Supra-Alveolar Periodontal Tissue Reconstruction in a Case with Severe Periodontitis: Case Report with a 2-Year Follow-up

Yudai Ogawa, DDS[1]
Shogo Maekawa, DDS, PhD[2]
Kentaro Imamura, DDS, PhD[3]
Tomohiro Ishikawa, DDS[4]

Periodontal regeneration therapy has developed tremendously since its inception, becoming a clinical tool to preserve the periodontally compromised natural dentition. More challenging esthetic defects can often benefit from the combination of bone and soft tissue regeneration, such as the application of connective tissue grafts (CTGs) and techniques that approach the bone defect without interdental papillae incisions. However, periodontal tissue regeneration vertical to the alveolar bone crest in cases of severe periodontitis, with loss of both soft and hard tissues, has not been predictably established. This case report describes a patient with severe periodontitis that was treated with in supra-alveolar periodontal tissue reconstruction. This innovative surgical technique requires both horizontal buccal incisions and several vertical palatal incisions, avoiding the interdental papillae on the periodontal defect. Then, a space is created by suspending and fixating the flap coronally, and CTG and regenerative materials (such as recombinant human fibroblast growth factor-2) and bone graft material are applied. This technique has the potential to gain clinical attachment, achieve supra-/intraperiodontal regeneration, and enhance esthetic outcomes, including a reduced gingival recession and interdental papillae reconstruction. The clinical results of the present case were well maintained over the 2-year follow-up. Int J Periodontics Restorative Dent 2023;43:213–221. doi: 10.11607/prd.6241

[1]Private Practice, Hamamatsu, Shizuoka, Japan; Department of Dentistry and Oral Surgery, Keio University, School of Medicine, Tokyo, Japan.
[2]Department of Oral Medicine, Infection, and Immunity, Harvard School of Dental Medicine, Boston, Massachusetts, USA; Department of Periodontology, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan.
[3]Department of Periodontology and the Oral Health Science Center, Tokyo Dental College, Tokyo, Japan.
[4]Private Practice, Hamamatsu, Shizuoka, Japan.

Correspondence to: Dr Tomohiro Ishikawa, Hamamatsu Perio Implant Center, 1743 Tennou-Cho, Higashiku, Hamamatsu, Shizuoka 435-0052, Japan. Fax: 053-466-6481. Email: tomohiro-i@k4.dion.ne.jp

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As periodontitis progresses, it causes attachment loss and alveolar bone resorption, resulting in diverse alveolar bone defect morphologies.[1] In cases of periodontitis with horizontal bone loss, the treatment often results in gingival recession and interdental papillae atrophy, but nonsurgical or resective surgical periodontal therapy can restore periodontal tissue to a healthy state. Regenerative therapy can be performed for vertical bone loss from periodontitis, and the results have been proven to increase clinical attachment, improve bone morphology, and ensure long-term tooth preservation, even if the defect has extended beyond the root apex.[2] However, the resulting risk of gingival recession, interdental papillae atrophy, and poor esthetics have consequently been a major dilemma for patients and dental professionals. In particular, gingival recession can have a strong impact on the patient quality of life (QoL),[3] and thus techniques that do not cause soft tissue complications are desirable.

Recently, in order to both achieve periodontal regeneration and minimize the risk of soft tissue complications, various surgical techniques have been developed.[4–8] Still, these techniques are only approachable from a limited area, and their efficacy has been reported only for infrabony defects. Reconstruction of

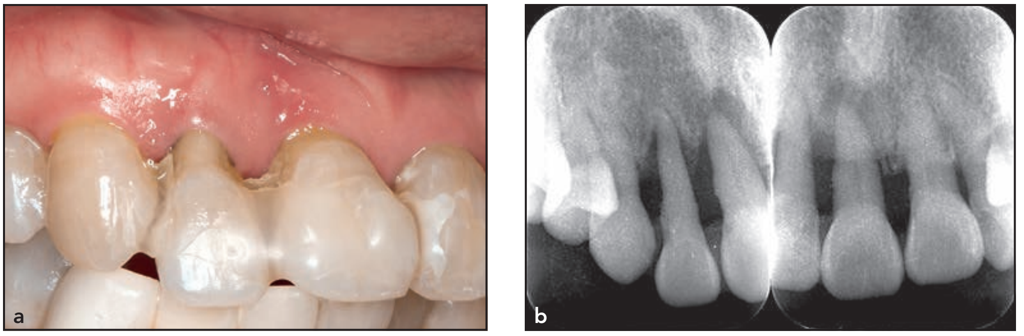

Fig 1 (a) *Buccal and* (b) *radiographic views at the initial visit.*

the interdental papillae is very important in the esthetic areas of the anterior teeth. In order to establish supra-alveolar periodontal tissue reconstruction, a variety of clinically challenging techniques have been performed in the past.[9,10] These techniques were able to achieve local interdental papillae reconstruction, but they were unfeasible for horizontal bone loss in multiple teeth. Based on the above findings, the present authors established an innovative regenerative therapy that was performed in a case with generalized stage IV/grade C periodontitis.

