Received: 4 March 2021 | Revised: 26 May 2021 | Accepted: 9 July 2021

DOI: 10.1002/JPER.21-0131

JOURNAL OF Periodontology

HUMAN RANDOMIZED CONTROLLED TRIAL

Efficacy of a harvest graft substitute for recession coverage and soft tissue volume augmentation: A randomized controlled trial

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[Correction added on 31 December 2021, after first online publication: In the abstract on page 333 and Table 2 on page 337, mm^2 was corrected to mm^3.]

Abstract

Background: The autogenous connective tissue graft (CTG) with coronally advanced flap (CTG+CAF) is the "gold standard" for recession defect coverage; however, researchers continue to pursue lower morbidity, more convenient and unlimited supply harvest graft substitutes, including those that could provide soft tissue volume augmentation.

Methods: A randomized, controlled, double-masked comparison of a volume-stable collagen matrix (VCMX) versus CTG was conducted at four clinical investigation sites. Single, contralateral, within patient matched-pair, RT1 recession defects were treated with VCMX+CAF (test) and CTG+CAF (control). The primary efficacy end point was percent root coverage at 6 months. Secondary efficacy end points included clinical measures such as soft tissue volume, attachment level, and keratinized tissue width. Patient-reported outcomes included measures such as discomfort, esthetics, and overall satisfaction; 6-month end point results were followed for 1 year.

Results: Thirty patients received control and test therapies, and all patients were available for follow-up measures. Average percent root coverage for CTG+CAF was 90.5% ± 14.87% versus 70.7% ± 28.26% for VCMX+CAF, $P < 0.0001$. Both therapies produced significant soft tissue volume increases (84.8 ± 47.43 mm^3 control versus 48.90 ± 35.58 mm^3 test, $P = 0.0006$). The test, harvest graft substitute produced less postoperative pain and was preferred by patients at the 6-month end point. All other end point measures were not significantly different.

Conclusions: VCMX+CAF root coverage was inferior to CTG+CAF but produced less morbidity and was preferred by patients. Case/patient selection and surgical technique appear key to achieving successful results with the harvest graft alternative.

KEYWORDS
collagen; connective tissue; esthetics, dental; gingival recession; personal satisfaction

1 | INTRODUCTION

The subepithelial connective tissue graft (CTG) combined with a coronally advanced flap (CAF) has been advanced as the "gold standard" for recession coverage around teeth.[1,2] But in the quest for easier to use, unlimited supply alternatives to painful harvest grafts, researchers continue to test harvest graft substitutes. Recently, a volume stable, fully resorbable, porous, collagen matrix of porcine origin and spongious consistency (volume stable collagen matrix [VCMX][*]) hasbecome available for soft tissue augmentation. The collagen is extracted from veterinary certified pigs and is purified to avoid antigenic reactions. Its scaffold is chemically cross-linked weakly and sterilized in double packaging using Gamma-irradiation. The biomaterial is indicated for insufficient tissue volume in the alveolar ridge and tissue recessions. It was designed to include mechanical properties appropriate to withstand the mechanical stresses that occur after wound closure in soft tissue augmentation procedures, that is, it provides volume stability and withstands early resorption, while encouraging formation of new soft tissue.[3,4] Because of its wettability, suturability, and biological properties, the device has been reported to become well integrated with surrounding soft tissue.[5,6]

Given these characteristics, the authors conducted a study to examine non-inferiority in the efficacy of VCMX+CAF compared with CTG+CAF with respect to percent root coverage (%RC) at 6 months (24 weeks) in the treatment of recession defects.

2 | MATERIALS AND METHODS

2.1 | Study design

The study was a prospective, randomized, controlled, split-mouth, double-masked (patients and calibrated examiners), multicenter evaluation assessing non-inferiority of VCMX (test) in comparison with CTG (control). The target population was patients aged 18 to 75 years, inclusive, with recession defects (RT1—2018 World Workshop), with two qualifying, matched-pair, contralateral defects. Qualifying defects had recessions >3 mm in both width and depth and occurred in either the maxilla or mandible, excluding the molar regions. Patients with esthetic concerns and hypersensitivity at qualifying recession sites were eligible for enrollment (for a full list of patient inclusion and exclusion criteria, please see supplementary Table S1 in online *Journal of Periodontology*). Matched-pair defects were randomized 1:1 to receive test or control therapies.

