Odovtos-International Journal of Dental Sciences (Odovtos-Int. J. Dent. Sc.), Online First, 2025.
https://doi.org/10.15517/ej1zsq84
ISSN: 2215-3411

ODOVTOS
International Journal of Dental Sciences

UNIVERSIDAD DE COSTA RICA
FOd Facultad de Odontología

https://revistas.ucr.ac.cr/index.php/Odontos

BASIC RESEARCH:

Clinical Efficacy of Volume Stable Collagen Matrix in the Management of Gingival Recession and Gingival Phenotype Modification-A Systematic Review

Eficacia clínica de la matriz de colágeno volumétricamente estable en el manejo de la recesión gingival y la modificación del fenotipo gingival: una revisión sistemática

Pooja V. BDS[1] https://orcid.org/0009-0001-2633-6288
Sangamithra Sidharthan BDS, MDS[2] https://orcid.org/0000-0002-1936-482X
Riddhi Rajesh Bafna BDS[1] https://orcid.org/0009-0007-8567-3480
Nomita Yein BDS[1] https://orcid.org/0009-0004-1217-2157
Sagar Sanjay Kadadhekar BDS[3] https://orcid.org/0009-0000-2420-9026
Amisha Sinha BDS[4] https://orcid.org/0009-0005-5310-027X

[1]Post graduate student. Department of Periodontology and Oral Implantology, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Sant Tukaram Nagar, Pimpri, Pune - 411 018, Maharashtra, India.
[2]Associate Professor. Department of Periodontology and Oral Implantology, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Sant Tukaram Nagar, Pimpri, Pune - 411 018, Maharashtra, India.
[3]Post graduate student. Department of Oral and Maxillofacial Surgery, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Sant Tukaram Nagar, Pimpri, Pune - 411 018, Maharashtra, India.
[4]Post graduate student. Department of Periodontology and Oral Implantology Bharati Vidyapeeth (Deemed to be) University Dental College & Hospital CBD Belapur, Navi Mumbai - 400614, Maharashtra, India.

Correspondence to: Sangamithra Sidharthan BDS, MDS - mithra.sidharthan@gmail.com

Received: 4-VIII-2025 Accepted: 1-X-2025

ABSTRACT: Gingival recession, the apical migration of the gingival margin beyond the cemento-enamel junction, leads to aesthetic and functional problems such as dentinal hypersensitivity and root caries. Volume-stable collagen matrices (VCMX) have been introduced as a less invasive alternative to connective tissue grafts (CTG), offering regenerative potential with reduced morbidity. To evaluate the clinical efficacy of VCMX compared to CTG in managing gingival recession and enhancing gingival phenotype. A systematic search of PubMed, Scopus, ScienceDirect, Cochrane Library, and Google Scholar identified RCTs on adults with Miller's Class I/II or Cairo's RT1/RT2 recession. Data extraction and bias assessment were performed independently using Cochrane RoB 2 and ROBINS-I tools, with GRADE applied for evidence quality. Five studies (120 participants, 6 weeks-12 months follow-up) were included. VCMX showed significant reductions in recession depth (RD) and increased keratinized tissue width (KTW), comparable or superior to CTG. Both improved clinical attachment level (CAL), though VCMX offered less postoperative pain and faster recovery. VCMX serves as an effective, minimally invasive alternative to CTG for treating gingival recession, improving patient comfort and reducing morbidity. However, further long-term, multicentre RCTs are needed to validate and standardize its clinical use.

KEYWORDS: Volume stable collagen matrix; Gingival recession; Gingival phenotype; Subepithelial connective tissue graft.

RESUMEN: La recesión gingival, definida como la migración apical del margen gingival más allá de la unión cemento-esmalte, ocasiona problemas estéticos y funcionales como hipersensibilidad dentinaria y caries radicular. Las matrices de colágeno volumétricamente estables (VCMX) se han introducido como una alternativa menos invasiva a los injertos de tejido conectivo (CTG), ofreciendo potencial regenerativo con menor morbilidad. Evaluar la eficacia clínica de las VCMX en comparación con los CTG en el manejo de la recesión gingival y en la mejora del fenotipo gingival. Se realizó una búsqueda sistemática en PubMed, Scopus, ScienceDirect, Cochrane Library y Google Scholar para identificar ensayos clínicos aleatorizados (ECA) en adultos con recesión de Clase I/II de Miller o RT1/RT2 de Cairo. La extracción de datos y la evaluación del sesgo se realizaron de forma independiente utilizando las herramientas Cochrane RoB 2 y ROBINS-I. La calidad de la evidencia se valoró mediante el enfoque GRADE. Se incluyeron cinco estudios (120 participantes, con seguimientos de 6 semanas a 12 meses). Las VCMX mostraron reducciones significativas en la profundidad de la recesión (RD) y aumentos en el ancho de tejido queratinizado (KTW), siendo comparables o superiores a los CTG. Ambos tratamientos mejoraron el nivel clínico de inserción (CAL); sin embargo, las VCMX se asociaron con menor dolor postoperatorio y una recuperación más rápida. Las matrices de colágeno volumétricamente estables constituyen una alternativa efectiva y mínimamente invasiva a los injertos de tejido conectivo para el tratamiento de la recesión gingival, mejorando el confort del paciente y reduciendo la morbilidad. No obstante, se requieren ensayos clínicos aleatorizados multicéntricos y a largo plazo para validar y estandarizar su aplicación clínica.

PALABRAS CLAVE: Recesión gingival; Fenotipo gingival; Matriz de colágeno volumétricamente estable; Injerto de tejido conectivo; Revisión sistemática.

INTRODUCTION

The integrity of the mucogingival complex is fundamental to oral health, as it provides the structural foundation required to maintain biomorphologic stability and durable attachment to the teeth and surrounding tissues. Mucogingival issues typically manifest in two forms: a closed disruption leading to pocket formation and an open disruption resulting in gingival clefts and recession (1). Gingival recession (GR) is characterized by the apical migration of the marginal gingiva from its normal position at the crown to the root surface beyond the cemento-enamel junction. GR not only poses aesthetic concerns, particularly in anterior teeth, but also contributes to functional challenges, including dentinal hypersensitivity, root caries, and the development of cervical wear or erosion due to root surface exposure (2,3). These issues often prompt patients to seek dental consultation, driven by concerns over the progression of tissue destruction and potential tooth loss.

The patient's gingival phenotype significantly influences the occurrence and progression of gingival recession. Individuals with a thin gingival phenotype are more susceptible to recession due to reduced connective tissue support and increased vulnerability to trauma and inflammation (4). Conversely, a thick gingival phenotype offers better resistance to mechanical forces and periodontal disease, thereby reducing the likelihood of recession. A systematic review indicated that subjects with thin and narrow gingiva experience

more gingival recession than those with thick and wide gingiva (5). Recognizing a patient's gingival phenotype is thus essential in periodontal treatment planning to minimize the risk of future recession and enhance long-term outcomes.

Notably, the World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions (2017) introduced a treatment-oriented classification for GR, emphasizing clinical parameters that inform surgical approaches and outcomes (6). Epidemiological data suggest that GR affects over 50% of the population globally, (7) with Yadav VS *et al*. meta-analysis study estimating that two-thirds of individuals are impacted, irrespective of oral hygiene standards (8).