Clinical Case Report

This case report describes a nonsmoking and systemically healthy 53-year-old woman. The patient was informed about the treatment and gave written informed consent to participate in the study. Her chief complaint was that her maxillary anterior teeth exhibited significant mobility. Deep intrabony defects and severe horizontal alveolar bone resorption existed around the maxillary right central and lateral incisors. Clinical attachment loss and bone loss extended to or beyond the apex of tooth 11 (FDI tooth-numbering system). In addition, vertical and horizontal bone loss were seen in the adjacent teeth (Fig 1). Tooth 11 was diagnosed with periodontal lesions with secondary endodontic involvement—a true combined lesion.[11] Following the new classification proposed in 2018,[12] tooth 11 was diagnosed with a grade 3 endoperiodontal lesion without root damage. Tooth 12 had 90% bone loss at the most advanced site, but the attachment loss and bone loss of the adjacent teeth (sites 21 and 13) were limited. Gingival recession was recession type (RT) 3,[13] and the loss of interdental papillae (Papilla Presence Index [PPI] score of 4)[14] was identified in teeth 11 and 12, as well as pathologic migration. Attachment loss and bone resorption were also observed in other areas, and thus the patient was diagnosed with generalized periodontitis (stage IV, grade C).[12]

Presurgical Treatment

Root canal treatment was performed during the initial treatment for teeth with necrotic pulp. Tooth 11 had an increased radiopacity at the root apex owing to root canal treatment. Nonsurgical initial periodontal therapy (including oral hygiene instructions, scaling, and root planing) was performed prior to periodontal surgery. Due to the residual bleeding on probing at the planned surgical site, gentle scaling, root planing, and application of a local antibiotic (amoxicillin hydrate) were performed 2 weeks before surgery. Marked gingival recession and papillae loss were observed due to nonsurgical periodontal therapy (baseline) (Fig 2).

Surgical Procedure

Following local anesthesia, bone sounding measurements were performed. A horizontal incision was made buccally into the oral vestibule. The apical position of this horizontal incision was chosen based on an estimation of how much coronal construction was needed. Additionally, the incision line was placed to accommodate this coronal adjustment and resulted in the final suture line being positioned above the intact bone, not a reconstructed area. This incision was mesially and distally extended a distance of one tooth from the target bone defect area. Rather than using one deep incision, apically oriented multiple staged incisions were used to reach the bony surface. This horizontal incision releases the flap and allows for multilayered suturing for primary healing.

Then, a full-thickness flap was elevated coronally to expose the buccal bony crest completely. As much granulation tissue as possible was then removed. The interdental papillae were then carefully elevated with precision instruments (Fig 3a). When the buccal flap and interdental papillae were completely released, the flap elevation procedure progressed to the palatal area. Vertical incisions were made in the mesial corner of the palate at tooth 11 and the distal corner at tooth 13. The palatal tunnel connecting both vertical incisions was elongated until the appropriate flexibility was achieved, allowing the space necessary to thoroughly debride the palatal defect (Fig 3b). Thorough debridement of the root surface and within the alveolar bone defect was performed from both the buccal and palatal sides. A connective tissue graft (CTG) was prepared from a free gingival graft by extraoral deepithelization.[15] The CTG length must be extended to cover both mesial and distal adjacent root surfaces (Fig 3c). The CTG was inserted under the buccal flap and positioned as coronally as possible. Tooth 12 was anchored to the adjacent teeth with methyl methacrylate bonding material (Super-Bond C&B, Sun Medical). Using these anchors, interrupted interproximal

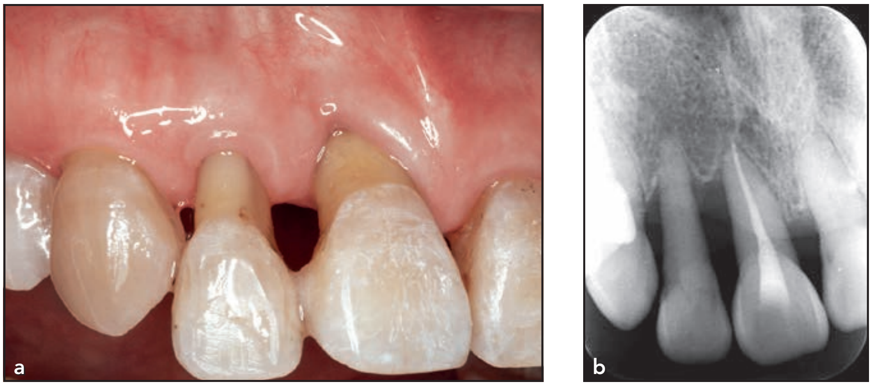

Fig 2 (a) *Buccal and* (b) *radiographic views at baseline (just before periodontal surgery).*