The study was performed in accordance with the Declaration of Helsinki, Good Clinical Practices, and ICH Guidelines and was registered with ClinicalTrials.gov, identifier NCT04260152. The protocol and patient informed consent process were approved by an Institutional Review Board[†] and complied with federal (21 CFR 56) and HIPAA requirements.

2.2 | Treatment

Pre-surgery, patients received full-mouth cleanings, and if diagnosed with parafunctional habits, bite guards. Indexing measurement stents were also fabricated. Patients provided their preoperative anxiety and esthetics satisfaction assessments and were instructed in the use of postoperative, PROs daily-diaries. Study teeth were scaled, root planed, and prepared using appropriate instrumentation. Exposed root surfaces were conditioned with EDTA[‡], and surgery was initiated (Fig. 1.)

Preparation of the recipient sites was the same for both test and control sites. Treatment site, randomized assignments to test or control were not revealed to investigators until immediately prior to surgery, and the right side of the mouth was treated first. Sites were prepared using a facial sulcular incision to join two vertical incisions. The mucoperiosteal flap—combined partial, full thickness—was elevated and released. VCMX was thinned to ≈3.0 mm after hydration (hydration increases the volume of VCMX by ≈25%) and cut to size for the defect, rounding and sloping the matrix edges so they were thinner around the perimeter (Fig. 1). For the CTG control therapy, the donor area for the subepithelial harvest graft was the bicuspid region of the palate on the side of the mouth receiving CTG+CAF therapy. The harvest site was sutured, but no surgical dressings or protective stents were used. VCMX and CTG were sutured in place to the papillary area using braided, resorbable (polyglycolic acid) 6-0/ 7-0 sutures. CTGs and VCMXs were positioned over the dehiscence defect ≈2 to 3 mm apical to the CEJ, and VCMX was also placed 2 to 3 mm away from vertical releasing incisions. Flaps were advanced using light pressure so as not to crush VCMX and were secured by suturing to the papillary area with monofilament polypropylene 6-0/7-0, with interrupted sutures to close the vertical releasing incisions. For both VCMX and CTG therapies, matrix and graft dimensions were recorded using manual and digital scan measures. Surgery times for test and control therapies were also recorded—from first incision to final suture.

[*] Geistlich Fibro-Gide, Geistlich Pharma, Wolhusen, Switzerland.

[†] Advarra, Columbia, MD, USA.

[‡] PrefGel, Straumann Holding, Basel, Switzerland.

