

Patient morbidity outcomes following root coverage procedures in association with the treatment of multiple gingival recessions: A Systematic Review and Meta-analysis

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Abstract

Background: Root coverage procedures for multiple gingival recessions often need an autogenous graft taken from the palate, which can cause considerable postoperative discomfort. This systematic review and meta-analysis aimed to identify which root coverage procedures for multiple gingival recessions are associated with the lowest patient morbidity, and to compare their clinical outcomes: complete root coverage (CRC), mean root coverage (MRC), and keratinized tissue width (KTW).

Methods: The review followed the PRISMA 2020 guidelines and was registered in PROSPERO (CRD42020203329). An electronic search was carried out in PubMed/MEDLINE, Embase, the Cochrane Central Register of Controlled Trials, Scopus, and Web of Science. Randomized controlled trials that treated multiple adjacent gingival recessions and reported self-reported postoperative pain or discomfort were included. Risk of bias was assessed with the Cochrane risk of bias tool. Meta-analyses were performed in RevMan 5.4.1 with a random-effects model. Results were expressed as standardized mean differences (SMD) for continuous outcomes and as risk ratios (RR) for CRC, each with 95% confidence intervals (CI).

Results: Of the 264 records identified, 32 randomized controlled trials met the inclusion criteria, and 27 were included in the meta-analysis. Patient morbidity was significantly lower with a xenogeneic collagen matrix than with a connective tissue graft (CTG) (SMD = -0.37, 95% CI -0.69 to -0.04, $p = 0.03$). It was also lower with the coronally advanced flap (CAF) combined with a biomaterial than with CAF + CTG (SMD = -0.16, 95% CI -0.29 to -0.04, $p = 0.01$). Adding a CTG to CAF significantly increased postoperative morbidity compared with CAF alone (SMD = 1.82, 95% CI 1.28 to 2.37, $p < 0.00001$). On the other hand, CAF + CTG achieved CRC more often than CAF alone (RR = 1.66, 95% CI 1.20 to 2.31, $p = 0.002$) and more often than CAF + biomaterial (RR for CAF + biomaterial = 0.75, 95% CI 0.66 to 0.84, $p < 0.00001$). CAF + CTG also produced the greatest gain in KTW (SMD = 1.71, 95% CI 1.26 to 2.17, $p < 0.00001$). The tunnel technique and CAF gave comparable outcomes when both were combined with a CTG. Heterogeneity was considerable for most outcomes.

Conclusion: Root coverage procedures that avoid palatal graft harvesting, particularly those using a xenogeneic collagen matrix, are associated with the lowest patient morbidity in the treatment of multiple gingival recessions. However, procedures that include a CTG give the most predictable complete root coverage and the greatest gain in keratinized tissue, at the cost of greater postoperative discomfort.

Keywords: gingival recession; root coverage; patient morbidity; connective tissue graft; collagen matrix; meta-analysis

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Introduction

Gingival recession means the gingival margin has moved apical to the cemento-enamel junction, which exposes part of the root surface to the oral environment¹. It is common in adults, and both its prevalence and severity increase with age. Many factors contribute to it: a thin periodontal phenotype, traumatic toothbrushing, inflammation caused by plaque, aberrant frenal attachments, orthodontic tooth movement, and a thin or deficient alveolar

bone.¹ Patients with exposed roots may complain of dentinal hypersensitivity, poor appearance, trouble keeping the area clean, and a higher risk of non-carious cervical lesions and root caries². For these reasons, root coverage has become one of the main goals of periodontal plastic surgery.

When recession affects several adjacent teeth, treatment is harder than for a single site. The surgeon

has to deal with a larger avascular root surface, recession depths that vary from tooth to tooth, differences in papilla dimensions and keratinized tissue, and the need for one flap design that suits the whole surgical area. Several techniques have been proposed for these cases². They include the coronally advanced flap (CAF) and its modifications, the tunnel technique (TUN), and the laterally or double positioned flap. These approaches are used either alone or together with a subepithelial connective tissue graft (CTG), a free gingival graft, or graft substitutes. The substitutes include acellular dermal matrix, xenogeneic collagen matrix, enamel matrix derivative, and platelet concentrates such as platelet-rich fibrin^{1,2,3}.