Over the years, numerous clinical techniques have been introduced to address gingival recession, promote keratinized tissue augmentation, and achieve complete root coverage. These approaches are grounded in scientific research with assessing the underlying causes and tissue involvement, focusing initially on correcting the etiological factors, patient-centered considerations, and gingival phenotype modification. Strengthening periodontal health by converting a thin gingival phenotype into a thicker one is crucial in reducing the risk of recession and ensuring long-term stability (9). Root coverage techniques use tissue displacement (pedicle flaps or grafts) and GTR membranes, with modifications to improve coverage and aesthetics. The combination of a subepithelial connective tissue graft (SCTG) with a coronally advanced flap (CAF) has been considered the gold standard for treating recession around teeth, effectively enhancing gingival thickness (GT) and keratinized tissue width (KTW) (10,11). However, in the quest for easier-to-use, unlimited-supply alternatives to painful harvest grafts, researchers continue to test graft substitutes (12).

Recently, a novel volume-stable collagen matrix (VCMX) that are porcine-derived, porous, resorbable scaffolds has been engineered with enhanced mechanical properties for soft-tissue regeneration in periodontal therapy. These matrices undergo controlled chemical cross-linking to enhance volume stability while maintaining biocompatibility (13). Their porous structure supports angiogenesis and connective tissue integration, making them effective alternatives to autogenous connective tissue grafts (CTG) for procedures like gingival phenotype modification. Clinical studies have demonstrated that VCMX can achieve comparable outcomes to CTG in terms of soft tissue augmentation, with the added benefits of reduced patient morbidity and elimination of the need for a secondary surgical site (13,14). This material provides a connective tissue alternative designed to support wound healing by promoting blood clot stabilization and creating space for host cell ingrowth. Preclinical and clinical studies have demonstrated its efficacy as a fibroblast scaffold, its safety profile in clinical applications, and its ability to integrate with surrounding soft and hard tissues (15-18). Such advancements hold promise for addressing the challenges associated with GR management and gingival phenotype modification.

To date, the existing evidence has not provided a comprehensive analysis of the effectiveness of VCMX for treating GR. Thus, this systematic review aims to evaluate the clinical effectiveness of the VCMX in managing GR and modifying the gingival phenotype, in comparison to CTGs/other biological substitute/biomaterials.

METHODS

REGISTRATION

This systematic review was conducted under preferred reporting items for systematic review and meta-analysis (PRISMA) statement (19) and registered in Prospective Registration of Systematic Review (PROSPERO)- CRD42023493715.

PICO FRAMEWORK AND RESEARCH QUESTION

The focused PICO question was: What is the clinical effectiveness of VCMX in managing GR and modifying gingival phenotype compared to other connective tissue grafts?

Population: Adult patients (≥18 years) with Miller's class I/Cairo's RT1 and RT2, multiple or single tooth gingival recession.

Intervention: Use of volume stable collagen matrix in the management of gingival recession and/or modification of gingival phenotype in and around natural teeth.

Comparison: Gingival recession coverage and gingival phenotype modification with treatment modalities such as connective tissue graft or any other substitute.

Outcome: Clinical outcomes related to both objective and patient-centered measures: Probing Depth (PD), Recession Width (RW), Recession Depth (RD), Keratinized Tissue Width (KTW), Gingival Thickness (GT), Mean Root Coverage (MRC), Complete Root Coverage (CRC), Root Coverage Esthetic Score (RES), Clinical Attachment Loss (CAL), Dentinal Hypersensitivity (DH).

Eligibility criteria for the systematic review are as follows:

Inclusion Criteria:

- Randomized Controlled Trials (RCTs), Non-randomized Clinical Trials (NRCTs), Retrospective Studies, and Prospective Studies to ensure comprehensive evidence synthesis.
- Studies reporting the clinical efficacy of VCMX in treating GR and/or modifying the gingival phenotype.
- Studies involving adult patients (≥18 years) with Miller's Class I or II single/multiple gingival recession or compromised gingival phenotype.
- Studies published in English or other languages with English translations.
- Studies published in the last 15 years (2015-2025) to ensure current clinical practices. This timeframe incorporates recent evidence, aligning findings with current therapeutic practices and guidelines, thereby enhancing the applicability of the review to clinical settings.

Exclusion Criteria:

- Case Series, Case Reports, Reviews, Editorials, Abstracts, Animal Studies, and *In Vitro* Studies.
- Studies that fail to provide measurable clinical outcomes or data on the specified outcomes (e.g., recession depth, gingival phenotype modification, or patient-reported outcomes).
- Inaccessible full text articles.

SCREENING AND SELECTION PROCESS

This systematic review employed a comprehensive search strategy to identify relevant studies by exploring multiple databases, including Scopus, Science Direct, PubMed, Cochrane Library, and

Google Scholar. The search utilized a combination of MeSH terms and keywords (Table 1). The retrieved literature records were imported into a web-based screening tool (Rayyan; https://rayyan.ai/). After the removal of duplicates, 2 reviewers (PV and SS) independently screened the articles through title-abstract screening based on the eligibility criteria. No limitation/ filter in language and date of publication was applied in each database during the preliminary search process. Full texts of potentially relevant articles were retrieved and assessed for inclusion. Additionally, the references cited in the retrieved articles were manually screened by two authors (PV and SS) to ensure the inclusion of all pertinent studies. For studies requiring additional clarity, authors were contacted directly to provide supplementary information.

DATA EXTRACTION

Data extraction was systematically performed by two independent reviewers (PV and SS) to ensure precision and consistency. The extracted data included essential study characteristics such as the author and year of the study, study setting, study design, sample size, mean age of participants, male-to-female ratio, modality utilized, follow-up period (in months), parameters assessed, and the mean ± standard deviation (SD) values for relevant outcomes. All data were categorized and recorded under pre-specified headings (Table 2, Table 3).

RISK OF BIAS ASSESSMENT

The methodological quality of involved studies was assessed individually by two reviewers (PV and SS) using appropriate tools. For randomized controlled trials (RCTs), the Cochrane Collaboration's Risk of Bias (RoB 2) tool was applied across 5 domains, (37) retrospective study were evaluated using Risk of Bias in Non-randomized Studies - of Interventions (ROBINS-I) tool across 7 domains, (38) while prospective split-mouth design studies were treated as RCTs due to their mention of random allocation. Any disagreements in bias assessment were resolved by consulting the third reviewer (DG), ensuring a consensus on the final risk of bias categorization. Robvis tool was used to visualize the risk of bias assessments for the included studies, providing standardized graphical representations, facilitating the interpretation and comparison of bias evaluations across studies.

ASSESSMENT OF QUALITY OF EVIDENCE BY GRADE APPROACH

The overall strength of evidence derived from the included RCTs regarding the efficacy of VCMX on GR was appraised by two reviewers, PV and SS. The quality of the evidence was evaluated using the GRADE approach, in accordance with established best practices in evidence-based medicine for applying GRADE in systematic reviews without meta-analysis. For this systematic review, the criteria outlined by Murad et al. for adapting the GRADE assessment in situations where meta-analysis is not performed or is not feasible were strictly followed. A detailed account of the GRADE assessment is provided in Table 4.

RESULTS

STUDY SELECTION

A total of 593 records were retrieved from four databases. After removing 96 duplicate records, 497 articles were screened based on titles and abstracts. Following this, 470 articles were excluded for being review articles (87), excluded by title (290), irrelevant to the study (91), or animal studies (2). Full-text retrieval was attempted for 27 records, all of which were assessed for eligibility. Among these, 22 articles were excluded due to inappropriate study designs (13), lack of a comparator group (4), implant studies (4), and studies on bony defects (1) (Table 5). Ultimately, 5 studies were included in the review (Figure 1).

Table 1. Search strategy for the study.

