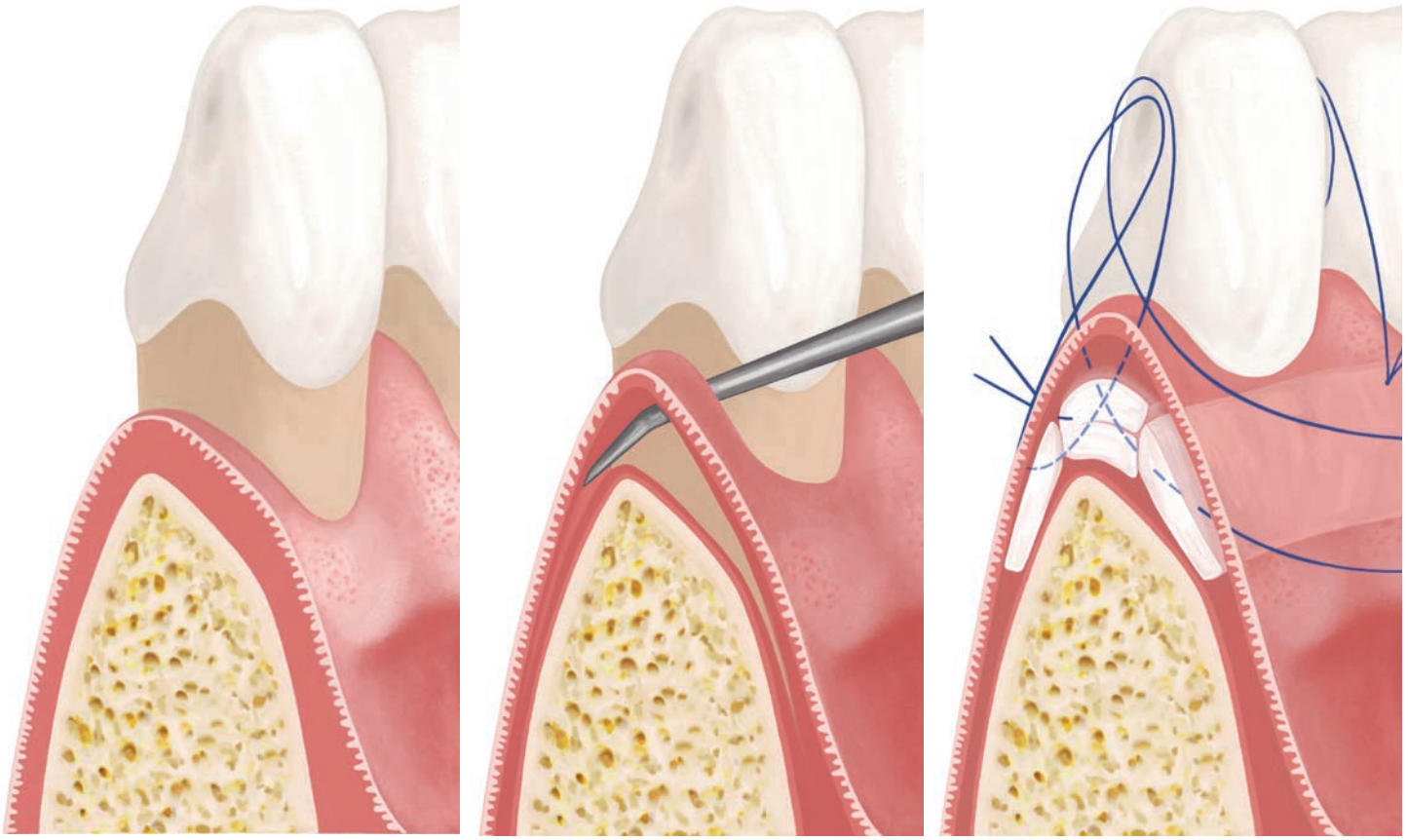

Submitted August 10, 2023;
accepted November 18, 2023.

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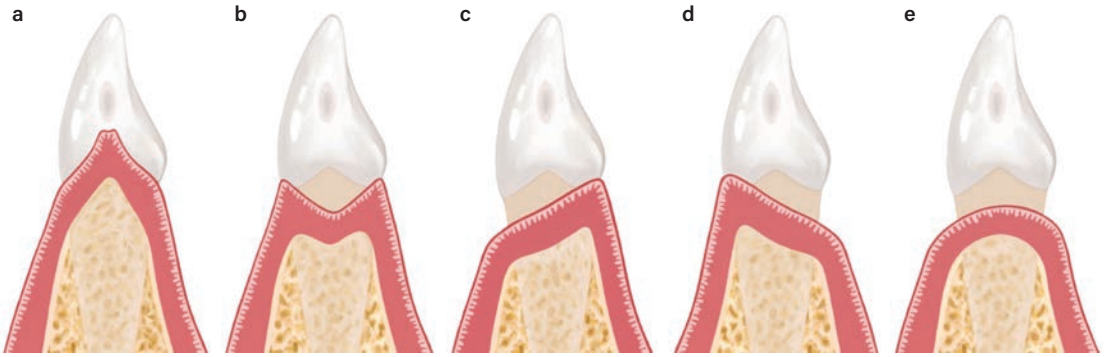
A Novel 3D Tunneling (3DT) Surgical Technique for the Treatment of Gingival Recessions with Reconstruction of the Deficient Interdental Papilla and Interproximal Attachment Regeneration: A Case Series

Current concepts in periodontology emphasize the interproximal attachment as an important distinguishing aspect with significant influence, making it a key diagnostic and prognostic factor. Complete regeneration of the interproximal clinical attachment has become a primary determinant of periodontal success. Since the mid-20th century, numerous articles have been published on root coverage procedures, mostly for nonproximal gingival recessions. When it comes to the interdental area, the literature does not inspire the same level of confidence. This case series introduces an innovative 3D tunneling surgical technique for gingival papilla reconstruction and supra-alveolar interproximal attachment regeneration. The technique is described step by step and shown with three selected clinical cases of multiple bilateral adjacent gingival recessions (types 2 and 3) in the anterior mandible with 6.5 years of follow-up. A total of 18 proximal, midbuccal, and midlingual recessions were treated simultaneously. Up to 88.9% of mean root coverage was achieved in the proximal area. Within its limits, this case series demonstrates the possibility of treating gingival recessions with deficient papillae in the anterior mandible, achieving a significant clinical improvement with long-term stability. *Int J Periodontics Restorative Dent 2025;45:31–45. doi: 10.11607/prd.6960*

Keywords: *case series, gingival papilla reconstruction, gingival recession, periodontal surgery*

Periodontology was initially aimed more at preservation and restoration than esthetic outcomes. Periodontal treatment has been considered successful once the infection is eliminated and the pocket depths are reduced. Along with the consequences of the disease, treatment methods failed to deliver esthetically presentable results to patients, forming interproximal spacing and significant root surface exposure.[1] With development of new instruments and materials,[2,3] periodontal therapy has moved from excisional to regenerative: respecting soft tissue integrity, limiting the gingival shrinkage during initial therapy,[4] and preserving the papilla position at the surgical step.[5–8] The combination of regenerative and mucogingival techniques[9,10] also made it possible to treat noncontained bone defects. Despite all of this, patients still experience an undesirable loss of papilla height and formation of black triangles.