CAF combined with CTG is still widely seen as the benchmark for predictable root coverage and gains in keratinized tissue. However, harvesting an autogenous graft creates a second surgical wound, usually on the palate. This site is often responsible for much of the patient's postoperative pain, bleeding, swelling, and discomfort.^{2,3,4} The problem grows in multiple recession cases, because covering several teeth needs a larger graft, a longer donor site, and more operating time. This has led clinicians to develop less invasive harvesting methods, minimally invasive flap designs, and graft substitutes that aim to reduce or remove the need for a donor site.³

In the past, treatment success was judged mainly by clinician-measured parameters: complete root coverage (CRC), mean root coverage (MRC), and the change in keratinized tissue width (KTW).⁴ Contemporary periodontal research increasingly accepts that the patient's own experience is also an important outcome. Patient-reported outcome measures (PROMs) show how the patient experiences the procedure and recovery. Examples include postoperative pain, discomfort, and how much the surgery interferes with daily life.^{3,4,5} A technique that gives excellent clinical results but causes considerable morbidity may be less acceptable to patients, and also may follow up less well afterwards.⁶ A technique that causes little morbidity and gives slightly smaller clinical gains may be the better choice for some patients.⁶

Many clinical trials and reviews have compared root coverage procedures. Most of them, however, focused on single recessions or on clinical endpoints alone, and patient morbidity was often reported only as a secondary result.^{5,6,21} Studies that do report morbidity measure it in very different ways, such as visual analogue scales, numerical rating scales, and analgesic counts, and at different time points. This makes it hard to compare techniques directly.^{7,20} To date, no clear evidence-based ranking shows which procedure for multiple gingival recessions keeps

patient morbidity lowest while still giving acceptable root coverage and keratinized tissue outcomes. A structured synthesis of the evidence that looks at patient-reported and clinical outcomes together would help clinicians choose a technique and counsel patients.^{7,8,19}

Therefore, the aim of this systematic review and meta-analysis was to assess and compare self-reported postoperative morbidity after different root coverage procedures for multiple gingival recessions.

Material and methods

Study registration

The review protocol was registered and allocated the identification number CRD42020203329 in the PROSPERO International Prospective Register of Systematic Reviews hosted by the National Institute for Health Research, University of York, Centre for Reviews and Dissemination.

Focused questions

- 1) Which root coverage was associated with the lowest patient morbidity (self-reported postoperative pain/discomfort)?
- 2) Which root coverage procedures were associated with complete root coverage, mean root coverage, and increased keratinized tissue width?

PICO Framework

□ **Population (P):** Systemically healthy adults with multiple adjacent gingival recessions (Miller Class I/II or Cairo RT1/RT2).

□ **Intervention (I):** Any surgical root coverage procedure (for example, CAF, TUN, or modified techniques), with or without autogenous grafts, graft substitutes, or biologics.

□ **Comparison (C):** An alternative root coverage procedure, such as CAF + CTG as the reference standard.

□ Outcomes (O):

- Primary: Self-reported postoperative pain or discomfort [The visual analogue scale (VAS)]
- Secondary: CRC (%), MRC (%), and KTW gain (mm).

□ **Study design (S):** Randomized controlled trials with a minimum follow-up of 6 months.

Eligibility Criteria

For the selection of the study the following inclusion and exclusion criteria were implemented:

Inclusion criteria:

- Randomized controlled trials with a parallel-group or split-mouth design.
- Studies that compared at least two different surgical root coverage procedures.
- Studies of systemically healthy adults aged 18 years or older.
- Studies of patients with at least two adjacent gingival recessions in the same quadrant.
- Recession defects classified as Miller Class I/II or Cairo RT1/RT2.
- Studies that used any surgical root coverage technique, with or without autogenous grafts, soft tissue substitutes, or biologic agents.
- Studies that reported self-reported postoperative pain or discomfort using VAS.
- Studies that reported at least one clinical outcome: complete root coverage, mean root coverage, or keratinized tissue width.
- Studies with a minimum follow-up of 6 months after surgery.