Database	Search string	N
PubMed	#1 (Volume stable collagen matrix OR VCMX) AND (gingival recession OR gingival phenotype)	23
	#2 ((Volume stable collagen matrix OR VCMX) AND (gingival recession OR gum recession OR receding gums)) AND (gingival phenotype OR gum phenotype OR gingival tissue type OR gingival morphology OR gingival appearance)	10
Scopus	#1 (TITLE-ABS-KEY ("volume stable collagen matrix" OR "VCMX" OR "collagen matrix") AND TITLE-ABS-KEY ("gingival recession" OR "gum recession"))	160
	#2 ((TITLE-ABS-KEY ("volume stable collagen matrix" OR "VCMX" OR "collagen matrix") AND TITLE-ABS-KEY ("gingival recession" OR "gum recession") AND TITLE-ABS-KEY ("Gingival Phenotype" OR "gingival tissue type")))	4
Science direct	((Volume stable collagen matrix OR VCMX) AND (gingival recession OR gum recession OR receding gums)) AND (gingival phenotype OR gum phenotype OR gingival tissue type OR gingival morphology)	331
Cochrane library	((Volume stable collagen matrix OR VCMX) AND (gingival recession OR gum recession OR receding gums)) AND (gingival phenotype OR gum phenotype OR gingival tissue type OR gingival morphology OR gingival appearance):ti,ab,kw	0
Google scholar	(("Volume stable collagen matrix" OR "VCMX") AND ("gingival recession" OR "gum recession" OR "receding gums")) AND ("gingival phenotype" OR "gum phenotype" OR "gingival tissue type" OR "gingival morphology" OR "gingival appearance")	65

Table 2. Summary of included studies on volume stable collagen matrix and connective tissue graft or other substitute in gingival recession patients.

Author, year of study	Study design	Study setting	Sample size	Mean age	M:F ratio	Modality used	Follow up period (months)	Parameters assessed
Lee CT *et al.* 2022 (39)	Retrospective study	Germany	10	38.7	5:5	VISTAX (VCMX), CAFT, CAST	Baseline, 3 months, 6 months	GR, KTW, PD, RD, RES, Postoperative pain (VAS) and DH
Mcguire MK *et al.* 2022 (40)	RCT	USA	30	50.7±11.4	11:19	VCMX + CAF, CTG + CAF	Baseline, 6 months, 1 year	RD, RW, KTW, PD, CAL, BOP, RC, DH
Di Domenico *et al.* 2023 (41)	RCT	Italy	20	37.6±10	9:11	VCMX + MCAF, VCMX + MCAT	Baseline, 12 months	RD, KTW, GT, PD, RecRed, mRC, CRC
Rajan R *et al.* 2024 (42)	RCT	India	30	22 – 54	Not mentioned	VCMX + MCAF, MCAF + SCTG	Baseline, 6 weeks, 3 months, 6 months	RD, RW, KTW, PD, CAL, GT
Harris J.J. *et al.* 2024 (43)	Prospective clinical study (Split mouth)	India	30	34.8 ± 6.2	6:4	CAF + CTG, CAF + Fibro-Gide (VCMX)	Baseline, 3 months, and 12 months	PD, RD, CAL, RW, KTW, VAS

GR-Gingival Recession , KTW- Keratinized tissue width , PD- Probing depth , RD- Recession depth , RES-Recession esthetic score, VAS-Visual analogue scale, GT- Gingival thickness, DH - Dentinal hypersensitivity, CRC- Complete root coverage, mCRC- Mean complete root coverage, RecRed - Recession reduction, CAL- Clinical attachment loss, BOP- Bleeding on probing, RW- Recession width, RT- Recession type , VISTA-Vestibular incision subperiosteal tunnel access, CAF/CAFT- Coronally advanced flap/ Technique, CTG- Connective tissue graft, MCAF/ MCAFT- Modified coronally advanced flap/ Technique , VCMX- Volume stable collagen matrix graft, SCTG- Subepithelial connective tissue graft, MARDs- Multiple adjacent recession defects.

Table 3. Summary of Outcomes and conclusion of the included studies.

Author, Year of study	Modality used	Mean ± SD Pre/Post	Conclusion
Lee CT *et al.* 2022 (39)	VISTAX (VCMX), CAFT, CAST	VISTAX: GR: 1.6±0.8/0.22±0.4 KTW: 2.98±1.15/2.8±0.96 PD: 1.94±0.76/NM DH: 3.75±2.82/1±1.42 CAST: GR: 2.0±0.76/0.47±0.61 PD:1.65±0.75/NM KTW: 3.25±0.86/2.17±0.87 DH: 7.6±1.9/0.8±1.1 CAFT: GR: 1.84±0.67/0.32±0.56 PD: 1.6±0.52 KTW: 2.75±0.86/2.57±0.84 DH: 5.13±8.3/0.78±1.72	VISTAX demonstrated equivalent clinical efficacy to SCTG flap procedures while offering reduced patient morbidity, indicating its potential as a viable alternative.
Mcguire MK *et al.* 2022 (40)	VCMX + CAF, CTG + CAF	VCMX + CAF RD- 3.63 ± 0.79 / 1.37 ± 1.22 RW- 3.7 ± 0.64 / 1.5 ± 1.27 KTW- 2.5 ± 1.25 / 3.3 ± 1.30 PD- 1.4 ± 0.5 / 2.3 ± 0.47 CAL- 4.7 ± 1.51 / 2.6 ± 1.16 RC - 70.7 ±28.26/63.2±31.56 CTG +CAF RD - 3.73 ± 0.95 / 0.62 ± 0.82 RW – 3.7 ±0.48 / 0.7±0.93 KTW – 2.3 ± 0.88/ 3.6± 1.31 PD – 1.5 ± 0.57 / 2.3 ±0.48 CAL – 4.90 ± 1.40/ 2.20 ±0.89 RC – 90.5±14.87/84.49±19.98	VCMX+CAF provided slightly inferior root coverage to CTG+CAF but reduced morbidity, minimized postoperative pain, and showed promise in RT1 defects with proper patient selection.
Di Domenico *et al.* 2023 (41)	VCMX + MCAF, VCMX + MCAT	MCAF + VCMX: RD:2.37±0.94/0.59±0.91 KTW:2.5±0.8/2.59±0.71 GT:1.34±0.48/1.57±0.51 PD:1.28±0.21/1.25±0.16 Rec red: 1.81±0.82/1.78±0.8.3 mRC %: 80.73±28.74/79.95±29.92 CRC %: 65.6/65.6 MCAT + VCMX: RD:2.24±0.78/0.8±0.91 KTW:2.28±0.89/2.52±0.71 GT:1.28±0.46/1.64±0.57 PD:1.31±0.22/1.39±0.28 Rec red: 1.44±1.04/1.44±1.04 mRC %: 64.74±16.3/64.74±40.5 CRC %:52/52	Comparable clinical outcomes can be anticipated when MAGRs are treated with MCAF or MCAT in conjunction with VCMX.

Author, Year of study	Modality used	Mean ± SD Pre/Post	Conclusion
Rajan R *et al.* 2024 (42)	VCMX + MCAF, MCAF + SCTG	VCMX +MCAF RD- 3.90 ± 0.99/ 1.30 ± 0.99 RW- 4.33 ± 1.06/ 0.93 ± 0.98 KTW- 2.47 ± 0.68/ 5.37 ± 0.96 PD- 1.60 ± 0.62/ 1.43 ± 0.50 CAL- 5.47 ± 1.31/ 2.97 ± 1.40 GT - 1.38 ± 0.10/ 1.50 ± 0.00 MCAF +SCTG RD – 3.33 ± 0.49/ 0.80 ± 0.77 RW – 3.93 ± 0.70/ 1.60 ± 0.51 KTW – 2.20 ± 0.77/ 4.33 ± 0.90 PD – 1.47 ± 0.52 / 1.53 ± 0.52 CAL – 4.87 ± 0.64 / 2.33 ± 0.82 GT - 1.30 ± 0.00 /1.50 ± 0.00	VCMX offers less invasive alternative to SCTG for managing MARDs, with reduced surgical time, faster recovery, and lower postoperative morbidity. It delivers predictable root coverage with clinically acceptable aesthetics and improved patient perception.
Harris JJ *et al.* 2024 (43)	CAF + CTG, CAF + Fibro-Gide (VCMX)	CAF + Fibro-Gide RD – 3.4±0.8/0.3±0.4 RW – 3.1 ± 0.2/ 0.4± 0.3 KTW- 2.2± 0.2 / 3.0± 0.8 PD - 2.4 ± 0.5 / 2.2±0.5 CAL- 5.4±1.03 / 2.4±0.7 CAF + CTG RD – 3.5 ± 0.8 / 0.2 ± 0.2 RW – 3.1 ± 0.1 / 0.3 ± 0.5 KTW – 2.1 ± 0.2 / 3.9 ± 5.5 PD – 2.4 ± 0.8 / 2.4 ± 0.7 CAL - 5.4 ± 1.02 / 2.3 ± 0.7	Fibro-Gide® with CAF provided comparable improvements in gingival recession to CTG, with the added benefits of reduced postoperative pain and shorter operation time. It serves as an effective alternative for managing multiple gingival recessions.