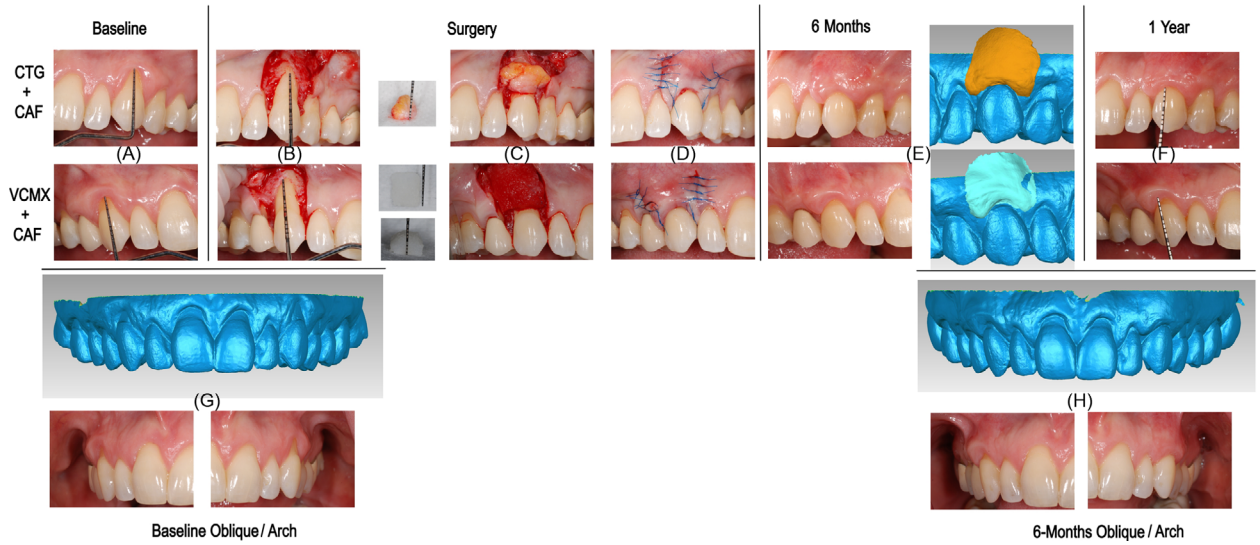

FIGURE 1 Case series. (**A**) Baseline, matched-pair defects. (**B**) CTG harvest and VCMX preparation. (**C**) Placement of control and test materials. (**D**) Suturing of sites. (**E**) Six-month end point including intraoral scan soft tissue augmentation volumes. (**F**) One-year follow-up, and (**G**) baseline and (**H**) 6-month full-mouth intraoral scans and oblique views

Patients were prescribed amoxicillin 500 mg, one tablet three times a day beginning the day before surgery and for 10-days post-surgery (with azithromycin used for allergies) and instructed to take 400 mg ibuprofen with 500 mg acetaminophen three times a day for the first 3 days following surgery. Patients recorded all medications in their daily diaries, were instructed to avoid muscle traction or trauma at the treatment sites, and told not to brush the surgical sites but to use chlorhexidine (0.2%) mouth rinse for 1 minute twice a day for the first 2 weeks following surgery. During weeks 3 and 4, patients were instructed to apply chlorhexidine to the treatment sites using a cotton swab, and starting week 4, patients were taught a soft brush technique to avoid apically directed trauma. Patients were recalled for professional cleanings at weeks 4, 7 (optional), 12, and 24.

2.3 | Assessments

The primary evaluation endpoint was percent recession coverage (%RC), measured by masked and calibrated examiners as recession depth, using UNC-15 probes[§] and rounding down to the nearest half millimeter. Secondary measures included clinical measures such as soft tissue dimensions, pocket depth, plaque and gingival inflammation indices, along with patient-reported outcome (PRO) measures for pain, esthetics and overall treatment preference. Soft tissue dimensions were measured using both indexing stents and an intraoral scanner[II]. Following previously published methodology, the scans were converted to stereolithography files of tissue contour and analyzed using non-contact reverse engineering software[¶] and indexed over time against subsequent visits to track volume changes.[7] For 7-days following surgery, patients completed daily diaries for pain/discomfort and analgesics and/or anti-inflammatories consumed, with additional PROs recorded at subsequent office visits by staff not involved in the patients' therapy and reading scripted questions. All assessments are listed in supplementary Table S2 in the online *Journal of Periodontology* and were evaluated at the 6-month end point, with follow-up at 1 year.

2.4 | Statistical analysis

As a randomized, controlled, multicenter study, each subject contributed paired defects to the study, and randomization was 1:1 for the paired defects within each subject. There was no need for blocking by center and/or stratification by any other variable. Patients were not allocated but rather treated at each investigation site as they appeared and met study criteria. The primary end point hypothesis was that %RC at 6 months for VCMX+CAF (test) was noninferior to CTG+CAF (control). The power analysis was based on 80% power and past McGuire/Scheyer matched-pair defect recession coverage studies.[8–13] A one-sided confidence interval of 0.025 indicated that, to detect a 12%

[§] 15 UNC Novatech Color Coded Probe, Hu-Friedy, Chicago, IL, USA.

[II] TRIOS 3 Scanner with Pen grip Pod, 3Shape, Copenhagen, Denmark.
[¶] Geomagic Control, 3D Systems, Santa Clarita, CA, USA.

TABLE 1 Sex, history of tobacco use, race/ethnicity, and baseline recession depth (mm ± SD)

Sex	Count	Prior tobacco use	Count	Race	Count	Recession depth
F	19	N	20	White	27	3.73 ± 0.95
M	11	Y	10	Asian	1	3.63 ± 0.79
				Asian+White	1	
				Other/Hispanic or Non-Hispanic	1	
Total	30		30		30	$P = 0.66$

difference in root coverage with ± 15% SD, a sample of 25 patients would be required; previous McGuire/Scheyer studies, as cited above, also used 25 patients.) Given the multicenter nature of the study and the intention to follow patients long-term, with normal attrition, 30 subjects were estimated as needed to ensure long-term follow-up and provide a "power buffer" for any outcome differences that might be seen between investigation centers.