Exclusion criteria:

- Non-randomized studies, cohort studies, case-control studies, case series, and case reports.
- Narrative reviews, systematic reviews, letters, editorials, and expert opinions.
- Studies that treated only single, isolated gingival recessions.
- Studies that mixed single and multiple recessions without reporting their data separately.
- Studies that included Miller Class III/IV or Cairo RT3 recession defects.
- Studies that included smokers of more than 10 cigarettes per day.
- Studies of patients with uncontrolled diabetes, pregnancy, or systemic conditions or medications that affect periodontal healing.
- Studies that included teeth with active periodontal disease or a history of root coverage surgery at the same site.
- Studies that did not report self-reported postoperative pain, discomfort, or analgesic consumption.

Search Strategy

Electronic Databases

We will search the following electronic databases from their inception to:

1. MEDLINE via PubMed
2. Embase
3. Cochrane Central Register of Controlled Trials (CENTRAL)
4. Scopus
5. Web of Science

6. Google Scholar

7. EMBASE

Search Terms

The search will combine Medical Subject Headings (MeSH) with free-text keywords using the Boolean operators "AND" and "OR".

The electronic search encompassed the following key terms: ("Gingival Recession"[MeSH] OR "gingival recession"[tiab] OR "multiple recession*"[tiab] OR "multiple adjacent recession*"[tiab] OR "root exposure"[tiab]) AND ("root coverage"[tiab] OR "coronally advanced flap"[tiab] OR "tunnel technique"[tiab] OR "tunneling"[tiab] OR "Surgical Flaps"[MeSH] OR "connective tissue graft"[tiab] OR "free gingival graft"[tiab] OR "acellular dermal matrix"[tiab] OR "collagen matrix"[tiab] OR "enamel matrix derivative"[tiab] OR "platelet-rich fibrin"[tiab]) AND ("Pain, Postoperative"[MeSH] OR "Patient Reported Outcome Measures"[MeSH] OR "morbidity"[tiab] OR "postoperative pain"[tiab] OR "discomfort"[tiab] OR "patient-reported"[tiab] OR "analgesic*"[tiab] OR "root coverage"[tiab] OR "keratinized tissue"[tiab] OR "keratinised tissue"[tiab])

Search Restrictions

The search will be limited to human studies published in English. There will be no restriction on publication date.

Study Selection

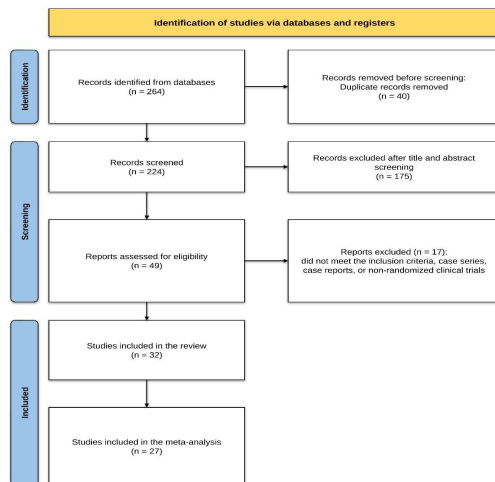
Two reviewers, Amrita Kumari (AK) and Ashish Yadav (AY), selected studies independently in two phases. Before they started, they ran a calibration exercise on a random sample of records to make sure they applied the eligibility criteria the same way.

In the first phase, AK and AY screened the titles and abstracts of all records retrieved by the electronic and manual searches. They removed duplicates first using reference management software. Any article that either reviewer considered potentially relevant, or that had too little information in its abstract to decide, went on to the next phase.

In the second phase, AK and AY read the full texts of the shortlisted articles and checked them against the predefined inclusion and exclusion criteria. Each excluded article was recorded with its reason for exclusion.