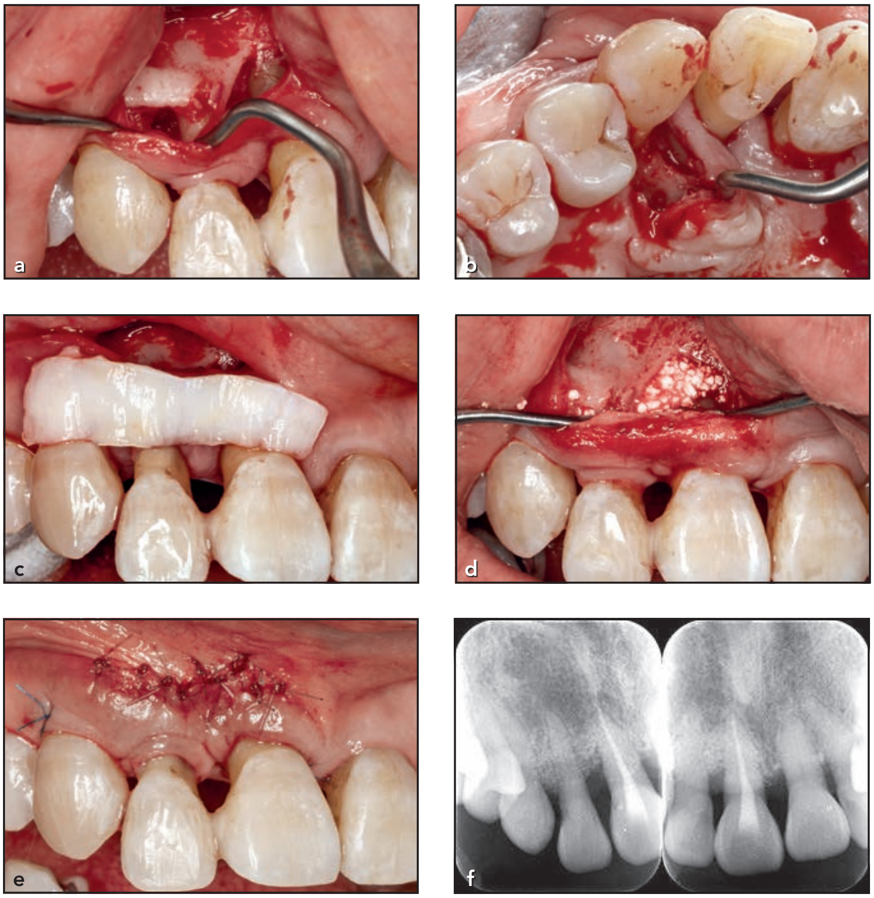

Fig 3 *Surgical procedures of supra-alveolar periodontal tissue reconstruction.* (a) *The horizontal incision was performed buccally in the oral vestibule, the flap was elevated toward the alveolar crest, and the defect area was then accessible.* (b) *Vertical incisions were made distal to teeth 11 and 13 (FDI tooth-numbering system) on the palatal side.* (c) *A CTG was harvested from the palate and placed at the defect site.* (d) *After anchoring the CTG and making the suspension suture, rhFGF-2 was applied into the intrabony defect, as well as carbonate apatite that had been premixed with rhFGF-2.* (e) *The vestibular incision was sutured by a combination of horizontal mattress sutures and simple interrupted sutures. The palatal side was closed with simple interrupted sutures only.* (f) *Radiographic view immediately after surgery.*

