusitis. Microbial characterizations and β-lactamase activity assays of the associated sinus aspirates were performed.	Not applicable.	BLPOs were isolated in 40% and 70% of patients with acute and chronic sinusitis, respectively.	Detection of β-lactamase activity in sinus aspirates provides support for the role of BLPOs in failure of penicillin therapy for sinusitis.

ABRS = acute bacterial rhinosinusitis; AMC = amoxicillin/clavulanate; AMP = ampicillin; AMX = amoxicillin; AZN = azithromycin; BID = twice daily; BLPO = β-lactamase producing organism; CA = clavulanate; CDC = Centers for Disease Control; CED = cefdinir; CEF = cefpodoxime proxetil; CEPH = cephalosporin; CER = cefuroxime axetil; CIP = ciprofloxacin; CLI = clindamycin; CLR = clarithromycin; DCN = doxycycline; ER = extended release; ERN = erythromycin; FDA = Food and Drug Administration; IDSA = Infectious Diseases Society of America; IV = intravenous; LVX = levofloxacin; MIC_{90} = minimum inhibitory concentration required to inhibit the growth of 90% of organisms; MTZ = metronidazole; MXF = moxifloxacin; PCN = penicillin; PO = per os (oral administration); QID = four times per day; RFQ = respiratory fluoroquinolone; SAHP = Sinus and Allergy Health Partnership; SES = sinus elevation surgery; TEL = telithromycin; TID = three times per day; TMP/SMX = trimethoprim/sulfamethoxazole.

TABLE 3 Recommended Sinus Elevation Antibiotic Prophylaxis Regimens

	Prophylaxis
No penicillin allergy	Amoxicillin/clavulanate, 875/125 mg twice daily for 7 days, start 24 hours before procedure, 14 tablets
Penicillin allergy	Doxycycline, 100 mg twice daily for 7 days, start 24 hours before procedure, 14 capsules

24 hours before SES (Table 3). This recommendation is congruent with published opinions from multiple experts,[8,17,19] in addition to guidelines proposed by expert panels for ABRS treatment[21,26,32] and SES antibiotic prophylaxis.[5] Similar regimens are common prescriptions for outpatient treatment of uncomplicated ABRS.[8,15,17,19,21] Furthermore, a pharmacokinetic study,[31] microbiologic characterization studies involving sinusitis patients,[18,22,24] and a clinical investigation of medical sinusitis management[23] all indirectly support the described approach. A Cochrane review[27] of antibiotic effects in acute sinusitis treatment, when considered together with subsequent updates,[28,29] suggests that amoxicillin alone may no longer represent a sound choice for SES antibiotic prophylaxis, owing to increased rates of penicillin-resistant microorganisms. It should be noted that, in addition to amoxicillin/clavulanate[1,4,7] and doxycycline,[38] practitioners have used perioperative amoxicillin,[2,3,36–38] clindamycin,[2,3,7,12,16] cephalosporins,[1,6,11] metronidazole,[12,16] tetracycline,[12,38] clarithromycin,[10] and levofloxacin[10] for SES or as treatment for postoperative sinus graft infection. For SES, perioperative antibiotics have been delivered locally,[3,16,38] orally,[1–4,6,7,10–12,16,36–38] or intravenously.[4,6,7,10]

Although direct evidence to validate amoxicillin/clavulanate and doxycycline as optimal medications for antibiotic prophylaxis before SES does not exist, these agents are justified in the setting of SES based on established principles of anti-infective therapy, available data on the target microbial profile, and target bacteria antibiotic susceptibility.