Table 4. Evaluation of quality of evidence using GRADE approach from included RCTs

Outcomes assessed	Studies	Reasons for downgrading the evidence	Quality of evidence
Efficacy of VCMX for Gingival recession and gingival phenotype modification	Study design: RCT Studies: Mcguire MK *et al.* Di Domenico *et al.* Rajan R *et al.* Harris JJ *et al.*	Downgrading factors: (-3) RoB: (-1) Serious Included RCT were with high Rob (n=1) and some concerns (n=1) based on Cochrane RoB 2.0 Indirectness: (-1) Serious, as some variability in primary outcome variable, study setting, intervention groups Imprecision: (-1) Serious, as the total sample size <400 Inconsistency: Not Serious, as the included RCTs were found with almost similar differences in outcomes between VCMX and other CTG. VCMX was found to be slightly superior in managing gingival recession and modifying gingival phenotype Publication bias: Not detected	Very Low ⊕⊖⊖⊖

Table 5. Excluded studies.

Reasons for exclusion	Authors
No comparator group	Kim S *et al.*, (11) Stefanini *et al.*, (20) Lee Y *et al.*, (21) Barootchi S *et al.* (22)
Other study designs	Miguel MMV *et al.*, (23) Kim HJ *et al.*, (24) Rossato A *et al.*, (25) Michels R *et al.*,(26) Jalilvand N. *et al.*, (27) Santamaria MP *et al.* (a),(28) Tavelli L *et al.*,(29) Santamaria MP *et al.* (b), (30) Schulze-Späte U *et al.*, (31) A Fathiazar *et al.*, A Adzhieva *et al.*, L Ferrantino *et al.*,
Studies focussed on soft tissue augmentation around implants	Badalyan K *et al.*, (32) Sanz-Martín I *et al.*, (33) Clem DS *et al.*, (34) Thoma DS *et al.*, (16) Hamdy A *et al.*, (35)
Bony Defects	Imber JC *et al.* (36)

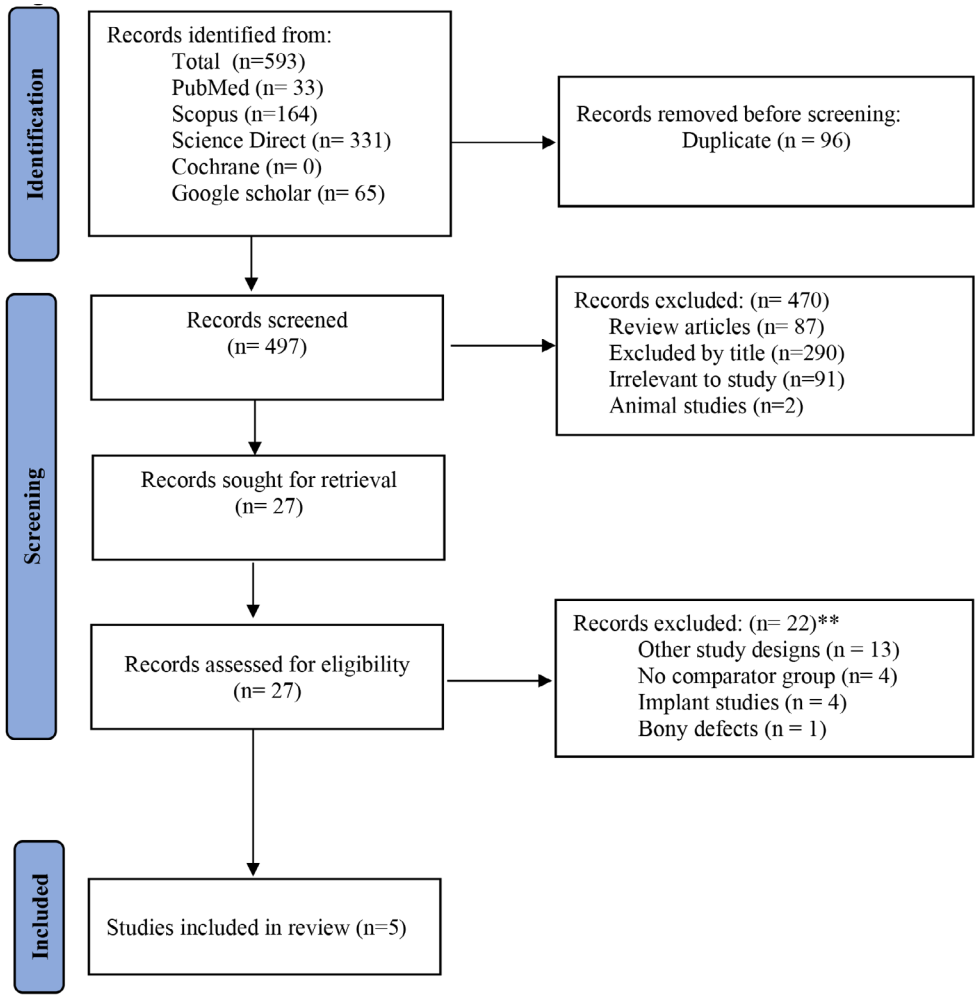

Figure 1. PRISMA Flowchart.

STUDY CHARACTERISTICS

The characteristics of the included studies for this systematic review are presented in Table 2 and Table 3. The included studies were published between 2022 and 2024, with two studies conducted in India,(42,43) one in Germany,(39) one in the USA,(40) and one in Italy (41). Among the five studies, three were randomized controlled trials (RCTs),(40-42) one was a retrospective study,(39) and one was a prospective clinical study using a split-mouth design (43). The sample sizes ranged from 10 to 30 participants, with mean ages varying from 34.8 to 50.7 years, except for one study where the age range was reported as 22 to 54 years (42). The male-to-female ratio was reported in four studies, ranging from nearly equal dwistribution to a higher female representation in one study (11:19)(40).

The interventions used included various combinations of vestibular connective tissue matrix xenografts, CTG, CAF, MCAF, and SCTG. Follow-up periods varied across studies, ranging from 6 weeks to 12 months.

RESULTS OF METHODOLOGICAL QUALITY ASSESSMENT OF THE INCLUDED STUDIES

Among the studies assessed, bias arising from the randomization process was predominantly evaluated as low, with three studies showing low bias (40-42) and one study presenting some concerns (43). Bias due to deviations from intended interventions and the selection of the reported result consistently displayed low risk, as all studies were rated as low risk. Bias due to missing outcome data emerged as a notable issue, with two studies rated as low risk,(40,41).