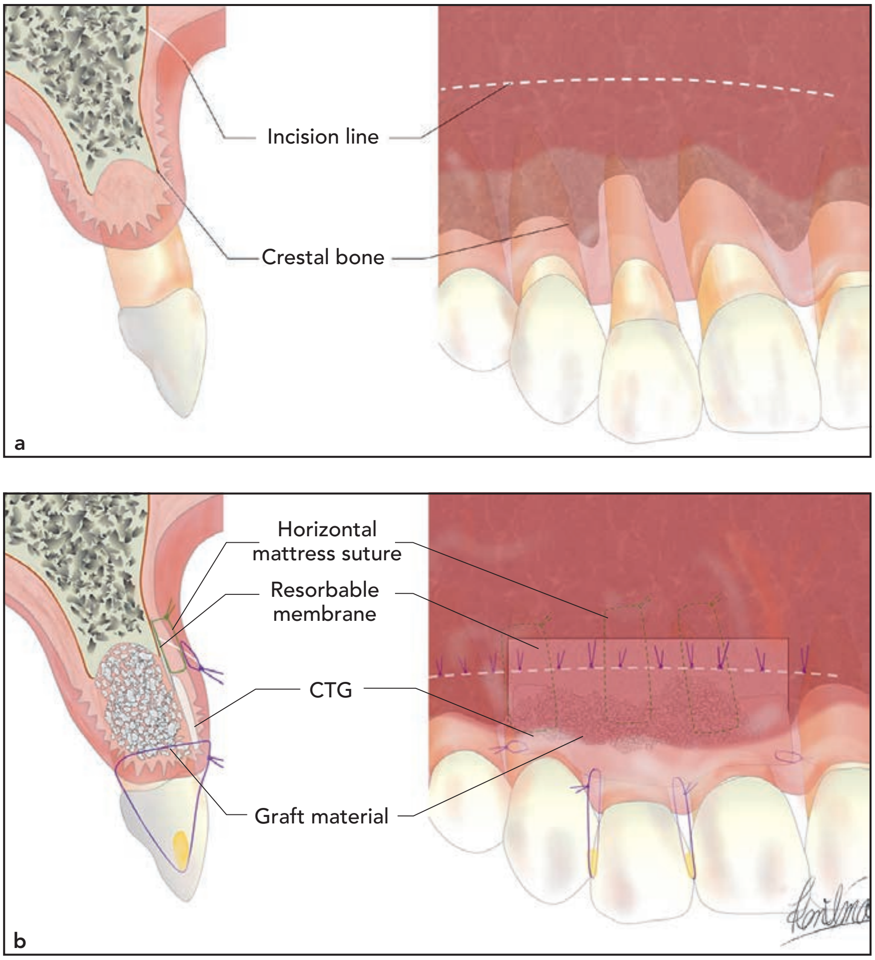

Fig 4 *Schematic illustration of the cross-sectional and buccal views* (a) *before and* (b) *after surgery.*

sling sutures penetrated the base of the buccal papillae, the CTG, and the base of palatal papillae at tooth 12 (mesially and distally). As a result, all supracrestal components, including the CTG and interdental papillae, were coronally pulled up to provide space for periodontal tissue regeneration. Recombinant human fibroblast growth factor-2 (rhFGF-2; Regroth, Kaken Pharmaceutical) was applied into both the intra- and suprabony defect components. Immediately after, a mixture of carbonate apatite (Cytrans Granules, GC) and rhFGF-2 was used to finish filling the intrabony components and suprabony spaces created by the sling sutures (Fig 3d). This method provided additional physical support and stabilization of the buccal and palatal flaps to maintain coronal stability.

A collagen membrane (Bio-Gide, Geistlich) was placed on the graft surface. The vestibular incision was closed with a combination of tension-free horizontal mattress and simple interrupted sutures (Fig 3e). The palatal side was closed with simple interrupted sutures only. The postsurgical radiograph shows increased radiopacity above the alveolar bone (Fig 3f).

Figure 4 shows a schematic illustration of the cross-sectional and buccal views before and after surgery.

Postsurgical Procedure

To prevent postoperative infection, antibiotics and analgesics were used for 3 days postsurgery. During the first 2 postsurgical weeks, oral hygiene was maintained by rinsing with a chlorhexidine mouthwash (ConCool F, Weltec), and professional hygiene care was provided every 3 days. All sutures were removed after 7 days except for sling sutures, which were kept until 14 days postsurgery to maintain soft tissue height. The patient was then instructed to start brushing with a soft toothbrush. At 1 month postsurgery, the patient could resume normal brushing. The patient was recalled for prophylaxis at 1, 2, 3, and 4 weeks postsurgery and at 3, 6, 12, and 24 months postsurgery.

At baseline and 1 and 2 years postsurgery, the following clinical parameters were evaluated: probing depth (PD), clinical attachment level (CAL), gingival recession (REC), the distance between the bottom of bone defect (BD) and the cemento-enamel junction (CEJ), and the distance from the bone crest (BC) to the CEJ.

Patient-reported outcome measures (PROMs) and the Oral Health Impact Profile-14 (OHIP-14; Japanese version) were used to assess the patient's level of oral health–related QoL.[16,17] Briefly, the OHIP-14 comprises 14 questions assessed on a scale of 0 to 4