Given within patient, defect pairing, patient-related variables were the same for both defects, so descriptive statistics only were used to describe patients treated, with no hypothesis testing. Baseline defect characteristics were used to ensure paired test and control defects were similar. Continuous variables were evaluated with one sample *t*-tests, categorical variables with Chi-squared analysis and dichotomous variables with McNemar test for paired observations. The primary outcome variable (%RC) was tested for non-inferiority by paired *t*-test. If significant, the primary outcome was further verified by repeated measures of variance with both subject and center as random effects. The secondary and exploratory measures were described by descriptive statistics (mean, standard error) and, where appropriate, tested for group differences by paired *t*-tests. If significant, they were also verified by repeated measures of variance, with subject and center as random effects. Safety end points, including adverse events, if any, were tested to determine occurrence differences using McNemar test for paired observations. 1-year follow-up analysis was done in a similar fashion to that done at the 6-months end point; however, time as a random effect was added to the overall ANOVA model.

3 | RESULTS

Thirty-patients, mean age 50.7 ± 11.4 years and meeting inclusion and exclusion criteria, were entered into the study between September 2018 and June 2019. All 30 patients were evaluated at the 6-month end point and 1-year follow-up. Patients were treated at three investigation centers by four investigators/surgeons (the authors), with masked and calibrated examiners at each center. All examiners were calibrated for inter- and intra-agreement of probing depth, clinical attachment level (CAL), and recession probing measures, and agreement was 94.9% within 1 mm, which compares favorably with the measures reported in other, published calibration reports.[14–16] Patient populations treated and results per center are reported in supplementary Table S3 in the online *Journal of Periodontology*. Overall patient population descriptive statistics are provided in Table 1. Clinical results and PROs are provided in Table 2.

The mean difference at 6 months for the primary outcome variable of %RC favored the control, CTG+CAF therapy by 19.81%, with a 95% confidence interval upper limit of 10.28% and lower limit of 29.34%. Given the non-inferiority limit of 12%, mean VCMX+CAF %RC did not meet the non-inferiority threshold. It should be noted that the standard deviation of this difference between therapies was 25.52%, indicating result variability. Remaining analyses of recession coverage, that is, linear horizontal and vertical recession measures, also demonstrated inferiority for VCMX, $P < 0.0002$. When center was added to the model it was not significant, nor was there an interaction between center and treatment type.

Figure 2 depicts paired defect comparisons of %RC results; 100% RC was achieved in 10 (33%) VCMX+CAF and 20 (66%) CTG+CAF defects, with an additional two-defects (7%) for each therapy within 0.5 mm of 100% coverage (please refer to case photos in Figure 1.) Using a masked evaluator (RH), an ad hoc assessment of preoperative, paired defects in which VCMX+CAF achieved ≤50% RC and ≥33% less recession coverage than CTG+CAF (five patients/17% of cases) was conducted. In all cases (100%), the masked evaluator chose the randomized CTG+CAF, control sites as likely to achieve better %RC. Reasons cited included root prominence, narrow interdental space, more severe recession on adjacent teeth and more inflammation at the test site (this site from a patient who did not follow home care instructions and brushed surgical sites postoperatively). Regardless, analysis of the entire population of defects indicated the test therapy, on average, was inferior.

In regard to the remaining, secondary and exploratory end points, only baseline graft dimensions, overall volume of soft tissue augmentation gained, and PROs results were significantly different between the two therapies.