One study showed some concerns,(42) and one demonstrated serious bias (43). Bias in the measurement of outcomes showed minimal issues, with two studies rated as low risk (40,41) and two studies showing some concerns (42,43). The overall risk of bias assessment revealed that two studies were rated as low risk,(40,41) one study had some concerns,(42) and one study demonstrated high risk due to deviations in intended protocols and incomplete outcome data reporting (43). In the case of the retrospective study, the risk of bias was rated as high (39). The graphical representation of the risk of bias is shown in Figure 2 and Figure 3.

QUALITY/CERTAINTY OF EVIDENCE

The preliminary assessment of evidence quality was rated as high because only randomized controlled trials (RCTs, n=4) were included in the GRADE analysis for this systematic review (SR). However, due to the influence of three factors leading to downgrading - namely "Risk of Bias" (RoB), "indirectness," and "imprecision" - the overall evidence quality for the outcome of this SR was ultimately rated as "very low." The factors contributing to the downgrade (RoB, indirectness, inconsistency, imprecision, and potential publication bias) were all taken into account when determining the overall evidence quality.

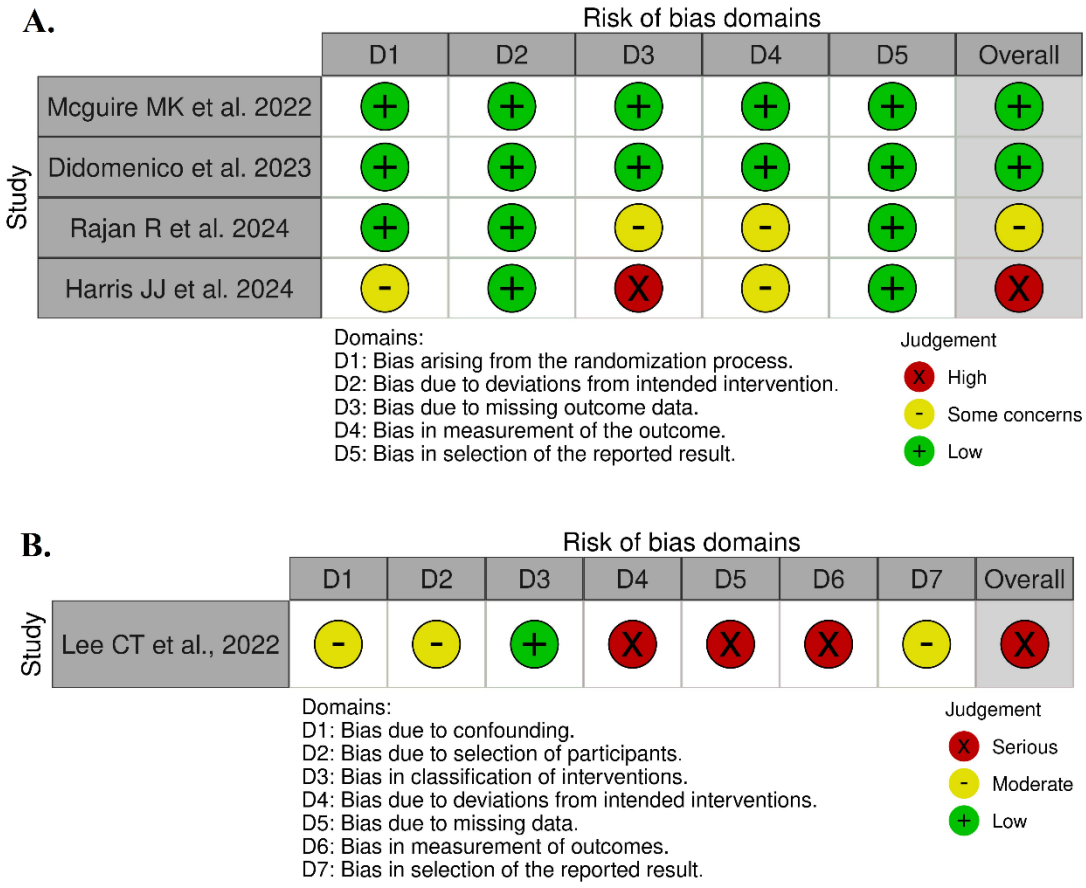

Figure 2. A. Risk of bias assessment of included RCTs using Revised Cochrane RoB tool (RoB 2.0); B. One retrospective study using ROBINS-I tool.

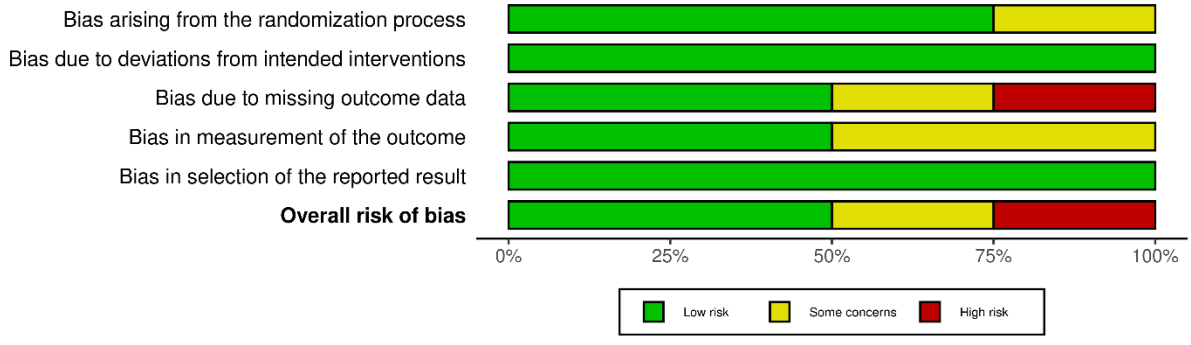

Figure 3. Overall risk of bias graph of included Randomized Controlled trial.

DISCUSSION

This systematic review evaluates the clinical efficacy of VCMX in managing GR and modifying gingival phenotype compared to other connective tissue grafts. The findings provide significant insights into the role of VCMX as a viable alternative to traditional autologous grafts, addressing challenges related to patient morbidity, surgical complexity, and tissue availability.

VCMX revealed significant improvements in key clinical parameters, including gingival RD, RW, CAL, and KTW. These outcomes were largely comparable to SCTG in terms of effectiveness, particularly for RD and RW. However, SCTG consistently showed superior long-term stability for KTW, indicating its continued advantage in enhancing gingival thickness.

Reduction in gingival recession depth (RD) is a key clinical outcome in evaluating root coverage procedures. Several studies have demonstrated that volume-stable collagen matrix (VCMX) provides RD reduction outcomes comparable to connective tissue graft (CTG) (41-43). Similarly, Lee *et al*. (39) showed that VISTAX achieved results equivalent to SCTG. A recent randomized clinical trial further supported these findings, showing that coronally advanced flap (CAF) combined with VCMX achieved recession reduction and combined defect coverage comparable to CAF alone, with the additional benefit of significantly greater gingival thickness gain (0.43 mm *vs* 0.15 mm; p=0.003). (44) Although McGuire *et al*. (40) reported slightly lower root coverage for VCMX+CAF compared with CTG+CAF, the evidence suggests that with appropriate patient selection, particularly in RT1 defects, VCMX can be considered a reliable minimally invasive alternative to CTG, with the added advantage of improving soft tissue phenotype.

In a recent systematic review and meta-analysis on soft tissue augmentation at implant sites, Tommasato G. *et al.* (2024)., reported that autogenous connective tissue grafts (CTG) achieved significantly greater gains in keratinized tissue width (KTW) compared to volume-stable collagen matrices (VCMX) (45). Thoma DS (2023) a randomized controlled clinical trial demonstrated that while both CTG and VCMX provided comparable volumetric soft tissue augmentation, only CTG maintained or slightly increased KTW, likely due to its inherent keratinized tissue composition. (46) Collectively, these findings underscore CTG's superiority in ensuring long-term stability of keratinized tissue, while highlighting VCMX as a less invasive alternative capable of achieving predictable volumetric gains without the drawbacks of donor site morbidity.