Table 1 Baseline and Postoperative Clinical Parameters

		Site 12			Site 11	
		Distal	Central	Mesial	Distal	Central
PD (labial), mm	Baseline	7	2	7	7	5
	1 y	4	3	4	5	3
	2 y	3	4	4	5	4
	Change	4	–2	3	2	1
PD (palatal), mm	Baseline	6	5	6	7	5
	1 y	4	4	5	4	4
	2 y	4	3	4	4	4
	Change	2	2	2	3	1
REC (labial), mm	Baseline	5	5	5	4	5
	1 y	1	0	1	1	0
	2 y	1	0	1	1	0
	Change	4	5	4	3	5
REC (palatal), mm	Baseline	3	3	3	3	2
	1 y	1	1	0	0	1
	2 y	1	1	0	0	1
	Change	2	2	3	3	1
CAL (labial), mm	Baseline	12	7	12	11	10
	1 y	5	3	5	6	3
	2 y	4	4	5	6	4
	Change	8	3	7	5	6
CAL (palatal), mm	Baseline	9	8	9	10	7
	1 y	5	5	5	4	5
	2 y	5	4	4	4	5
	Change	4	4	5	6	2
CEJ–BD, mm	Baseline	12.7	–	13.0	11.3	–
	1 y	7.9	–	8.9	8.8	–
	2 y	7.9	–	7.4	8.1	–
	Change	4.8	–	5.6	3.2	–

BD = bottom of the bone defect; CAL = clinical attachment level; CEJ = cementoenamel junction; PD = probing pocket depth; REC = gingival recession.
Tooth sites are numbered according to the FDI system. Baseline is the time point after initial root canal treatment and scaling and root planing, prior to surgery. "Change" represents the difference between baseline and 2 years postsurgery. CEJ–BD was measured radiographically.

(maximum score: 56 points), with lower scores indicating a worse oral health–related QoL. Additionally, the patient's esthetic concerns and masticatory function were each evaluated with a 5-point Likert-type scale at baseline, 1 year, and 2 years postsurgery, assessed as follows: no concern (4), some concern (3), concerned (2), clearly concerned (1), and very concerned (0) as the points on the scale.

Results

A periodontal examination showed an overall decrease in periodontal pockets and marked CAL gain (Table 1). Moreover, the supra-alveolar

Table 2 Baseline and Postoperative Parameters for Interdental Papilla Sites

	Site 12–13	Site 11–12
Top of papilla, mm		
Baseline	–4	–5
1 y	1	1
2 y	+1	+1
Change	+5	+6
BC–CEJ, mm		
Baseline	9.3	11.4
1 y	6.7	8.1
2 y	6.4	7.2
Change	2.9	4.2

BC = bone crest; CEJ = cementoenamel junction.
Tooth sites are numbered according to the FDI system. Baseline is the time point after initial root canal treatment and scaling and root planing, prior to surgery. "Change" represents the difference between baseline and 2 years postsurgery. The "top of papilla" location is the distance from the top of the interdental papilla to the adjacent tooth's proximal distoangular CEJ. BC–CEJ was measured radiographically.

Table 3 Baseline and Postoperative Assessments of Patient Oral Health–Related Quality of Life

		PROMs	
	OHIP-14	Masticatory function	Esthetics
Baseline	30	0	0
1 y	44	2	3
2 y	44	2	3

OHIP-14 = Oral Health Impact Profile-14 (Japanese version); PROMs = patient-reported outcome measures.[16,17]

periodontal tissue reconstruction with clinical attachment was successful (Table 2). Gingival recession was improved to RT2, the esthetic score was 3, PPI was scored as 2, and an OHIP-14 score of 44 were all seen at both 1 and 2 years postsurgery (Table 3). Radiographic results were also stable, but some alloplast resorption was observed at 1 year (Fig 5) and 2 years postsurgery (Fig 6).

Discussion

The present case report proposed an approach for achieving esthetic supra-alveolar periodontal reconstruction. Within the limitations of this case, this procedure showed significant improvements in clinical parameters at 2 years postoperative. Moreover, this technique contributed to an improved patient QoL, such as good esthetics and masticatory function.

Per the original surgical design of Non-Incisal Papilla Surgical Approach (NIPSA),[18,19] bone defects localized on the buccal side can be approached through a horizontal incision in the oral vestibule, resulting in regeneration mainly on the buccal side. The present procedure requires flaps to be extended coronally, and thus the horizontal incision location is crucial. Moreover, on the palatal side, vertical incisions are placed mesially and distally to preserve the papilla on the periodontal defect, which is similar to the entire papillae preservation technique.[20] Those buccal and palatal incisions enable tenting flaps, as well as an approach to bone defects extending from the buccal to the palatal sides, without severing the interdental papilla. Buccal horizontal incisions should be placed apically enough so that the incisions do not interrupt the blood supply to the flap, which in turn may enhance periodontal tissue regeneration in the intra- and suprabony defects. In addition, another significant advantage of this combined incision is impossibility of papillae dehiscence associated with the defect. Preventing papillae dehiscence allows the periodontal soft tissues (supracrestal components) to be slung in one unit coronally, which creates a regenerative space on the alveolar bone crest. Please note that a stepwise dissection is necessary for labial horizontal incision. Eventually, this requires multilayered sutures (Fig 4).