▲ **Fig 1** Illustrations of the different categories of horizontally deficient interdental gingival papillae. *(a)* Type A. Vestibular and oral papillae are intact. *(b)* Type B. Concave form of the defect: Buccal and oral papillae are still fully present, the col is shifted apically, and the interproximal CEJ is already visible. *(c)* Type C. The vestibular papilla and the col area are apical to the CEJ, but the oral papilla is intact. *(d)* Type D. The opposite of Type C. The oral papilla is positioned apical to the CEJ with the col, but there is no lack of buccal papilla. *(e)* Type E. There is a lack of both vestibular and oral papillae, with the col area located apical to the CEJ.

Apart from esthetic complaints, food impaction and phonetic problems due to air and saliva in the passage are noted. Exposed roots have rough surfaces and hypersensitivity and open gingival embrasures are difficult-to-reach areas, which leads to faster plaque accumulation, thus increasing the potential risk of periodontal disease relapse.

In addition to the loss of the periodontal support because of plaque-associated lesions, factors such as tooth position, midline diastema, changes in tooth alignment during orthodontic treatment,[11] interradicular distance < 0.3 mm or > 1.5 mm,[12–14] loss of interproximal bone height > 5 mm in relation to the contact point (CP),[15] crown shape,[13] improper restorations, age-related tissue decay,[16] and traumatic oral hygiene procedures may also affect the integrity of the gingival papilla, which plays a critical role in esthetics.

In 1998, Nordland and Tarnow published a widely accepted classification[17] of deficient interdental papillae by considering the cementoenamel junction (CEJ) and the interdental CP as references. However, theirs is a one-dimensional description that does not consider mesiodistal and faciolingual aspects of the papilla. In 2018, Miller updated the classification, dividing the papilla into three types according to its width: > 3 mm, ≤ 3 mm with additional bone loss, and ≤ 3 mm without additional bone loss.[18] He noticed that the papilla volume is of great significance to the outcomes, particularly regarding the mesiodistal papilla width at the line angle of adjacent teeth. A papilla with adequate size provides a greater blood supply for the graft.

Additionally, the interdental gingival papilla is divided into vestibular and oral by the concave point in the middle, known as *col*.[19] According to the integrity of the buccal and oral portions, five categories of horizontally deficient papilla are proposed (Fig 1): Type A, in which vestibular and oral papillae are intact; Type B, a concave defect form, in which the buccal and oral papillae are still fully present, col is shifted apically, and the interproximal CEJ is already visible; Type C, in which the vestibular papilla and the col area are apical to the CEJ, but the oral papilla is intact; Type D (opposite of Type C), in which the oral papilla is positioned apical to the CEJ with the col, and no lack of buccal papilla is noted; and Type E, in which there is a lack of both vestibular and oral papillae, with the col area located apical to the CEJ.

Defects associated with severe interdental hard and soft tissue loss are challenging for the periodontist, mainly due to the loss of the interproximal bone and soft tissues, resulting in an increased avascular surface and a reduced interproximal periosteal bed. Reports on the surgical techniques used to address recession type 2 (RT2) or 3 (RT3)[20] defects or Miller Class III or IV defects[21] mostly showed statistics on the midfacial root coverage and yielded outcomes that

do not encompass coverage of the interdental exposed root surface,[22–31] which highlights areas of controversy in their use for papilla reconstruction. Several case reports and clinical studies[10,32–46] have shown encouraging results, but the long-term data are not available in the literature yet. Nowadays, equally evaluating both clinician capabilities and patient esthetic needs, results such as interproximal root exposure are no longer sufficient. This study aims to report the performance of an innovative surgical design, 3D tunneling (3DT), over a period of up to 6.5 years.