However, other clinical investigations (39-42) have demonstrated favorable outcomes with VCMX, showing KTW augmentation comparable to CTG, although Harris *et al*. reported superior KTW gains with CTG. Regarding gingival thickness, these studies found no significant differences between the two approaches over 6-12 months. Collectively, these findings suggest that while both VCMX and CTG are effective for soft tissue phenotype modification, VCMX offers reduced morbidity and improved patient comfort, whereas CTG remains the gold standard in cases requiring maximal KTW augmentation and long-term stability."

Clinical attachment level (CAL) improvements with VCMX have been shown to be comparable to those achieved with CTG across multiple studies. McGuire *et al*. (40), Rajan *et al*. (42), and Harris *et al*. (43) reported similar CAL gains with both treatment modalities, reinforcing VCMX as an effective alternative. While CTG demonstrated marginal superiority in some parameters, VCMX consistently provided reliable CAL improvements.

Additionally, significant reductions in probing depth (PD) were observed in both VCMX and CTG treatment groups. Studies by McGuire *et*

al. (40), Rajan *et al*. (42), and Harris *et al*. (43) Di Domenico *et al*. (41) and Lee *et al*. (39) confirmed these findings. Chambrone *et al*. (47) reported that SCTG + CAF was the most effective method for CRC, MRC, and KTW gain at 6 and 12 months. This supports the notion that SCTG + CAF remains the gold standard for treating gingival recession, particularly for single GRD. However, the key advantage of VCMX is its ability to reduce patient morbidity. Unlike CTG, VCMX eliminate the requirement for donor tissue harvesting, thereby reducing surgical complexity and patient morbidity. Multiple studies have consistently reported significantly lower postoperative pain scores with VCMX compared to CTG (39,43). For example, Fibro-Gide®, a well-studied VCMX, has been shown to result in less discomfort and faster recovery than subepithelial connective tissue grafts (SCTG)(43). Its cross-linked collagen architecture not only resists early collapse under soft tissue pressure but also delays enzymatic degradation, allowing the matrix to maintain volume for extended periods. Over time, the scaffold is gradually replaced by the patient's own connective tissue, ensuring stable long-term results as confirmed by several clinical trials(40,39). Naomi *et al*. (48) conducted a comprehensive review of collagen's effects on gingival recession, and found that collagen promoted gingival tissue regeneration effectively and without adverse effects. These findings align with this review, highlighting the regenerative potential and biocompatibility of collagen-based matrices like VCMX.

Lee *et al*., (39) McGuire *et al*.,(40) and Harris *et al*.,(43) assessed patient-related outcomes, with both Harris *et al*.(43) and Lee *et al*.(39) reporting lower VAS scores for VCMX compared to CTG. Similarly, McGuire *et al*. (40) reported that patients experienced less postoperative pain with VCMX than with CTG. VCMX procedures also demonstrate shorter surgical times and higher patient satisfaction, aligning with the growing focus on patient-centered periodontal therapy. Although it is well known that, use of a substitute will demonstrate higher patient satisfaction in terms of post-operative morbidity, future research should include Patient-Reported Experience Measures (PREM) and Patient-Reported Outcome Measures (PROM) in clinical trials to have a valuable insight on patients' perspective. Lee et al. reported that esthetic outcomes, assessed through root coverage esthetic scores (RES) and marginal tissue contour evaluations, were comparable between VCMX and SCTG (39). However, any research on recession management should include RES scoring system as it is an invaluable tool for aesthetic assessment of the root coverage measures.

The success of VCMX in clinical applications is influenced by surgical techniques and patient selection. Studies highlighted the importance of using appropriate flap designs, including CAF and tunnelling approaches, to optimize biomaterial integration and vascularization. Kim HJ et al. study demonstrated that using a VCMX combined with CTG effectively modified the periodontal biotype, enhancing facial contour stability and reducing exposure risk compared to CTG alone. VCMX supported thickened, physiologically contoured facial aspects, improving oral hygiene and serving as a resilient barrier against trauma. Volumetric analysis using 3D measurement software confirmed increased facial volume, primarily on the apical part. The technique, combined with a CAF, achieved complete root coverage with high graft survival rates, highlighting VCMX's role in optimizing outcomes in periodontal plastic surgery.(24) . Systematic review by Moraschini *et al*. confirmed that xenogenic collagen matrices offer comparable clinical outcomes to SCTG, reinforcing VCMX as a viable, minimally invasive alternative for gingival recession management (49).

While Volume-Stable Collagen Matrices offer advantages in gingival recession coverage, they also present certain limitations. A systematic review by Valles *et al*. (2022) highlighted that

VCMX may not achieve the same level of tissue integration and long-term stability as SCTG in implant sites. The research indicated that VCMX, despite being a less invasive option, might not provide the same degree of soft tissue augmentation and stability as CTG, which remains the gold standard for such procedures (50).

This review is constrained by marked heterogeneity in study designs, surgical protocols, and outcome measures, which precludes direct comparison and consensus recommendations. Inconsistent calibration of critical parameters (gingival thickness, keratinized width, root coverage) and lack of validated baseline phenotype classification limit reproducibility and phenotype-specific insights. The absence of histologic or immunohistochemical validation restricts mechanistic understanding of VCMX integration, and follow-up rarely exceeded 12-18 months, impeding long-term stability assessment. Furthermore, the limited number of available studies and insufficient homogeneity across trials precluded the possibility of conducting a meta-analysis, restricting the strength of evidence synthesis.

This systematic review highlights that VCMX provides significant clinical improvements in gingival recession depth, recession width, clinical attachment level, and keratinized tissue width, with outcomes largely comparable to those of SCTG. Across multiple studies, both approaches demonstrated effective root coverage and favourable patient-reported outcomes, though SCTG consistently showed greater stability in keratinized tissue width and gingival thickness at long-term follow-up. Within the limitations of the available evidence, the findings suggest that VCMX represents a clinically effective alternative to SCTG, while SCTG remains superior in maintaining long-term tissue stability.

Future research should focus on conducting large-scale, multicentre, randomized controlled trials with standardized protocols and longer follow-up periods. Studies evaluating patient-reported outcomes (PROs), cost-effectiveness, and the role of angiogenic growth factors in enhancing VCMX integration are also needed

CLINICAL SIGNIFICANCE

The findings of this systematic review hold direct relevance for clinical decision-making in the management of Miller's Class I and II gingival recession and phenotype modification. By synthesizing evidence on the clinical efficacy of VCMX, the review supports its use as a viable alternative to autogenous grafts, particularly in cases requiring minimally invasive approaches with reduced patient morbidity. The documented improvements in root coverage, gingival thickness, and keratinized tissue width reinforce VCMX's utility in enhancing both functional and esthetic outcomes.

CONCLUSION

VCMX is an effective and less invasive alternative to other CTG for managing gingival recession and modifying gingival phenotype. While SCTG remains the gold standard for achieving optimal root coverage and gingival thickness, VCMX offers significant advantages in terms of reduced morbidity, shorter surgical time, and improved patient comfort. With appropriate patient selection and surgical technique, VCMX represents a promising advancement in periodontal therapy, paving the way for more patient-centered treatment approaches.

AUTHOR CONTRIBUTION STATEMENT: Conceptualization, Formal analysis, Resources, Visualization: P.V., S.S., R.R.B. and N.Y.; Data curation, Methodology, Project administration: P.V., S.S. and N.Y.; Investigation: P.V. and N.Y.; Software: P.V., S.S.K. and A.S.; Supervision, Validation: S.S., R.R.B. and N.Y.; Visualization: P.V., S.S., R.R.B., N.Y. and A.S.; Writing-original, Writing-review and editing: P.V., S.S., R.R.B., S.S.K. and A.S. All authors have made substantive contribution to this study and/or manuscript, and all have reviewed the final paper prior to its submission.