The main challenge is maintaining the periodontal tissue in the coronally lifted position. Zucchelli et al described the use of CTG as a "wall" for periodontal regeneration of defects lacking buccal bone.[21] In the present study, this technique was applied, and a CTG was placed. Coronally anchored CTG stabilized the flaps and created space for supracrestal regeneration (Fig 4), which was expected to increase the labial gingiva thickness and prevent future gingival and papillae recession.[22]

The use of a resorbable collagen matrix (CM) such as Mucograft (Geistlich) has demonstrated improved gingival recession, and its effects are proven to be similar to CTG in randomized clinical trials.[23,24] Although McGuire and Scheyer found no significant differences in the percentage of root coverage, percentage of complete root coverage, keratinized tissue width, and probing pocket depth, the mean root coverage at 6 months and 5 years postsurgery was 89.5% and 77.6% in the CM group, respectively, and was 97.5% and 95.5% in the CTG group, respectively.[24] In 2015, an American Academy of Periodontology consensus report also addressed CTG as the best clinical practice for treating gingival recession due to its significant keratinized tissue increase and superiority in achieving high percentages of mean and complete root coverage.[25] Based on the network meta-analysis for gingival phenotype modification therapies, CM showed gingival thickness outcomes similar to CTG and ADM, while improvement of keratinized tissue width were only seen in CTG and ADM.[26] That meta-analysis also revealed that gingival thickness modification significantly and inversely predicts future gingival recession, and an increase in keratinized tissue may also enhance gingival margin stability. In addition, Rasperini et al indicated that using CTG may facilitate interproximal clinical attachment gain in periodontal regeneration.[27]

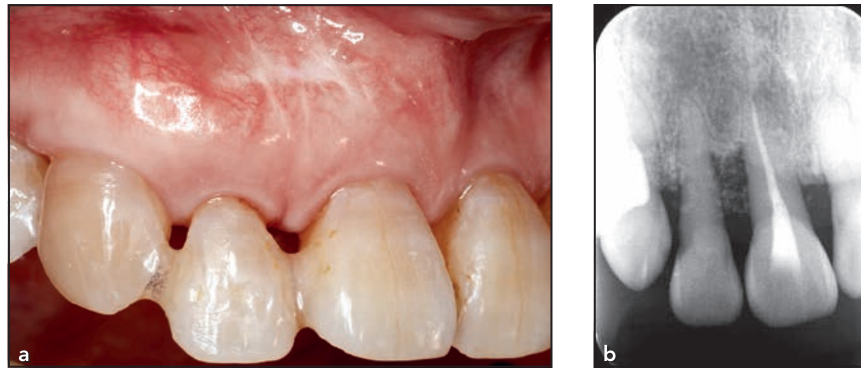

Fig 5 (a) *Buccal and* (b) *radiographic views at 1 year postsurgery.*

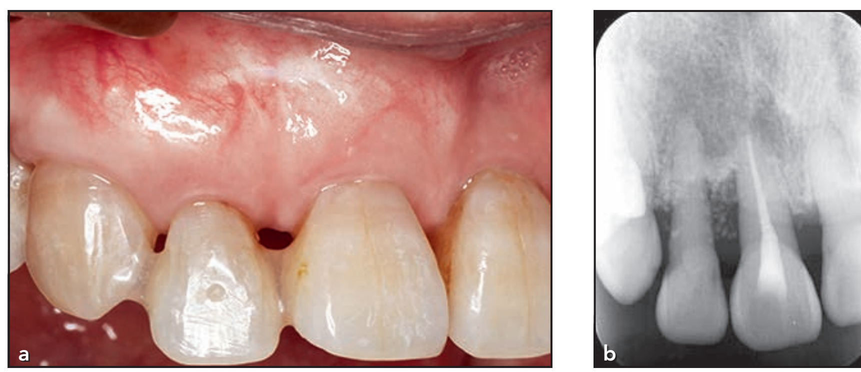

Fig 6 (a) *Buccal and* (b) *radiographic views at 2 years postsurgery.*

Overall, CTG has great potential to improve gingival recession, gingival thickness, keratinized tissue width, and clinical attachment gain, which are crucial for the present treatment outcomes. Tavelli et al showed that rhPDGF significantly increased gingival thickness and mean root coverage when CAF is performed with CM[28]; thus, using

CM in combination with biologic materials could be indicated for more clinical practice, but further investigations are still needed. Based on the above reasons, the present authors selected CTG as a first choice for the surgical procedure.