Materials and Methods

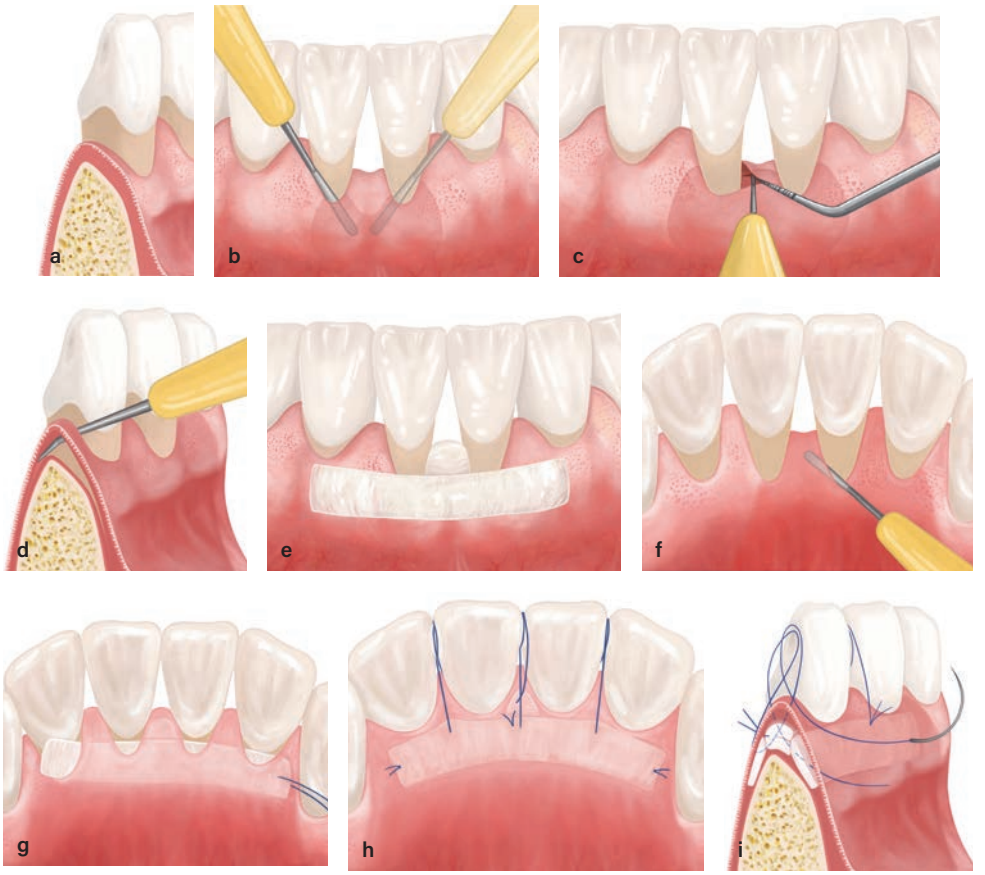
This prospective case series is reported in line with the PROCESS guidelines.[47] The study involved three nonsmoking women, aged 23 to 37 years old, without systemic diseases, who consulted because of an esthetic problem caused by a lack of interdental papilla on mandibular anterior teeth. None of the patients had prosthetic restorations with a cervical edge in the CEJ area, no history of periodontal surgery, and identifiable CEJ in the experimental sites. Patients were informed about the treatment and gave informed consent. The protocol is in full accordance with the 1975 Declaration of Helsinki, as revised in 2013. All baseline (which varied for cases 1, 2, and 3) and follow-up measurements were carried out between February 2017 and August 2023 in a private clinic (Moscow, Russia) by one trained examiner (E.K.).

3DT Technique

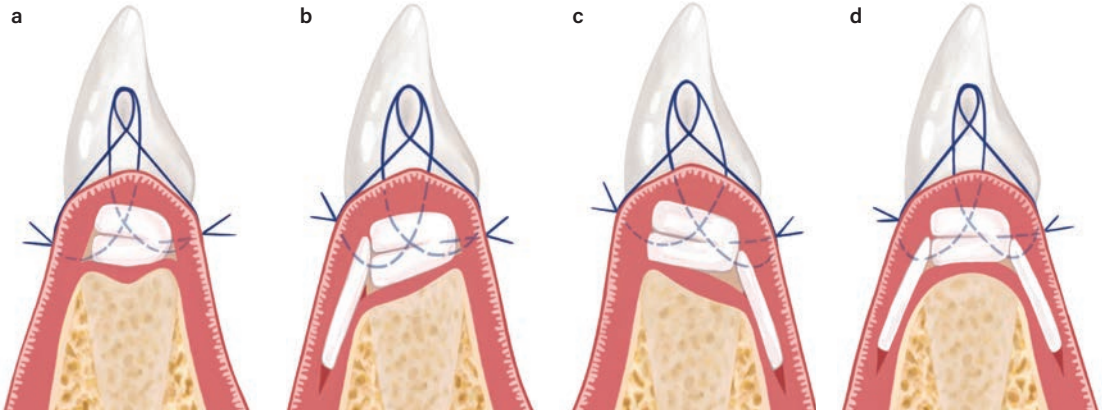
Prior to the procedure, the patient is instructed to rinse for 1 minute with chlorhexidine gluconate solution 0.2%. Following local anesthesia with articaine plus 1:200,000 epinephrine apical to the region, an ophthalmic crescent knife (MCB10, Mani) is used to make intrasulcular incisions around the teeth involved in the procedure. With a bendable spoon microsurgical blade (SB003, MJK), a partial-thickness tunneling flap is created from both buccal and lingual sites on the affected teeth, as well as the two adjacent teeth. If there is bad visibility from the lingual site, the patient is unable to open their mouth wide enough, or the mandibular anterior teeth have oral inclination, the lingual tunnel can be created through vertical incisions distally right and left from the operative area. After the buccal and lingual tunnels are elevated, interproximal tissues will need to be split to partial thickness; this can be done using a spoon bendable blade for wide papillae (≥ 2 mm) or an ophthalmic microblade for narrow papillae (< 2 mm), taking care not to perforate the lingual flap. Tunneling knives ae used to control the absence of muscle attachments and the flap mobility (TKN2 and TKN1, Hu-Friedy; for buccal and lingual sites, respectively). The flap is considered tension-free when the tip of each papilla is able to passively reach the CP. Once mobility of flaps and papillae are obtained, measurements of the recipient buccal and lingual sites and papilla size/length are taken (Fig 2).

The horizontal papilla categories described in the introduction (see Fig 1) can help clinicians select the correct connective tissue graft (CTG) positioning during 3DT (Fig 3). The soft tissue phenotype should be evaluated from the buccal and lingual sites of the operated teeth with a color-coded Colorvue Biotype Probe (Hu-Friedy) before surgery. After palatal anesthesia and using a new 15c blade, the free gingival graft (1 mm thick, dimensions as needed) is harvested in the distal area of the palate. The graft is carefully de-epithelialized extraorally with a new 15c blade and divided according to the measurements and the grafting strategy.

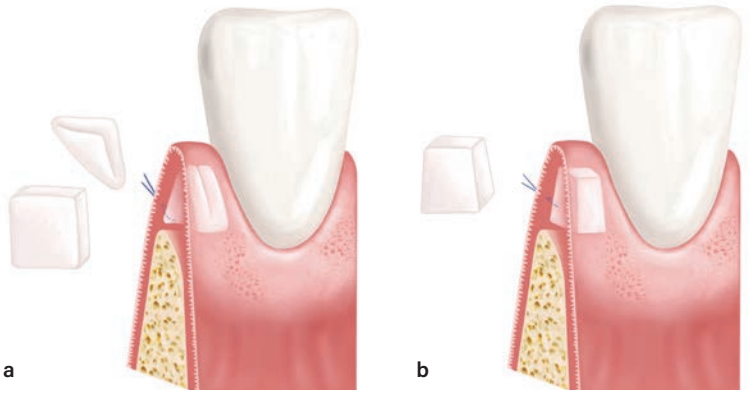
The interdental part of the graft may have two different forms and dimensions (Fig 4): If it is possible to harvest a 2-mm–thick CTG, the graft would be inserted vertically, but for CTG 1 mm thick, the graft may be inserted and folded in two as a triangle. After the exposed root surfaces are etched with 24% EDTA (Prefgel, Straumann) for 2 minutes and rinsed with saline solution, the vestibular and lingual grafts are placed in tunnels and sutured at their corners with polypropylene 6-0 sutures (Prolene, Ethicon). To adapt and stabilize the CTG below the papilla, a 6-0 polypropylene suture with a 13-mm noncutting needle is inserted at the base of the lingual papilla. The needle emerging from the buccal site can