PATIENT'S/GUARDIAN'S CONSENT: Not applicable.

SOURCES OF FUNDING: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGEMENTS: None.

ETHICAL CLEARANCE: Not required.

REFERENCES

1. Mythri S., Arunkumar S.M., Hegde S., Rajesh S.K., Munaz M., Ashwin D. Etiology and occurrence of gingival recession - An epidemiological study. J Indian Soc Periodontol. 2015; 19 (6): 671-5.
2. Patel M., Nixon P.J., Chan M.F.W.Y. Gingival recession: Part 1. Aetiology and non-surgical management. Br Dent J. 2011 Sep 23; 211 (6): 251-4.
3. Löe H., Ånerud Å., Boysen H. The Natural History of Periodontal Disease in Man: Prevalence, Severity, and Extent of Gingival Recession. Journal of Periodontology. 1992 Jun; 63 (6): 489-95.
4. Alasiri M.M., Almalki A., Alotaibi S., Alshehri A., Alkhuraiji A.A., Thomas J.T. Association between Gingival Phenotype and Periodontal Disease Severity-A Comparative Longitudinal Study among Patients Undergoing Fixed Orthodontic Therapy and Invisalign Treatment. Healthcare (Basel). 2024 Mar 14; 12 (6): 656.
5. da Silva D.M., Castro F., Martins B., Fraile J.F., Fernandes J.C.H., Fernandes G.V.O. The influence of the gingival phenotype on implant survival rate and clinical parameters: a systematic review. Evid Based Dent. 2025 Feb 5. Epub ahead of print.
6. Cortellini P., Bissada N.F. Mucogingival conditions in the natural dentition: Narrative review, case definitions, and diagnostic considerations. J Periodontol. 2018 Jun;89 Suppl 1: S204-13.
7. Kassab M.M., Cohen R.E. The etiology and prevalence of gingival recession. The Journal of the American Dental Association. 2003 Feb; 134 (2): 220-5.
8. Yadav V.S., Gumber B., Makker K., Gupta V., Tewari N., Khanduja P., et al. Global prevalence of gingival recession: A systematic review and meta-analysis. Oral Diseases. 2023 Nov;29 (8): 2993-3002.
9. Mohan Kumar P., Nagate R.R., Chaturvedi S., Al-Ahmari M.M.M., Al-Qarni M.A., Gokhale S.T., et al. Importance of periodontal phenotype in periodontics and restorative dentistry: a systematic review. BMC Oral Health. 2024 Jan 8; 24 (1): 41.
10. Langer L., Langer B. The subepithelial connective tissue graft for treatment of gingival recession. Dent Clin North Am. 1993 Apr; 37 (2): 243-64.
11. S. Kim H,. M. Cacho D., R. George A., K. Retrum J., R. McDaniel C., R. Lincicum A, et al. Patient-oriented and clinical considerations supporting the single-incision subepithelial connective tissue harvest. GTM. 2024 Dec 16; 0 (0): 4860.
12. Chackartchi T., Gleis R., Sculean A., Nevins M. A Novel Surgical Approach to Modify the Periodontal Phenotype for the Preven-

tion of Mucogingival Complications Related to Orthodontic Treatment. Int J Periodontics Restorative Dent. 2021 Nov; 41 (6): 811-7.
13. Zeltner M., Jung R.E., Hämmerle C.H.F., Hüsler J., Thoma D.S. Randomized controlled clinical study comparing a volume-stable collagen matrix to autogenous connective tissue grafts for soft tissue augmentation at implant sites: linear volumetric soft tissue changes up to 3 months. J Clinic Periodontology. 2017 Apr; 44 (4): 446-53.
14. Thoma D.S., Zeltner M., Hilbe M., Hämmerle C.H.F., Hüsler J., Jung R.E. Randomized controlled clinical study evaluating effectiveness and safety of a volume-stable collagen matrix compared to autogenous connective tissue grafts for soft tissue augmentation at implant sites. J Clinic Periodontology. 2016 Oct; 43 (10): 874-85.
15. Thoma D.S., Jung R.E., Schneider D., Cochran D.L., Ender A., Jones A.A., et al. Soft tissue volume augmentation by the use of collagen-based matrices: a volumetric analysis. J Clinic Periodontology. 2010 Jul; 37 (7): 659-66.
16. Thoma D.S., Zeltner M., Hilbe M., Hämmerle C.H.F., Hüsler J., Jung R.E. Randomized controlled clinical study evaluating effectiveness and safety of a volume-stable collagen matrix compared to autogenous connective tissue grafts for soft tissue augmentation at implant sites. J Clinic Periodontology. 2016 Oct; 43 (10): 874-85.
17. Thoma D.S., Hämmerle C.H.F., Cochran D.L., Jones A.A., Görlach C., Uebersax L., et al. Soft tissue volume augmentation by the use of collagen-based matrices in the dog mandible – a histological analysis. J Clinic Periodontology. 2011 Nov; 38 (11): 1063-70.
18. Mathes S.H., Wohlwend L., Uebersax L., Von Mentlen R., Thoma D.S., Jung R.E., et al. A bioreactor test system to mimic the biological and mechanical environment of oral soft tissues and to evaluate substitutes for connective tissue grafts. Biotech & Bioengineering. 2010 Dec 15; 107 (6): 1029-39.
19. Page M.J., Moher D., Bossuyt P.M., Boutron I., Hoffmann T.C., Mulrow C.D., et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ. 2021 Mar 29; n160.
20. Stefanini M., Mounssif I., Barootchi S., Tavelli L., Wang H.L., Zucchelli G. An exploratory clinical study evaluating safety and performance of a volume-stable collagen matrix with coronally advanced flap for single gingival recession treatment. Clin Oral Invest. 2020 Sep; 24 (9): 3181-91.
21. Lee Y., Lee D., Kim S., Ku Y., Rhyu I.C. Modified tunneling technique for root coverage of anterior mandible using minimal soft tissue harvesting and volume-stable collagen matrix: a retrospective study. J Periodontal Implant Sci. 2021; 51 (6): 398.
22. Barootchi S., Rodriguez M.V., Chan H.L., Kripfgans O.D., Wang H.L., Tavelli L. Coronally Advanced Flap with Xenogeneic Collagen Matrix for the Treatment of Gingival Recessions at Sites Presenting with Cervical Restorations or Noncarious Cervical Lesions: A Clinical and Ultrasonographic Study. Int J Periodontics Restorative Dent. 2023 Mar; 43 (2): 146-54.
23. Miguel M., Mathias-Santamaria I., Kopereck M., Martins T., Nunes M., Santamaria M. A volume-stable collagen matrix (VCMX) to treat single gingival recession associated with partially restored non-carious cervical lesions: a case series. Int J Periodontics Restorative Dent. 2025; 45 (1): 21-9.
24. Kim H.J., Chang H., Kim S., Seol Y.J., Kim H.I. Periodontal biotype modification using a volume-stable collagen matrix and autogenous subepithelial connective tissue graft for