After establishing an enlarged space above the alveolar bone, carbonate apatite mixed with rhFGF-2 was applied in the intrabony defects and on the crest to stabilize a blood clot, with the additional expectation of achieving supra-alveolar bone regeneration. In terms of rhFGF-2, Shirakata et al's preclinical study reported outcomes comparing rhFGF-2, enamel matrix derivative (EMD), and recombinant human platelet-derived growth factor-BB (rhPDGF-BB) in the treatment of a one-wall bony defect.[29] The histomorphometric analysis revealed that rhFGF-2 was significantly superior to EMD in bone regeneration, and it was comparable to rhPDGF-BB. New cementum formation and new connective tissue attachment were similar among the biomaterials. In addition, Kitamura et al reported the superiority of rhFGF-2 in bone regeneration compared to flap surgery alone and EMD for infrabony defect treatment in a three-phase randomized clinical trial.[30] That clinical study also showed CAL gain results that were comparable among rhFGF-2 and EMD.[30] On the other hand, rhFGF-2 has been shown to enhance soft tissue maturation, stimulate collagen maturity, promote granulation thickness, accelerate wound healing, and enhance wound vascularization,[31] although rhFGF-2 concentrations differ among the reports in the field of plastic surgery. Thus, rhFGF-2 can be expected to play a significant role in soft tissue regeneration and healing.[32] Taken together, rhFGF-2 might be a suitable biomaterial to apply for supracrestal periodontal reconstruction, especially to gain alveolar bone height. It could be used for grafting bone with other growth factors, such as EMD or rhPDGF-BB, but further investigations and discussions are needed.

In the present technique, bone grafts and CTG were placed in the space between the alveolar bone and the gingiva. As a result, the flap shifted toward the coronal side, relative to the size of the horizontal component of the defect (Fig 4). In order to provide adequate blood supply to the flap after suturing, it is necessary to place the vestibular horizontal incision with consideration towards the approach to the bone defect as well as with the expectation that the flap will be shifted coronally. Thus, the NIPSA vestibular incision was modified, making it bigger and placing it more apically. In addition, the palatal flap cannot be fully advanced coronally, and thus the labial flap needs to be released more to compensate for the palatal flap shift.

This report evaluated only one case for up to 2 years. Long-term studies with a larger number of cases are necessary to further evaluate and understand the clinical efficacy of supra-alveolar periodontal tissue reconstruction. Moreover, a preclinical study may be needed to confirm the histology.

Conclusions

This tissue reconstruction technique may allow the successful reconstruction of supra-alveolar periodontal tissue, and it has the potential to address patient esthetic concerns in cases of severe periodontal disease. Nevertheless, future studies are needed to further evaluate this novel surgical approach.

Acknowledgments

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References

1. Ercoli C, Caton JG. Dental prostheses and tooth-related factors. J Periodontol 2018;89(suppl 1):s223–s236.
2. Cortellini P, Stalpers G, Mollo A, Tonetti MS. Periodontal regeneration versus extraction and prosthetic replacement of teeth severely compromised by attachment loss to the apex: 5-year results of an ongoing randomized clinical trial. J Clin Periodontol 2011;38:915–924.
3. Needleman I, McGrath C, Floyd P, Biddle A. Impact of oral health on the life quality of periodontal patients. J Clin Periodontol 2004;31:454–457.
4. Cortellini P, Tonetti MS. A minimally invasive surgical technique with an enamel matrix derivative in the regenerative treatment of intra-bony defects: A novel approach to limit morbidity. J Clin Periodontol 2007;34:87–93.
5. Cortellini P, Tonetti MS. Improved wound stability with a modified minimally invasive surgical technique in the regenerative treatment of isolated interdental intrabony defects. J Clin Periodontol 2009;36:157–163.