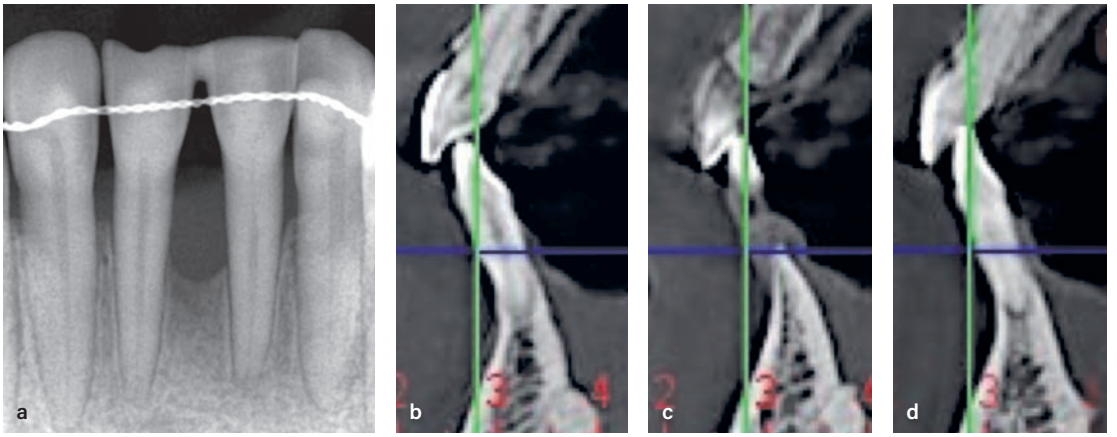
▲ **Fig 2** Illustration of the 3D tunneling (3DT) surgical technique. *(a)* Side view before treatment. *(b)* Buccal intrasulcular envelopes were split on each tooth involved in procedure, connected in one buccal tunneling flap. *(c)* Microsurgical step. The interproximal tissue was split to the lingual papilla base, using the periodontal probe to gently push the tissue to visualize the plane of the cut. *(d)* Interproximal splitting (side view). *(e)* Measuring and positioning buccal and proximal CTGs. *(f)* The split lingual envelopes on each tooth were connected. *(g)* CTG insertion in the lingual tunnel. *(h and i)* Lingual and side views, respectively, of the final double-crossed suspended sutures.



▲ **Fig 3** Illustrations of the correct CTG positioning during the 3DT procedure, according to the different categories of horizontally deficient interdental gingival papillae. *(a)* Type B requires CTG placement in the interproximal area. If the buccal phenotype is thin, a vestibular CTG might also be added. *(b)* For Type C, it is recommended to place the CTG on the vestibular side. Depending on the interproximal defect extension, an interproximal CTG might also be added. *(c)* For Type D, it is recommended to place the CTG from the oral side, with an additional interproximal CTG if needed. *(d)* In Type E, the vestibular and oral CTGs are placed simultaneously, keeping the height of the coronally positioned 3D tunnel as two vertical walls. Depending on the interproximal defect extension, if the defect is severe, dead-space formation should be avoided. A small CTG with enamel matrix derivative (Emdogain, Straumann) might also be added in the interdental area.



▶ **Fig 4** Illustrations of the two types of interdental CTG shape and placement during 3DT. *(a)* A 1-mm–thick CTG may be inserted by folding the CTG in two to form a triangle. *(b)* A 2-mm–thick CTG would be inserted vertically. CTG dimensions depend on the size of the recipient area (interdental tissue deficiency) and the thickness of the donor area (distal palate).



▲ **Fig 5** Case 1. *(a)* Radiograph and *(b to d)* computed tomography scans of mandibular incisors, showing the width, height, and depth of the bone crest between teeth 31 and 41.

engage one corner of the CTG and then be inserted back from buccal side (below the interdental flap), emerging at the base of the lingual papilla. Pulling the suture, the CTG will move in an interdental direction; when the desired position is reached, a surgical knot should be used to stabilize it. The double-crossed suture technique[48] with a polypropylene 5-0 suture will allow the coronal stabilization of each papilla engaging the buccal flap, grafts, and lingual flap all together (see Fig 2i). Additional composite sutures on midbuccal (see Fig 6c) and/or midlingual tooth surfaces will help keep the flap in the coronal position. The palatal wound may be covered with the Hemostatic gauze (BloodStop, Salvin) and a palatal stent, without the need for sutures.

Case Reports

Case 1

A 35-year-old woman presented with stage IV, Grade C generalized periodontitis[49]; deep, noncontained supraosseous bone defects on the mandibular incisors (Fig 5); 11 teeth with probing depths (PDs) > 5 mm; bleeding on probing in 26% of sites; and pathologic mobility of teeth 31 and 41 (FDI numbering system). The patient underwent initial nonsurgical periodontal treatment with P3 ultrasonic tips (EMS), airflow erythritol-based powder (EMS), scaling and root planing with mini curettes, and oral hygiene instructions. The surgical phase proceeded 3 months later, when excellent soft tissue tone was seen overlying the defect, periodontal pockets were completely reduce, and the inflammation and occlusal trauma were removed.

◀ **Fig 6** Case 1. 3DT was performed on the mandibular central incisors with bilateral adjacent GRs (RT3), loss of interproximal CAL, and deficient papillae. *(a)* Baseline. *(b)* The interdental CTG was sutured in position, and the buccal graft was inserted into the buccal tunnel flap. *(c)* The flaps and grafts were sutured with the double-crossed technique in the interdental areas and composite sutures on the buccal side. *(d)* Clinical outcome 1 year after the second 3DT procedure.