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TABLE 2 Baseline, 6-month, and 1-year results

		Baseline		6 Months		1 Year	
Group	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
	Percent recession coverage (%RC)						
CTG+CAF	30	0	na	90.5	14.87	84.49	19.98
VCMX+CAF	30	0	na	70.7	28.26	63.2	31.56
P value			na		<.0001		<.0001
	Recession depth (mm)						
CTG+CAF	30	3.73	0.95	0.38	0.63	0.62	0.82
VCMX+CAF	30	3.63	0.79	1.08	1.08	1.37	1.22
P value		0.5214			<.0001		<.0001
	Recession width (mm)						
CTG+CAF	30	3.7	0.48	0.6	0.99	0.7	0.93
VCMX+CAF	30	3.7	0.64	1.4	1.25	1.5	1.27
P value			0.91		<.0001		<.0001
	Probing pocket depth mid-buccal (mm)						
CTG+CAF	30	1.5	0.57	2.1	0.48	2.3	0.48
VCMX+CAF	30	1.4	0.50	2.0	0.41	2.3	0.47
	No clinically significant differences, thus no hypothesis testing						
	Clinical attachment level (CAL in mm)						
CTG+CAF	30	4.90	1.40	1.80	0.66	2.20	0.89
VCMX+CAF	30	4.70	1.51	2.23	1.17	2.60	1.16
	No clinically significant differences, thus no hypothesis testing						
	Keratinized tissue width (KTw in mm)						
CTG+CAF	30	2.3	0.88	3.6	1.32	3.6	1.31
VCMX+CAF	30	2.5	1.25	3.2	1.50	3.3	1.30
P value	0.4051						
	Digital scan soft tissue volume (mm^3)						
CTG+CAF	30	158.37*	72.89	84.80	47.43	72.35	38.40
VCMX+CAF	30	189.40*	73.87	48.90	35.58	39.23	30.92
P value	0.0006						
*Baseline immediately post-surgery as compared with pre-surgery							
	Linear soft tissue dimensions at margin using stent (mm)						
CTG+CAF	30	5.7	1.69	4.3	1.49	na	na
VCMX+CAF	30	5.5	1.66	4.5	1.63	na	na
	No clinically significant differences, thus no hypothesis testing						
	Measure	**Count**		**Count**		**Count**	
	Bleeding on probing (Yes/No)						
CTG+CAF	N	24		30		29	
	Y	6		0		1	
VCMX+CAF	N	24		28		29	
	Y	6		2		1	
	No clinically significant differences, thus no hypothesis testing						
	Root dentinal hypersensitivity (Yes/No)						
CTG+CAF	N	25		30		29	
	Y	5		0		1	
VCMX+CAF	N	26		28		29	
	Y	4		2		1	
	No clinically significant differences, thus no hypothesis testing						

(Continues)

TABLE 2 (Continued)

	Measure	Count (baseline)	Count (6 mos.)	Count (1 yr.)
Gingival index/inflammation	(0 = absent , 1 = mild/partial gingiva or papillary, 2 = mild/all gingiva or papillary, 3 = moderate, 4 = severe)			
CTG+CAF	0	27	25	24
	1	3	3	5
	2	0	2	1
	3	0	0	0
VCMX+CAF	0	25	25	24
	1	5	5	3
	2	0	0	2
	3	0	0	1
	No clinically significant differences, thus no hypothesis testing			
	Tissue biotype (1 = thin, 2 = thick)			
CTG+CAF	1	15	0	0
	2	15	30	30
VCMX+CAF	1	17	3	6
	2	13	27	24
	No clinically significant differences, thus no hypothesis testing			
	Soft tissue texture (1 = firmer, 2 = less firm, 3 = equally firm)			
CTG+CAF	1	0	1	2
	2	3	13	12
	3	27	16	16
VCMX+CAF	1	1	0	1
	2	2	16	10
	3	27	14	19
	No clinically significant differences, thus no hypothesis testing			
	Soft tissue color (1 = redder, 2 = less red, 3 = equally red)			
CTG+CAF	1	4	7	7
	2	0	0	0
	3	26	23	23
VCMX+CAF	1	8	10	5
	2	1	0	1
	3	21	20	24
	No clinically significant differences, thus no hypothesis testing			
	PRO appearance preference (count/%)			
CTG+CAF		na	17 (59%)*	22 (73%)
VCMX+CAF		na	12 (41%)*	8 (27%)
	*29 of 30 patients reporting			
	PRO treatment preference (count/%)			
CTG+CAF		na	10 (33%)	16 (53%)
VCMX+CAF		na	20 (67%)	14 (47%)