6. Aslan S, Buduneli N, Cortellini P. Entire papilla preservation technique in the regenerative treatment of deep intrabony defects: 1-year results. J Clin Periodontol 2017;44:926–932.
7. Najafi B, Kheirieh P, Torabi A, Cappetta EG. Periodontal regenerative treatment of intrabony defects in the esthetic zone using modified vestibular incision subperiosteal tunnel access (M-VISTA). Int J Periodontics Restorative Dent 2018;38:e9–e16.
8. Moreno Rodríguez JA, Ortiz Ruiz AJ, Caffesse RG. Periodontal reconstructive surgery of deep intraosseous defects using an apical approach. Non-incised papillae surgical approach (NIPSA): A retrospective cohort study. J Periodontol 2019;90:454–464.
9. Han TJ, Takei HH. Progress in gingival papilla reconstruction. Periodontol 2000 1996;11:65–68.
10. Azzi R, Takei HH, Etienne D, Carranza FA. Root coverage and papilla reconstruction using autogenous osseous and connective tissue grafts. Int J Periodontics Restorative Dent 2001;21:141–147.
11. Simon JH, Glick DH, Frank AL. The relationship of endodontic-periodontic lesions. J Endod 2013;39:e41–46.
12. Tonetti MS, Greenwell H, Kornman KS. Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. J Periodontol 2018;89(suppl 1):s159–s172.
13. Cairo F, Nieri M, Cincinelli S, Mervelt J, Pagliaro U. The interproximal clinical attachment level to classify gingival recessions and predict root coverage outcomes: An explorative and reliability study. J Clin Periodontol 2011;38:661–666.
14. Cardaropoli D, Re S, Corrente G. The Papilla Presence Index (PPI): A new system to assess interproximal papillary levels. Int J Periodontics Restorative Dent 2004;24:488–492.
15. Ho FC. A modified combined approach to harvest connective tissue grafts with high quality, less morbidity, and faster healing. Int J Esthet Dent 2020;15:56–67.
16. Slade GD, Spencer AJ. Development and evaluation of the Oral Health Impact Profile. Community Dent Health 1994;11:3–11.
17. Cortellini P, Stalpers G, Mollo A, Tonetti MS. Periodontal regeneration versus extraction and dental implant or prosthetic replacement of teeth severely compromised by attachment loss to the apex: A randomized controlled clinical trial reporting 10-year outcomes, survival analysis and mean cumulative cost of recurrence. J Clin Periodontol 2020;47:768–776.
18. Moreno Rodriguez JA, Ortiz Ruiz AJ, Zamora GP, Pecci-Lloret M, Caffesse RG. Connective tissue grafts with nonincised papillae surgical approach for periodontal reconstruction in noncontained defects. Int J Periodontics Restorative Dent 2019;39:781–787.
19. Moreno Rodriguez JA, Caffesse RG. Nonincised Papillae Surgical Approach (NIPSA) in periodontal regeneration: Preliminary results of a case series. Int J Periodontics Restorative Dent 2018;38(suppl):s105–s111.
20. Aslan S, Buduneli N, Cortellini P. Entire papilla preservation technique: A novel surgical approach for regenerative treatment of deep and wide intrabony defects. Int J Periodontics Restorative Dent 2017;37:227–233.
21. Zucchelli G, Mounssif I, Marzadori M, Mazzotti C, Felice P, Stefanini M. Connective tissue graft wall technique and enamel matrix derivative for the treatment of infrabony defects: Case reports. Int J Periodontics Restorative Dent 2017;37:673–681.
22. Rasperini G, Acunzo R, Pellegrini G, et al. Predictor factors for long-term outcomes stability of coronally advanced flap with or without connective tissue graft in the treatment of single maxillary gingival recessions: 9 years results of a randomized controlled clinical trial. J Clin Periodontol 2018;45:1107–1117.
23. Cardaropoli D, Tamagnone L, Roffredo A, Gaveglio L. Treatment of gingival recession defects using coronally advanced flap with a porcine collagen matrix compared to coronally advanced flap with connective tissue graft: A randomized controlled clinical trial. J Periodontol 2012;83:321–328.
24. McGuire MK, Scheyer ET. Long-term results comparing xenogeneic collagen matrix and autogenous connective tissue grafts with coronally advanced flaps for treatment of dehiscence-type recession defects. J Periodontol 2016;87:221–227.
25. Chambrone L, Tatakis DN. Periodontal soft tissue root coverage procedures: A systematic review from the AAP Regeneration Workshop. J Periodontol 2015;86(2 suppl):s8–s51.
26. Barootchi S, Tavelli L, Zucchelli G, Giannobile WV, Wang HL. Gingival phenotype modification therapies on natural teeth: A network meta-analysis. J Periodontol 2020;91:1386–1399.
27. Rasperini G, Tavelli L, Barootchi S, et al. Interproximal attachment gain: The challenge of periodontal regeneration. J Periodontol 2021;92:931–946.
28. Tavelli L, Barootchi S, Rodriguez MV, et al. Recombinant human platelet-derived growth factor improves root coverage of a collagen matrix for multiple adjacent gingival recessions: A triple-blinded, randomized, placebo-controlled trial. J Clin Periodontol 2022. Epub ahead of print.
29. Shirakata Y, Taniyama K, Yoshimoto T, et al. Regenerative effect of basic fibroblast growth factor on periodontal healing in two-wall intrabony defects in dogs. J Clin Periodontol 2010;37:374–381.
30. Kitamura M, Akamatsu M, Kawanami M, et al. Randomized placebo-controlled and controlled non-inferiority phase III trials comparing Trafermin, a recombinant human fibroblast growth factor 2, and enamel matrix derivative in periodontal regeneration in intrabony defects. J Bone Miner Res 2016;31:806–814.
31. Matsumoto S, Tanaka R, Okada K, et al. The effect of control-released basic fibroblast growth factor in wound healing: Histological analyses and clinical application. Plast Reconstr Surg Glob Open 2013;1:e44.
32. Funato A, Katayama A, Minami M (eds). Chapter 4: Periodontal regeneration. In: Regenerative Therapy in Periodontal and Implant Treatment: Focusing on Regroth and Cytrans Granules, ed 1. Tokyo: Quintessence, 2022:104–149 [in Japanese.]