Table 1 Baseline and Postoperative Clinical Parameters

		Case 1 (41–31*)	Case 2 (42–41*)	Case 3 (41–31*)
BC–PT, mm	Baseline	5.6	5	5
	8 mo	–	–	7
	1 y	8.7	–	–
	6.5 y	–	8.5	–
	Change	**3.1**	**3.5**	**2**
PT–CP, mm	Baseline	7.5	6.5	5
	8 mo	–	–	3
	1 y	4.4	–	–
	6.5 y	–	3	–
	Change	**3.1**	**3.5**	**2**
BC–CP, mm	Baseline	13.1	11.5	10
	8 mo	–	–	10
	1 y	13.1	–	–
	6.5 y	–	11.5	–
	Change	0	0	0

Papilla gain data are bolded. BC–PT and BC–CP distances were measured using radiographic data. No difference was registered at the BC level. Change representes the difference between surgical day 0 (baseline) and 1 year (Case 1), baseline (before nonsurgical treatment) and 6.5 years (Case 2), and baseline (before nonsurgical treatment) and 8 months (Case 3). *FDI numbering system.

The mandibular anterior teeth were splinted. Teeth 31 and 41 showed an RT3 defect with the loss of interproximal clinical attachment level (CAL) up to 9 mm, as well as a papilla defect Class III,[17] Type E.

Two 3DT procedures were performed, 4 months apart (Fig 6). Clinical and radiographic parameters were evaluated at baseline (surgical day 0), 3 months (surgical day 0), 6 months (at the frenectomy), and 1 year postoperative. These parameters included: PD, measured from the gingival margin to the bottom of the pocket; CAL, measured from the CEJ to the bottom of the pocket; recession depth (REC), measured from the CEJ to the gingival margin at three points (distal, middle, mesial) at the buccal and lingual aspects of teeth; keratinized tissue width (KTW), measured from the gingival margin to the mucogingival junction at the midbuccal point; and papilla tip width (PTW), measured as the distance between roots at the level of the papilla tip. Further, distances from the bone crest (BC) to the papilla tip (PT), BC to CP, and PT to CP were measured using clinical and radiographic diagnostic data (Tables 1 and 2).

Table 2 Case 1: Baseline and Postoperative Clinical Parameters

		Tooth 41*			Tooth 31*		
		Distal	**Central**	**Mesial**	**Distal**	**Central**	**Mesial**
REC buccal, mm	Baseline	1	2	3	5	3	2
	Surgical day 0	1	2	3	6	4	2
	6 mo	1	2	0.5	2	2	2
	1 y	1	1	1	1	1	1
	Change	0	**1**	**2**	**5**	**3**	**1**
REC lingual, mm	Baseline	1	4	4	3	3	1
	Surgical day 0	1	4	4	4	3	1
	6 mo	1	2	1	1	2	0
	1 y	1	2	1	1	2	1
	Change	0	**2**	**3**	**3**	**1**	0
PD buccal, mm	Baseline	3	2	3	4	5	2
	Surgical day 0	3	2	3	3	2	2
	6 mo	3	2	4	4	2	2
	1 y	3	2	3	3	2	2
	Change	0	0	0	0	0	0
PD lingual, mm	Baseline	2	2	3	2	2	2
	Surgical day 0	2	2	3	2	2	2
	6 mo	2	2	3	3	2	2
	1 y	2	2	3	2	2	2
	Change	0	0	0	0	0	0
CAL buccal, mm	Baseline	4	4	6	9	8	4
	Surgical day 0	4	4	6	9	6	4
	6 mo	4	4	4.5	6	4	4
	1 y	3	3	4	3	3	3
	Change	**1**	**1**	**2**	**6**	**3**	**1**
CAL lingual, mm	Baseline	3	6	7	5	5	3
	Surgical day 0	3	6	7	6	5	3
	6 mo	3	4	4	4	4	2
	1 y	3	4	4	3	4	3
	Change	0	**2**	**3**	**3**	1	0
KTW, mm	Baseline	1			0		
	1 y	9			10		
	Change	**8**			**10**		

Baseline is initial data before nonsurgical periodontal treatment. Surgical day 0 is 3 months after nonsurgical periodontal therapy. At 6 months, an additional lower lip frenectomy was performed. Change represents the difference between surgical day 0 and 1 year. Positive results are bolded.
*FDI numbering system.

◀ **Fig 7** Case 2. 3DT was performed on the mandibular incisors with bilateral adjacent GRs (RT2 and RT3), loss of interproximal CAL, and deficient papillae. *(a)* Baseline. *(b)* Clinical outcome 2 years after 3DT, when the patient was sent to receive restorative treatment. *(c)* Clinical outcome 6.5 years after 3DT. No pathologic PD was registered.

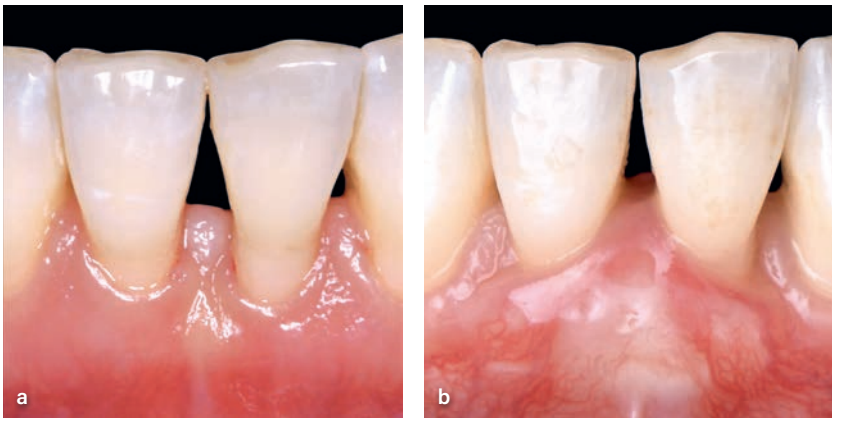
Case 2

A 23-year-old woman with a history of untreated periodontal disease and orthodontic treatment at age 17 was referred for a root-coverage procedure. She was diagnosed with stage IV, grade C localized periodontitis, RT2, and papilla defect class III, type E on teeth 31, 41, and 42. A lingual orthodontic retainer, traumatic pathologic occlusion, and severe horizontal bone resorption were registered in the anterior mandible. Following professional oral hygiene procedures and nonsurgical periodontal treatment and instructions, the patient underwent the 3DT procedure twice, with 4 months between each procedure. At 2 years postoperative, the shapes of teeth 31 and 41 were modified with composite restorations (Fig 7). PD, CAL, REC, KTW, PTW, BC–PT, BC–CP, and PT–CP were evaluated at baseline (before nonsurgical treatment) and at 1 year (frenectomy), 2 years (restorative step), and 6.5 years postoperative (Tables 1 and 3).