Both therapies added significant soft tissue volume. At implantation VCMX+CAF, trimmed to be larger than traditional CTGs, produced more soft tissue volume than CTG+CAF, but volume at 6 months and 1 year, as measured by intraoral scanner, was less for VCMX+CAF, though not significantly less at 6 months according to direct, mechanical measures using indexing stents. Wound closure and soft tissue dehiscence measures indicated two test (VCMX+CAF) therapy sites were not closed and remained dehisced out to 2 weeks, with all sites closed at 4 weeks; however, there was no significant difference in inflammation between the two therapies, and healing progressed uneventfully for all sites at all time point. Gingival phenotype at baseline was roughly split between

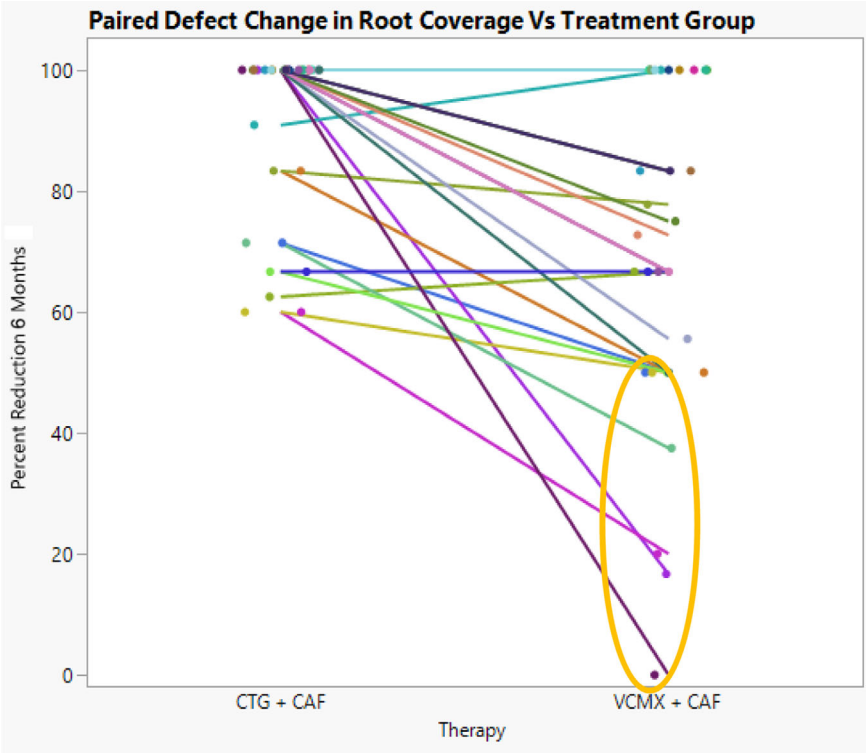

FIGURE 2 Paired defect change in %RC by treatment. Note: Dots indicate the number of sites/teeth for each recorded result. Orange oval indicates paired teeth used for ad hoc evaluation (five patients/17% of cases)

"thick" and "thin" for both therapies, with all (30) of the control sites exhibiting thick phenotype at 6 months and 1 year, and with 27 and 24 test sites, respectively, exhibiting thick phenotype at 6 months and 1 year. There was a significant (P <0.0001) keratinized tissue width increase for both control and test therapies from 2.3 ± 0.9 to 2.5 ± 1.2 mm preoperative at baseline to 3.6 ± 1.3 and 3.2 ± 1.3 mm at 6 months, respectively, producing no statistical difference for keratinized tissue width between therapies. Likewise, and also significantly (P <0.0001), over the course of the investigation CAL improved by 2 to 3 mm, and inflammation decreased significantly for both therapies, with no significant differences between therapies. Surgery time for the test therapy was, on average, 3 minutes faster than the control therapy, though this difference was not statistically significant. Regarding tissue texture and color, there were no differences between therapies at any time points.

Over the first 7-days post-surgery, patients reported significantly more pain for the control therapy, at both the gumline treatment site and the palatal harvest site (see Figure 3 for combined gumline and harvest site discomfort). Also, over the first week following surgery, from days 4 to 7, all patients avoided chewing on the CTG+CAF/harvest graft side of their mouths. At baseline, pre-surgery root dentinal sensitivity (patient response to 3-second air blast) was reported for five control sites and four test sites, with no control and three test sites reporting sensitivity at 1 year. PRO appearance preference was roughly split between test and control at 6 months but favored CTG+CAF at 1 year. At 6 months, considering the therapies overall, 20 patients (two-thirds) preferred VCMX+CAF, but their opinions changed at 1 year so that preference was roughly split between the two therapies.