Principles of Anti-Infective Therapy

When prescribing an antimicrobial therapy for any reason, practitioners should give primary consideration to the target microbial profile. The microbes present should be empirically susceptible to the selected agent if susceptibility testing is not practical.[39] The dose should be high enough to reach therapeutic concentration at the site while balancing the need to minimize toxicity and side effects.[39] Ideally, clinicians should use the shortest effective antibiotic duration, and a single agent is preferred over multidrug therapy unless the target infection justifies combining medications.[39]

Target Bacteria

The term rhinosinusitis has largely replaced *sinusitis*, because the nasal mucosa is almost always inflamed when maxillary sinusitis is present.[15] Most sinus infections are caused by viruses,[8,15,17] but it is well accepted that *Haemophilus influenzae*, *Streptococcus pneumonia*, *Moraxella catarrhalis*, and *Staphylococcus aureus* are the bacterial species most associated with ABRS.[8,15,17,26,32] These species are also isolated from non-inflamed maxillary sinuses.[40] Bacterial contamination of graft material during SES may arise from two different sources—the oral cavity or the maxillary sinus—each source representing a distinct microbiota.[15,40,41] Surgical access to the antrum through the lateral maxillary sinus wall may allow entry of bacteria from the oral cavity, and intraoperative perforation of the Schneiderian membrane, a complication detected in up to 60% of cases,[2,4,6,7,42] may permit graft access to commensal species in the maxillary sinus. In perspective, graft contamination during SES may be inevitable.[18,41]

Whether ABRS and acute postsurgical sinus infection exhibit similar microbiology is unclear. However, distinct forms of maxillary sinusitis do exist.[15,22,43–47] ABRS, chronic rhinosinusitis (CRS), acute exacerbation of chronic rhinosinusitis (AECRS), and sinusitis of odontogenic origin are all manifestations of sinusitis with distinct microbial signatures.[15,22,43–47] Evidence suggests that commensal species residing in the non-inflamed antrum,[15,40] bacteria associated with odontogenic infection,[8,22,45–47] and bacteria introduced during surgical procedures[10,12,22,47] may represent etiologic organisms in acute sinusitis. Despite presence of atypical species in some cases,[10,12] the pathogens commonly associated with ABRS and AECRS—*H. influenzae*, *S. pneumonia*, *M. catarrhalis*, and *S. aureus*—are probably also represented in postsurgical sinus infection with unknown frequency.

Antibiotic Resistance in Target Bacteria

A concerning characteristic common to all manifestations of maxillary sinusitis is the increasing prevalence of antibiotic-resistant and β-lactamase-producing organisms (BLPOs). High BLPO prevalence has been reported in both ABRS (mostly *H. influenzae* and *M. catarrhalis*) and CRS (predominantly *S. aureus*, *Prevotella* species, *Fusobacterium* species, and *Bacteroides fragilis*).[24,26,32,35] In fact, penicillin-resistant *S. pneumoniae* have been isolated in 25% to 75% of sinus aspirates from CRS patients.[22,24] Of further concern is the potential for BLPOs to protect other bacteria from penicillin activity.[35] Among sinusitis patients, sinus fluid β-lactamase activity was detected in 86% of sinus aspirates when BLPOs were present, suggesting protection of penicillin-sensitive organisms via β-lactam deactivation.[35] Indeed, evaluation of sinus bacterial isolates obtained from patients treated for maxillary sinusitis revealed the presence of BLPOs in 89% of patients *after* treatment with amoxicillin.[35] Data from the SENTRY Antimicrobial