Table 3 Case 2: Baseline and Postoperative Clinical Parameters

		Tooth 42*			Tooth 41*			Tooth 31*		
		Distal	**Central**	**Mesial**	**Distal**	**Central**	**Mesial**	**Distal**	**Central**	**Mesial**
REC buccal, mm	Baseline	1	3.5	3	3	5	1	1	3	0.5
	1 y	0	0	0.5	1	2	2	1	1	0.5
	2 y	0	0	0.5	0	1	1	1	1	0.5
	6.5 y	0	0	0	0	0	0	0	0	0
	Change	**1**	**3.5**	**2.5**	**3**	**4**	0	0	**2**	0
		1	**3.5**	**3**	**3**	**5**	**1**	**1**	**3**	**0.5**
REC lingual, mm	Baseline	1	3	3	3	3	2	1	2	1
	1 y	0	2	1	0	1	1	1	1	1
	2 y	0	2	1	0	1	1	1	1	1
	6.5 y	0	1	0	0	0	0	0	00	0
	Change	**1**	**1**	**2**	**3**	**2**	**1**	0	**1**	0
		1	**2**	**3**	**3**	**3**	**2**	**1**	**2**	**1**
PD buccal, mm	Baseline	2	2	2	2	1	2	2	1	2
	1 y	2	2	2	2	3	2	2	1	2
	2 y	2	1	2	2	1	2	2	1	2
	6.5 y	2	1	2	2	1	2	2	1	2
	Change	0	**1**	0	0	0	0	0	0	0
PD lingual, mm	Baseline	2	1	2	2	2	2	2	2	1
	1 y	2	1	2	2	2	3	2	2	1
	2 y	2	1	2	2	2	2	1	1	1
	6.5 y	2	1	2	2	1	2	1	1	1
	Change	0	0	0	0	0	0	**1**	**1**	0
CAL buccal, mm	Baseline	3	5.5	5	5	6	3	3	4	2.5
	1 y	2	2	2.5	3	5	4	3	2	2.5
	2 y	2	1	2.5	2	2	3	3	2	2.5
	6.5 y	2	1	2	2	1	2	2	1	2
	Change	0	**4.5**	**2.5**	**3**	**4**	0	0	**2**	0
CAL lingual, mm	Baseline	3	4	5	5	5	4	3	4	2
	1 y	2	3	3	2	3	4	3	3	1
	2 y	2	3	3	2	3	3	2	2	2
	6.5 y	2	2	2	2	1	2	1	1	1
	Change	**1**	**1**	**2**	**3**	**2**	**1**	**1**	**2**	0
KTW, mm	Baseline	2			1			3.5		
	6.5 y	9			10			9		
	Change	**7**			**9**			**5.5**		

Baseline is initial data. At 1 year, an additional lower lip frenectomy was performed. At 2 years, after 3DT, the patient received restorative treatment. Change represents the difference between baseline and 2 years (when teeth were not yet covered with restorations) in the top row and between baseline and 6.5 years in the bottom row. Positive results are bolded. For tooth 31, data is shown, but it was not included in statistical analyses because the 3DT treatment was only focused on sites 41 and 42 for this clinical case.
*FDI numbering system.



◀ **Fig 8** Case 3. 3DT was performed on the mandibular central incisors with bilateral adjacent GRs (RT2), loss of interproximal CAL, and deficient papillae. *(a)* Base-line. *(b)* Clinical outcome 8 months after 3DT, when the patient was sent to receive orthodontic treatment.

Table 4 Case 3: Baseline and Postoperative Clinical Parameters

		Tooth 41*			Tooth 31*		
		Distal	**Central**	**Mesial**	**Distal**	**Central**	**Mesial**
REC buccal, mm	Baseline	0.5	2	2	2.3	2.5	1
	2 mo	0.5	1	1	1	1	1
	8 mo	0.5	0	0	0	0	1
	Change	0	**2**	**2**	**2.3**	**2.5**	0
REC lingual, mm	Baseline	0	2	1	2	3	1
	2 mo	0	1	1	0	2	1
	8 mo	0	0	0	0	2	1
	Change	0	**2**	**1**	**2**	**1**	0
PD buccal, mm	Baseline	2	1	2	2	1	2
	2 mo	2	1	2	2	1	2
	8 mo	2	1	2	2	1	2
	Change	0	0	0	0	0	0
PD lingual, mm	Baseline	2	1	2	2	1	2
	2 mo	2	1	2	2	1	2
	8 mo	2	1	2	2	1	2
	Change	0	0	0	0	0	0
CAL buccal, mm	Baseline	2.5	3	4	4.3	3.5	3
	2 mo	2.5	2	3	3	2	3
	8 mo	2.5	1	2	2	1	3
	Change	0	**2**	**2**	**2.3**	**2.5**	0
CAL lingual, mm	Baseline	2	3	3	4	4	3
	2 mo	2	2	3	2	3	3
	8 mo	2	1	2	2	2	3
	Change	0	**2**	**1**	**2**	**1**	0
KTW, mm	Baseline	3			2		
	8 mo	5			5		
	Change	**2**			**3**		

Baseline is initial data. At 2 months, an additional lower lip frenectomy was performed. At 8 months after 3DT, the patient received orthodontic treatment. Change represents the difference between baseline and 8 months. CAL gain and root coverage data are bolded.
*FDI numbering system.

Table 5 Mean Proximal RC at Baseline and Observation Interval for Cases 1, 2, and 3

Case	Tooth	Proximal GR (mm)				RC (%)		mRC ± SD, %
		Buccal		Lingual				
		Baseline	At the OI	Baseline	At the OI	Buccal	Lingual	
1	41	3	1 (1 y)	4	1 (1 y)	66.7	75	70.8 ± 5.9
	31	6	1 (1 y)	4	1 (1 y)	83.3	75	79.1 ± 5.9
2	42	3	0.5 (2 y)	3	1 (2 y)	83.3	66.7	75 ± 11.7
	41	3	0 (2 y)	3	0 (2 y)	100	100	100
3	41	2	0 (8 mo)	1	0 (8 mo)	100	100	100
	31	2.3	0 (8 mo)	2	0 (8 mo)	100	100	100

mRC = mean root coverage; OI = observation interval; RC = root coverage.
The difference from baseline was statistically significant in all three cases ($P < .01$).