4 | DISCUSSION

This multicenter, double-masked (patients and study site examiners), split-mouth recession coverage evaluation compared the effectiveness of a volume stable, harvest graft substitute (VCMX) with subepithelial CTG for coverage of single-tooth recessions. Increased root coverage and decreased CAL for both therapies suggest that the %RC achieved was attributable to new, attached tissue—a result further reinforced by the lack of any clinically significant changes in probing pocket depth at 1 year. While mean %RC was inferior for the test therapy, the most disparate results between test and control therapies occurred in a small subset (17%) of patients.

Though CTG+CAF has been considered the recession coverage gold standard, harvest graft substitutes that provide similar, though not necessarily equivalent, root coverage have been advanced as acceptable alternatives.[1,2,12] Clinicians appear interested in less time consuming and unlimited supply harvest graft alternatives, and patients tend to prefer less painful and reduced postoperative morbidity procedures. Also, patients do not appear to discrim-

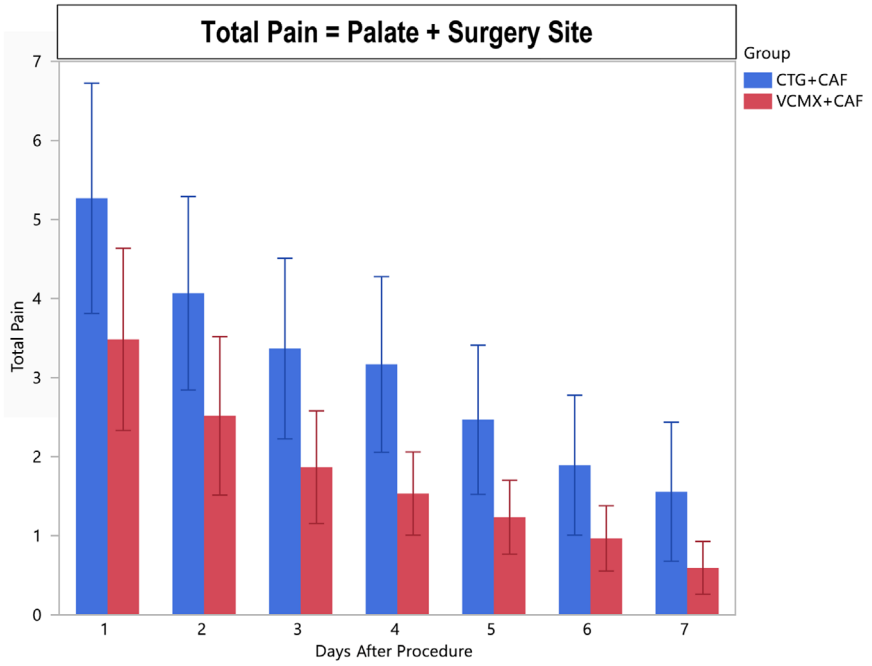

FIGURE 3 Combined surgery site/palatal roof pain by procedure. Note: Differences are significant, and error bars were constructed using the 95% confidence interval for each mean

inate between 0.5 and 1.0 mm (10% to 20%RC) defect coverage differences in RT1 recession defects.[12,17] The authors' (MM and ES) experience with harvest graft alternatives in similar matched-pair defect comparisons, including experiences with a non-cross-linked collagen matrix[#] and an amelogenins biologic,[**] indicate harvest graft alternatives can produce acceptable %RC that can be maintained long-term, while being preferred by patients overall.[10,13] In this regard, and as proposed by Chambrone et al., in 2016, clinical rather than statistical significance may be important, and PROs might be the key differentiators between treatment alternatives.[18]