the treatment of gingival recession: a case series. J Periodontal Implant Sci. 2018; 48 (6): 395.
25. Rossato A., Miguel M.M.V., Bonafé A.C.F., Mathias-Santamaria I.F., Nunes M.P., Santamaria M.P. Treatment of single gingival recessions using biofunctionalized collagen matrix: A case series. Clin Adv Periodontics. 2024 Sep; 14 (3): 180-4.
26. Michels R., Magrin G.L., Cruz A., Magini R., Benfatti C.A.M. Functionalization of a Volume-Stable Collagen Matrix Using Liquid Platelet-Rich Fibrin: A Case Report Presenting a New Approach for Root Coverage. Shibli JA, editor. Case Reports in Dentistry. 2023 Mar 22; 2023: 1-8.
27. Jalilvand N., Kasapoudis D., Altun E., Aarabi G, Hajilou S., Baker T. Treatment of Maxillary Gingival Recessions Using the Modified Coronally Advanced Tunnel Technique in Combination with a Volume-Stable Collagen Matrix: A Prospective Case Series with a 12-Month Follow-up. Int J Periodontics Restorative Dent. 2023 Nov 3; 43 (6): 655-63.
28. Santamaria M.P., Rossato A., Ferreira Ferraz L.F., Bonafé A.C., Miguel M.M.V., Nunes M.P. Collagen matrix biofunctionalized with injectable platelet-rich fibrin for the treatment of single gingival recession: A case report. Clin Adv Periodontics. 2023 Jun; 13 (2): 110-4.
29. Tavelli L., Barootchi S. A Minimally Invasive Approach for the Treatment of Multiple Adjacent Gingival Recessions with a Volume-Stable Collagen Matrix: A Case Series. Int J Periodontics Restorative Dent. 2022 Mar; 42 (2): 155-62.
30. Santamaria M.P., Miguel M.M.V., Rossato A., Bonafé A.C.F., Ferraz L.F.F., Dos Santos L.M., et al. New Volume-Stable Collagen Matrix and Modified Coronally Advanced Flap to Treat Multiple Gingival Recessions Associated With Partially Restored Non-Carious Cervical Lesions: A Case Report. Clin Adv Periodontics. 2022 Jun; 12 (2): 69-74.
31. Schulze-Späte U., Lee C.T. Modified Vestibular Incision Subperiosteal Tunnel Access Procedure with Volume-Stable Collagen Matrix for Root Coverage: Report of Three Cases. Int J Periodontics Restorative Dent. 2019 Oct; 39 (5): e181-7.
32. Badalyan K., Posessor A., Stepanyan Z., Levonyan E., Melkumyan I. Use of volume-stable collagen matrix for soft tissue augmentation at teeth and dental implants site. Georgian Med News. 2022; (328-329): 38-42.
33. Sanz-Martín I., Encalada C., Sanz-Sánchez I., Aracil J., Sanz M. Soft tissue augmentation at immediate implants using a novel xenogeneic collagen matrix in conjunction with immediate provisional restorations: A prospective case series. Clin Implant Dent Rel Res. 2019 Feb; 21 (1): 145-53.
34. Clem D.S., McClain P.K., McGuire M.K., Richardson C.R., Santarelli G.A., Schallhorn R.A., et al. Harvest graft substitute for soft tissue volume augmentation around existing implants: A randomized, controlled and blinded multicenter trial. Journal of Periodontology. 2024 Aug; 95 (8): 740-8.
35. Hamdy A., Ibrahim S.S.A., Ghalwash D., Adel-Khattab D. Volumetric assessment of volume stable collagen matrix in maxillary single implant site development: A randomized controlled clinical trial. Clin Implant Dent Rel Res. 2024 Oct; 26 (5): 930-41.
36. Imber J., Bosshardt D.D., Stähli A., Saulacic N., Deschner J., Sculean A. Pre-clinical evaluation of the effect of a volume-stable

collagen matrix on periodontal regeneration in two-wall intrabony defects. J Clinic Periodontology. 2021 Apr; 48 (4): 560-9.
37. Sterne J.A.C., Savović J., Page M.J., Elbers R.G., Blencowe N.S., Boutron I., et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019 Aug 28; l4898.
38. Sterne J.A., Hernán M.A., Reeves B.C., Savović J., Berkman N.D., Viswanathan M., et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016 Oct 12; i4919.
39. Lee C.T., Lange M., Jureidini A., Bittner N., Schulze-Späte U. Clinical and patient-reported outcomes after recession coverage using modified vestibular incision subperiosteal tunnel access with a volume-stable collagen matrix as compared to a coronally advanced flap with a subepithelial connective tissue graft. J Periodontal Implant Sci. 2022; 52 (6): 466.
40. McGuire M.K., Janakievski J., Scheyer E.T., Velásquez D., Gunsolley J.C., Heard R.H., et al. Efficacy of a harvest graft substitute for recession coverage and soft tissue volume augmentation: A randomized controlled trial. Journal of Periodontology. 2022 Mar; 93 (3): 333.
41. Di Domenico G.L., Guglielmi D., Aroca S., De Sanctis M. Treatment of Multiple Adjacent Gingival Recessions with a Coronally Advanced Flap vs a Modified Coronally Advanced Tunnel with a Volumetrically Stable Collagen Matrix: A 12-Month Randomized Controlled Clinical Tri. Int J Periodontics Restorative Dent. 2024 Sep; 44 (5): 498-509.
42. Rajan R., Chickanna R., M.L. Venkatappa P., Poonkundran P. Novel Membrane for the Treatment of Multiple Gingival Recession Defects-RCT. rjms. 2024; 14 (1): 12434021.
43. Harris J.J., Navya P.D., Rajasekar A. Efficacy of Fibro-Gide® in coronally advanced flap for the treatment of multiple gingival recession: A prospective clinical study. JIOH. 2024 Mar; 16 (2): 145-9.
44. Santamaria M.P., Miguel M.M.V., Rossato A., Bonafé A.C.F., de Souza I.V., Martins T.M., Nunes M.P., Mathias-Santamaria I.F. Volume-stable collagen matrix to treat gingival recession associated with non-carious cervical lesions: Randomized clinical trial. J Periodontol. 2025 Aug 21. doi: 10.1002/jper.11386. Epub ahead of print.
45. Tommasato G., Del Fabbro M., Oliva N., Khijmatgar S., Grusovin M.G., Sculean A., Canullo L. Autogenous graft versus collagen matrices for peri-implant soft tissue augmentation. A systematic review and network meta-analysis. Clin Oral Investig. 2024 May 5; 28 (5):300. doi: 10.1007/s00784-024-05684-5
46. Thoma D.S., Gasser T.J.W., Hämmerle C.H.F., Strauss F.J., Jung R.E. Soft tissue augmentation with a volume-stable collagen matrix or an autogenous connective tissue graft at implant sites: Five-year results of a randomized controlled trial post implant loading. J Periodontol. 2023 Feb; 94 (2): 230-243. doi: 10.1002/JPER.22-0226
47. Chambrone L., Chambrone D., Pustiglioni F.E., Chambrone L.A., Lima L.A. Can subepithelial connective tissue grafts be considered the gold standard procedure in the treatment of Miller Class I and II recession-type defects? Journal of Dentistry. 2008 Sep; 36 (9): 659-71.
48. Naomi R., Ardhani R., Hafiyyah O.A., Fauzi M.B. Current Insight of Collagen Biomatrix for Gingival Recession: An Evidence-Based Systematic Review. Polymers. 2020 Sep 13; 12 (9): 2081.
49. Moraschini V., De Almeida D.C.F., Sartoretto S., Bailly Guimarães H., Chaves Caval-

cante I., Diuana Calasans-Maia M. Clinical efficacy of xenogeneic collagen matrix in the treatment of gingival recession: a systematic review and meta-analysis. Acta Odontologica Scandinavica. 2019 Aug 18; 77 (6): 457-67.

50. Valles C., Vilarrasa J., Barallat L., Pascual A., Nart J. Efficacy of soft tissue augmentation procedures on tissue thickening around dental implants: A systematic review and meta-analysis. Clinical Oral Implants Res. 2022 Jun; 33 (S23): 72-99.