Case 3

A 37-year-old woman with the chief complaint of a gap between her mandibular central incisors was diagnosed with stage IV, grade A localized periodontitis (stage II diagnosis was not given due to the patient missing 2 teeth and need for orthodontic treatment). Radiographic and clinical examinations revealed loss of the interdental tissue (RT2, papilla class III, type E) and bone crest height, forming supraosseous periodontal defects on teeth 31 and 41. Contact points of the mandibular anterior teeth were splinted with an orthodontic ligature. After preparation (professional oral hygiene procedures, nonsurgical periodontal treatment, and receiving instructions), the patient underwent 3DT (Fig 8). The following clinical and radiographic parameters were evaluated at baseline (before nonsurgical treatment) and at 2 months (frenectomy step) and 8 months postoperative: PD, CAL, REC, KTW, PTW, BC–PT, BC–CP, and PT–CP (Tables 1 and 4).

Postsurgical Care

Patients should be instructed to gently rinse for 1 minute with a 0.12% chlorhexidine digluconate mouthwash twice a day for 3 weeks. Ibuprofen (600 mg) 3 times per day for 5 days should be prescribed. Sutures should not be removed earlier than 3 weeks but can be kept in place for 1.5 to 2 months. Patients should be recalled for control and prophylaxis at postoperative weeks 1, 2, and 3, and until complete suture removal. At 4 weeks postoperative, the patient is instructed to start brushing with a soft toothbrush. At 1.5 months postoperative, the patient can resume normal brushing, even if sutures are still in place.

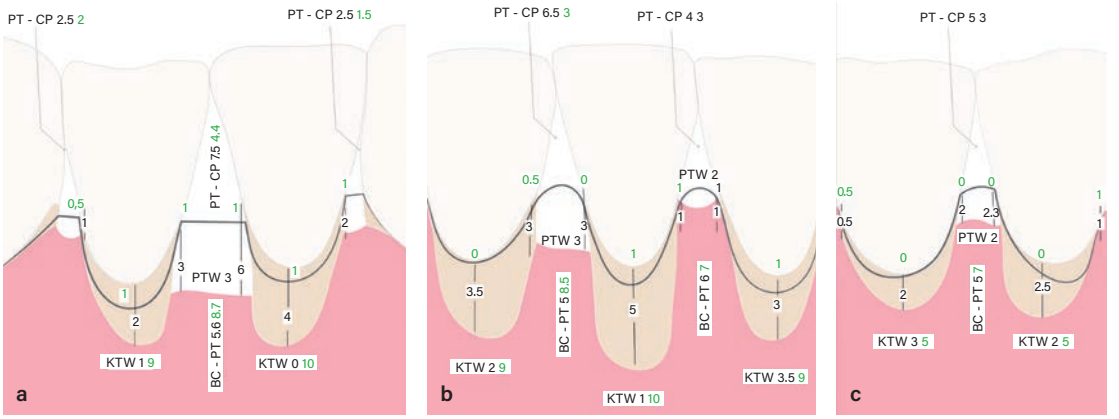
Data Analysis

Statistical analysis was performed with SPSS software (version 26.0, IBM). At the first stage, descriptive statistics were carried out using exploratory data analysis. Because there were fewer than 10 samples, nonparametric tests were used for analysis. Due to the absence of homogeneous observation intervals, proximal mean root coverage (mRC) and standard deviations were calculated using the exploratory data analysis from buccal and lingual papilla sites in each case. The comparative analysis before and after treatment was evaluated with Mann-Whitney test. In all cases, differences were considered statistically significant at $P < .001$. Percentage differences were calculated using the following formula: $(a - b) / a * 100\%$

...in which a is the first value (before treatment) and b is the second value (after treatment).

Results

A total of six proximal gingival recessions (GRs; mean REC of 3 ± 2 mm) in the mandibular incisor area were treated with 3DT. A proximal mRC of up to 100% was achieved in Cases 2 and 3, and up to 79.1% ± 5.9% in Case 1 (Table 5). Complete proximal root coverage was achieved in three of the six sites, and complete buccolingual root coverage



▲ **Fig 9** Schematic drawings of the changes in clinical and radiographic outcomes. The pink areas are the baseline gingival shape. The *black line* is the gingival margin level at *(a)* 1 year for Case 1, *(b)* 2 years (before restorative treatment) for Case 2, and *(c)* 8 months for Case 3. REC is shown on three points (distal, middle, and mesial) at the buccal aspects of teeth. KTW is shown from the midbuccal aspect of each tooth. PTW is the distance between the roots at the level of the tip of the papilla. BC–PT, BC–CP, and PT–CP distances are also shown. Baseline data are shown in black text, with final-result data in green text.

was achieved in four sites. After 6.5 years, Case 2 showed improvements in REC and CAL gain (see Table 3).

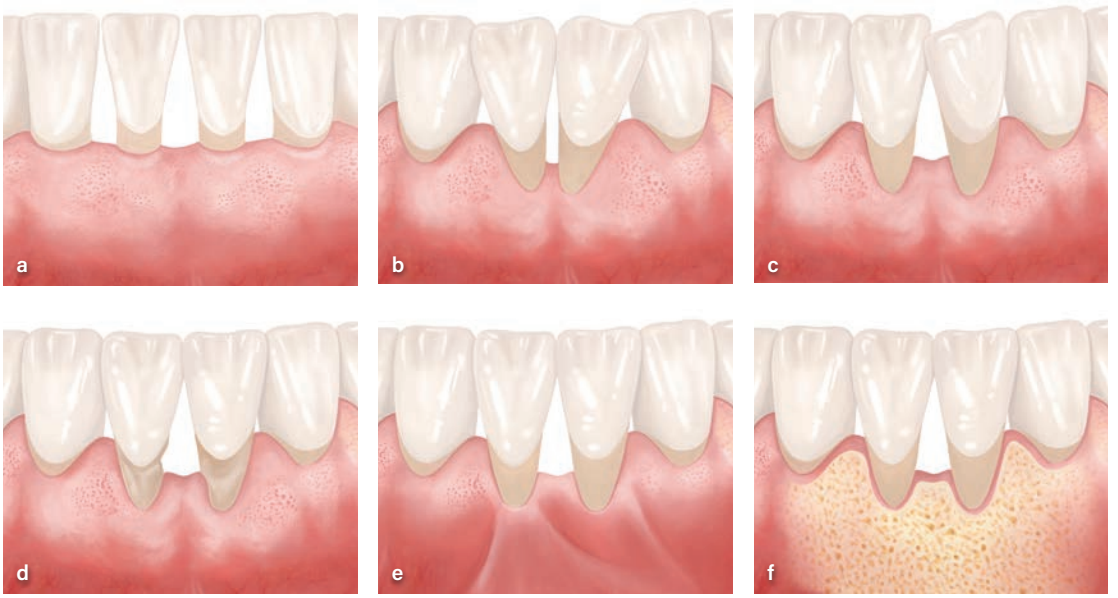
Significant increases in keratinized tissue (up to 9 mm) and supra-alveolar interproximal attachment gain (up to 5 mm) were seen. The PT–CP distance was reduced by 3.5, 2, and 3 mm in Cases 1, 2, and 3, respectively. All of the areas where a CTG was transplanted showed a thicker gingival phenotype. The combined clinical and radiographic measurements were determined by superimposing the CBCT or radiographic data with clinical photos at the baseline and the end of the observation intervals for each clinical case. No changes at the BC level were registered, and the BC–CP distance remained stable; this combination of data confirms that no orthodontic movement occurred, nor was the CP position corrected (Fig 9).