Depending on patient and defect selection, VCMX appears to provide patient and clinical benefits. It is available in unlimited supply; and, if indicated and desired, increases soft tissue volume, though not to the extent that CTG did within the recession defects studied herein. Digital, intraoral scanning measures revealed volume differences not detected by the more variable and error prone indexing stent/manual probe measures. Likewise, others have reported good root coverage and esthetics outcomes, but gingival thickness increases without statistical significance.[19] VCMX may also provide procedure time saving, as shown in previous studies with the biomaterial, but these savings could depend on clinician experience.[20,21] VCMX was not as "forgiving" as CTG in the range of defect anatomies tested, with more soft tissue dehiscences reported—2 out of 30, or 6%—and providing root coverage results more similar to CTG and the harvest graft substitutes noted above in selected patients and defect anatomies. Better and more predictable results might be expected in patients compliant with postoperative healing instructions and in defects favoring roots within the arch (non-prominent), with suitable interproximal space and limited recession of adjacent teeth. The harvest graft substitute appears best indicated for patients concerned about harvest graft morbidity and/or with limited harvest graft potential, with more predictable results expected in patients compliant with postoperative healing instructions and in defects favoring roots within the arch (non-prominent), with suitable interproximal space and limited recession of adjacent teeth.[22]

Patients experienced less pain with VCMX, not only because of the additional harvest site required for CTG+CAF therapy but also because CTG treatment sites themselves proved to be more painful. Anti-inflammatories and analgesics diminish pain measures overall and, therefore, modulate reported pain differences,[23,24] so the differences reported here may have also been modulated. Additional PRO esthetic and overall satisfaction ratings, though equivalent or favoring VCMX at 6 months, favored CTG (esthetics) or were more evenly matched (overall preference) at 1 year. Perhaps, over time, patients' memories of oral surgery pain, which might initially outweigh esthetic concerns, also fade, so that their overall preferences for and their ability to discriminate between harvest and non-harvest graft therapies diminish. However, such

[#] Geistlich Mucograft, Geistlich Pharma, Wolhusen, Switzerland.
[**] Straumann Emdogain, Straumann Holding, Basel, Switzerland.

conjecture could only be addressed through further PRO investigations.

Additional studies suggested by this investigation could include a test of the preferred patient and case selection criteria proposed by this investigation, that is, patients compliant with postoperative care instructions and recession defects that avoid root prominences and provide suitable interproximal/papillary spaces for the matrix to engage surrounding tissues. Considering surgical technique, rather than the extended, CAF technique used to accommodate VCMX, a tunneling approach might improve results by preventing exposure of the biomaterial and favoring earlier vascularization of and tissue integration with the collagen matrix.[25] Angiogenic and soft tissue proliferative growth factors might also aid in early integration of VCMX with surrounding tissues and, in effect, more closely mimicking "live" harvest CTGs.[26]

5 | CONCLUSIONS

VCMX+CAF was inferior to CTG+CAF in providing root coverage, but it may be a suitable substitute for harvest graft therapy where additional soft tissue volume is desired and in selected patients and recession defects. VCMX+CAF created significantly less postoperative pain and produced similar %RC in the majority of RT1 defects treated.

ACKNOWLEDGMENTS

This study was supported, in part, by an educational grant provided by Geistlich Pharma, Wolhusen, Switzerland. The authors wish to thank Peggy Christian, DDS (Phoenix, AZ) for overseeing the study and Rebecca Williams, RDH (Houston, TX), Andrew Rossi, DDS, MSD (Houston, TX), David Lipton (Bloomfield Township, MI), Diane Stefanowicz, RDH (Tacoma, WA), and Angela Spees, RDH (Fenton, MI) for their help as expert examiners.

CONFLICTS OF INTEREST

This study was supported by a grant from Geistlich Pharma, Wolhusen, Switzerland. Drs. McGuire, Scheyer, Janakievski, and Velasquez have provided lectures sponsored by the company (and other companies), and Dr. Gunsolley's statistical and Dr. Morelli's digital scan analyses were supported by Geistlich. Dr. Heard reports no conflicts of interest.

AUTHOR CONTRIBUTIONS

Drs. McGuire, Scheyer, Janakievski, and Velásquez were investigators (performed surgeries). Dr. Heard was the masked evaluator. Dr. Morelli performed intraoral scanner soft tissue volume analyses, and Dr. Gunsolley was the biostatistician.

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SUPPORTING INFORMATION

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

How to cite this article: McGuire MK, Janakievski J, Scheyer ET, et al. Efficacy of a harvest graft substitute for recession coverage and soft tissue volume augmentation: A randomized controlled trial. *J Periodontol*. 2022;93:333–342. https://doi.org/10.1002/JPER.21-0131