TABLE 4 Comparison of Prophylactic Antibiotics for Sinus Elevation Surgery

Antibiotic	Advantages / rationale	Disadvantages
AMC	An expert panel on prevention of postoperative complications recommended prophylactic AMC before SES.[5] Current ABRS treatment guidelines support AMC as first-line therapy due to growing penicillin resistance among typical ABRS pathogens.[15,17,21]	Compared with AMX alone, AMC is more expensive,[8] has a broader spectrum of activity,[21] and has a less favorable side effect profile.[26–29,32] When administered TID, AMC has been associated with a high incidence of gastrointestinal side effects compared with most alternatives.[26] Mixed results appear in the literature regarding achievable concentrations of CA in the mucosa of the maxillary sinus.[31,33] One study found favorable tissue concentrations of both AMX and CA 2 to 6 hours after oral AMC administration.[31] In another study, mucosal CA concentrations varied widely among individuals, with undetectable tissue concentrations recorded at almost half of evaluated sinonasal sites.[33] Technical aspects of CA assessment may partially account for this discrepancy.[33]
AMX	AMX is a relatively safe and well-tolerated bactericidal agent with excellent bioavailability.[26,32] This medication is generally acknowledged as the most active β-lactam antibiotic against streptococci, including pneumococci.[26,32]	Increasing prevalence of BLPOs (particularly *H. influenzae* and *M. catarrhalis*) and PNS *S. pneumoniae* coincides with reduced antimicrobial activity of AMX.[8,19,21,24,26,32,35] Even high doses of AMX may be ineffective against PNS *S. pneumoniae* strains.[26,32]
Tetracyclines (TTC, DCN)	Tetracyclines exhibit antimicrobial activity against some gram-positive and many gram-negative bacteria, including both aerobic and anaerobic organisms.[49] With repeated oral dosing, TTC concentrations in maxillary sinus secretions approach serum concentrations, although saliva and tear concentrations remain low.[50] Upon systemic or topical administration, TTC substantively binds mineralized tissue.[51–55] In vitro, dentin slabs immersed in a 50 mg/mL solution, then rinsed, retained biologically active TTC concentrations over at least 48 hours.[52] DCN may be used for initial empiric antimicrobial treatment of ABRS due to high activity against respiratory pathogens and favorable pharmacokinetics.[8,15,17,21] Locally applied DCN[3] and TTC[38] have been used in management of sinus infection following SES.	*S. pneumoniae* resistance to DCN varies considerably by region, with reported frequencies ranging from 2% to >20%.[50] Bacteriologic failure rates of 20% to 25% are possible when ABRS is treated with DCN.[26,32]
Fluoroquinolones (MXF, LVX, CIP, GAT)	Fluoroquinolones exhibit favorable antibacterial activity against anaerobic and aerobic pathogens identified in acute[56] and chronic sinusitis.[22] These antibiotics are highly potent against all common respiratory pathogens, including BLPOs and PNS *S. pneumoniae*.[21,32,48,56,57] MXF, in particular, exhibits excellent tissue pharmacokinetics, with extensive distribution in both inflamed and non-inflamed sinus mucosa.[25,30]	Numerous adverse effects can occur with RFQ use, including tendinitis, Achilles tendon rupture, disruption of glucose homeostasis, neurologic disturbances (headaches, dizziness), and QT interval prolongation.[21] The FDA advises that side effects associated with RFQ outweigh benefits for most ABRS patients.[58] Widespread use of RFQ for patients with mild sinusitis may promote resistance (especially of gut organisms) to this antibiotic class.[26]
MTZ	MTZ exhibits favorable antibacterial activity against gram-negative aerobes associated with CRS.[22]	*Propionibacterium acnes* isolates from CRS patients exhibit high rates of resistance to MTZ.[22] MTZ is not a recommended first-line treatment for ABRS.[15,17,21]
CLI	CLI exhibits good antimicrobial activity against gram-negative anaerobes with low rates of resistance against *Peptostreptococcus, Prevotella*, and *Porphyromonas* species.[22]	*S. aureus* and *S. pneumoniae* exhibit high rates of resistance to CLI.[18,22] CLI is not active against *H. influenzae* or *M. catarrhalis*.[18,30]

(Continued)

TABLE 4 (Continued)

Antibiotic	Advantages / rationale	Disadvantages
Cephalosporins (second and third generations: CEF, CER, CED, CEM, CEZ, other agents)	Cephalosporins exhibit favorable side-effect profiles.[26,32] These antibiotics present good activity against respiratory pathogens with high potency against most strains of *H. influenzae*.[18,26,32]	Activity against *S. pneumoniae* and *H. influenzae* varies among cephalosporin antibiotics.[26,32] CEF has been regarded as the preferred treatment for sinusitis patients in whom treatment with high-dose AMX or AMC fails.[26] However, oral cephalosporins are no longer recommended for empiric monotherapy of ABRS due to variable rates of resistance among *S. pneumoniae*.[21]
Macrolides (CLR, AZN, ERN)	Macrolides are active against gram-positive and some gram-negative bacteria, including *M. catarrhalis*.[26,32]	Macrolides are not recommended for empiric ABRS therapy due to high resistance rates among *S. pneumoniae*,[21,26,32] *S. aureus*,[22,34] and *H. influenzae*.[34]
No antibiotic prophylaxis	SES without antibiotic prophylaxis preserves bacterial antibiotic sensitivity, avoids untoward side effects, and reduces cost. Periodontal surgeries generally exhibit low infection rates with or without antibiotics prophylaxis,[59] and no controlled research has established reduction in post-SES infection rates with antibiotic prophylaxis. Avoiding prophylaxis is supported by evidence that antibiotics produce only small treatment effects in patients with uncomplicated acute sinusitis,[27,28] with $\geqslant$80% of sinusitis patients not receiving antibiotics improving within 2 weeks.[27,28]	Sinus surgery predisposes patients to ABRS,[8] and most reports involving SES do describe perioperative antibiotic use.[1–4,6,7,10–12,14,16,36–38] Indeed, postoperative sinus infection may result in treatment failure and considerable morbidity for the patient.[1–7,9,10,12,14,16] SES involves a small risk of severe postoperative sequelae secondary to infection, such as pansinusitis, osteomyelitis, blindness, and neurologic morbidity.[15–17]