Discussion

While the 3DT can address also buccal and lingual root coverage, as seen in the present clinical cases, its core focus is the regeneration of deficient gingival papilla and lost interproximal attachment. The primary aim of coronally repositioned buccal and lingual tunnels is a tension-free suturing of the proximal part of the flap and the transplanted graft below it. If any nonproximal GRs remain after completing the proximal restoration, they can be addressed later using conventional methods. 3DT should not be carried out if there is no papillary deficiency.

In order to guide clinicians in identifying other situations wherein 3DT should not be provided, it is highly important to examen clinical cases on the contraindication criteria. Contraindications can be divided into three types: orthodontic, restorative, and surgical.

Orthodontic contraindications—such as tooth extrusion (Fig 10a), root angulation (Figs 10b), and tooth rotation (Fig 10c), isolated or in combination—limit the possibility of obtaining a complete interproximal root coverage after surgery and increase the risk of the CTG necrosis due to the lack of blood supply to the recipient area. In cases characterized by presence of a large black triangle resulting from a coronally positioned CP or diastema, wherein the width between the roots at the interdental CEJ exceeds 2 mm, it should be acknowledged that it is not possible to achieve a complete fill of the black triangle only using surgical methods. In such cases, 3DT can be considered with the primary objective of covering the exposed interdental root surface and repositioning the gingival margin to the interproximal CEJ level.



▲ **Fig 10** Illustrations of the orthodontic, restorative, and surgical contraindications to 3DT. Orthodontic contraindications include *(a)* tooth extrusion, *(b)* root angulation, *(c)* and tooth rotation. *(d)* Restorative contraindications include root caries, noncarious cervical lesions, and nonvital root surface. Surgical contraindications include papillary frenal attachments with muscle fibers extending and penetrating the area close to the interdental papilla, insufficient width of keratinized attached gingiva *(e)*, and supracrestal interproximal soft tissue thickness < 1.5 mm *(f)*.

This type of clinical scenario is demonstrating the fundamental disparity between the objective of closing a black triangle and of closing a proximal GR, highlighting their distinct nature. After the complete maturation of interproximal tissues, restorative or orthodontic treatment with the aim to close completely the black triangle is recommended (see Figs 7b and 7c).

Restorative contraindications (Fig 10d) include root caries, noncarious cervical lesions, and nonvital root surfaces. These conditions should be solved prior to the surgery by restoring a smooth, straight root surface without steps, sharpness, protrusions, or invaginations.

Insufficient width of keratinized attached gingiva (Fig 10e) is a surgical contraindication to 3DT. Baldi et al[50] and Pini Prato et al[51] underscored the critical role of flap thickness > 0.8 mm and flap tension < 4 g, respectively. The accurate split-thickness flap preparation forms an important part of the technique, and the use of both overlying and underlying vascular sources (the bilaminar blood supply) plays an essential role in enhancing the donor tissue perfusion and graft survival by promoting rapid postoperative establishment of a blood supply and tissue viability. If the supracrestal interproximal soft-tissue thickness is < 1.5 mm (Fig 10f), the overlying and underlying tissue would be insufficient for survival. Proper management of flap tension is essential to ensure optimal tissue adaptation and minimize undue mechanical stress at the surgical site. In case of papillary frenal attachments with muscle fibers extending to and penetrating the area close to the interdental papilla (see Fig 10e), it is possible to provide 3DT treatment, but note that there is a high risk of flap tearing and being unable to achieve tension-free healing, which leads to failure. It is important to highlight that, even if before the surgery the frenulum tension is not visible, the elasticity of mucosa becomes insufficient during the healing and maturation process as the transplanted subepithelial portion of the graft is growing, due to the significant surgical coronal repositioning of tissues. Consequently, this often leads to frenulum tension, despite its correct splitting during the tunneling procedure. The presence of such postsurgical tension stops the growth

and the CAL regenerative process, resulting in the apical retraction of coronally displaced soft tissues. Thus, in all three of the present cases, an additional lower lip frenectomy was performed 2 to 6 months after the 3DT procedure.

Conclusions

Within its limitations, the present case series demonstrates an up-to-date evidence-based summary of the current concepts and future prospectives on interproximal papilla regeneration, categories of horizontally deficient papilla, and the possibility of treating proximal GR in the anterior mandible using 3DT, a novel surgical technique. The 3DT method achieved a significant clinical improvement with long-term stability. Nevertheless, additional research is needed to find factors most associated with the successful and predictable outcomes and to validate 3DT for its routine clinical use.

Acknowledgments

The authors do not have any financial interests, either directly or indirectly, in the products or information enclosed in the paper. The study was self-supported by the authors.

Author contributions: E.K. was involved in the study conception and design, preparation and distribution of clinical cases, manuscript preparation, analysis and interpretation of data, initial and final drafting of the work, and final approval of the version to be published. K.I. was involved in the analysis and interpretation of data from the literature and the final review of the work. E.L. was involved in the preparation and distribution of clinical cases and the final review of the work. All authors confirm they are accountable for all aspects of the work.

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