ABRS = acute bacterial rhinosinusitis; AMC = amoxicillin/clavulanate; AMX = amoxicillin; AZN = azithromycin; BLPO = β-lactamase producing organism; CA = clavulanate; CED = cefdinir; CEF = cefpodoxime proxetil; CER = cefuroxime axetil; CEM = cefixime; CEZ = cefprozil; CLI = clindamycin; CLR = clarithromycin; CRS = chronic rhinosinusitis; DCN = doxycycline; ERN = erythromycin; FDA = Food and Drug Administration; GAT = gatifloxacin; PNS = penicillin non-susceptible; RFQ = respiratory fluoroquinolone; SES = sinus elevation surgery; TID = three times daily; TTC = tetracycline.

Surveillance Program in Latin America, which demonstrated the inefficacy of amoxicillin against 13% of *H. influenzae* isolates and 92% of *M. catarrhalis* isolates, revealed that amoxicillin/clavulanate and the newer fluoroquinolones were active against both strains.[48] Goldstein et al. likewise found significantly greater susceptibility of antral bacterial strains to amoxicillin/clavulanate than to amoxicillin in adult sinusitis patients.[34] Furthermore, amoxicillin/clavulanate was active against all isolated strains and exhibited the greatest activity against the spectrum of aerobic and anaerobic specimens examined.[34]

Clinical Bottom Line

Despite published literature characterizing the microbial flora of normal and inflamed maxillary sinuses, the particular microbiology of sinusitis following SES remains poorly defined. Furthermore, antibiotic resistance among sinusitis-associated bacteria has increased, and factors delineating patients susceptible to infection after SES are not fully established. Consequently, very limited evidence informs clinical decisions regarding antibiotic prophylaxis before SES. Nevertheless, indirect evidence suggests that, before SES, prophylactic amoxicillin/clavulanate or doxycycline may be preferred over alternatives (Table 4). Current ABRS treatment guidelines support amoxicillin/clavulanate or doxycycline as first-line therapy due to growing penicillin resistance among typical ABRS pathogens,[15,17,21] and alternatives to these agents for SES antibiotic prophylaxis appear unsatisfactory. Perioperative amoxicillin is commonly used in SES.[2,3,36–38] However, if medical literature identifying appropriate ABRS treatment[15,17,21,26–29,32] can be extrapolated to SES, prophylactic amoxicillin may no longer offer acceptable efficacy. Likewise, second- and third-generation cephalosporins appear to offer unacceptably inconsistent activity against *S. pneumoniae*.[21] Fluoroquinolones exhibit excellent pharmacokinetics and activity against sinusitis-associated bacteria.[21,22,25,26,32,56] However, these agents are not appropriate for first-line management of uncomplicated ABRS[15,17,21,26,32,58] or routine SES antibiotic prophylaxis. The United States Food and Drug Administration advises that side effects associated with fluoroquinolones outweigh benefits for most ABRS patients.[58] Therefore, based upon the aggregate indirect evidence and published expert panel guidelines, amoxicillin/clavulanate and doxycycline may be the prophylactic antimicrobial agents of choice for patients undergoing SES.

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