Disagreements at either phase were resolved by discussion between AK and AY. If they could not agree, a third reviewer, Soumya Sanghmitra (SS), made the final decision. Agreement between the two reviewers was measured with Cohen's kappa statistic at both phases. The whole selection process was documented in a PRISMA 2020 flow diagram (Figure 1)

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Data Extraction

Two reviewers, (AK) and (AY), independently extracted data from each included study using a standardized form designed in advance. Before full extraction began, they tested the form on three randomly chosen studies and revised it so that it captured every relevant variable consistently. They compared their completed forms and resolved any differences by discussion. If they could not agree, a third reviewer, (SS) made the final decision.

The following information was extracted from each study:

1. **Study details:** first author, year of publication, country, setting, and source of funding.
2. **Study design:** parallel-group or split-mouth randomized controlled trial, number of study arms, and follow-up period.
3. **Participant characteristics:** number of patients and number of treated recessions in each group, age, sex, smoking status, and recession classification (Miller or Cairo).
4. **Defect characteristics:** tooth type, arch (maxillary or mandibular), baseline recession depth, baseline keratinized tissue width, and gingival phenotype.
5. **Intervention and comparison details:** flap design (for example CAF, modified CAF, or tunnel technique), type of graft or substitute (connective tissue graft, free gingival graft, acellular dermal matrix, xenogeneic collagen matrix, or biologic agents), donor site and graft harvesting technique, and suturing method.
6. **Patient morbidity outcomes:** postoperative pain and discomfort, the assessment tool used (VAS), the time points when it was recorded, analgesic consumption, and any other reported complications, such as swelling, bleeding, or donor-site morbidity.
7. **Clinical outcomes:** complete root coverage (%), mean root coverage (%), and

change in keratinized tissue width (mm) at the final follow-up.

8. **Additional information:** surgical time, patient satisfaction, aesthetic scores, and the authors' main conclusions, where these were reported.

Continuous outcomes were recorded as means and standard deviations. Where a study reported only medians with ranges or interquartile ranges, means and standard deviations were estimated using established conversion methods. If outcome data were missing or unclear, the corresponding authors were contacted by email. A reminder was sent after two weeks, and studies whose data could not be obtained were described narratively.

For split-mouth studies, data were extracted with the within-patient design taken into account. If a study reported more than one follow-up time, the longest follow-up was used for the clinical outcomes. For patient morbidity, the time point closest to the first postoperative week was used. Agreement between the two reviewers on data extraction was measured with Cohen's kappa.

Risk of Bias Assessment

Two reviewers, (AK) and (AY), independently assessed the risk of bias of each included randomized controlled trial using the Cochrane Collaboration's tool for assessing risk of bias, as described in the Cochrane Handbook for Systematic Reviews of Interventions (version 5.1.0). Any disagreement between the two reviewers was settled through discussion, and when consensus could not be reached, a third reviewer, (SS) was consulted.

Each trial was evaluated across seven domains: random sequence generation and allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other potential sources of bias. Every domain was judged as having a low, unclear, or high risk of bias. A domain was rated as unclear when the trial report did not provide enough information to permit a clear judgement.

A study was considered to have an overall low risk of bias when all domains were rated as low risk, an unclear risk when at least one domain was rated as unclear and none as high, and a high risk when one or more domains were rated as high risk. The judgements were generated and displayed using Review Manager (RevMan) software.

Statistical Analysis

The meta-analysis of the trials included in this systematic review was carried out in Review Manager (RevMan) software [Version 5.4.1; The Cochrane Collaboration, Copenhagen, Denmark]. Quantitative synthesis covered the following outcomes:

- self-reported postoperative pain or discomfort

- complete root coverage (CRC)
- mean root coverage (MRC)
- gain in keratinized tissue width (KTW)

Only data recorded at the [6-month] follow-up were pooled, so that the trials could be compared at the same time point.

All outcomes were analysed as continuous variables. The mean difference (MD) with its 95% confidence interval (CI) was calculated for postoperative pain or discomfort (VAS scores), CRC (%), MRC (%), and KTW gain (mm). When trials measured pain on different scales, the standardized mean difference (SMD) with its 95% CI was used.

Heterogeneity among the trials was assessed with the chi-square (Cochran's Q) test and quantified with the I^2 statistic. When heterogeneity was low ($p \geq 0.10$ and $I^2 \leq 50\%$), the results were pooled with a fixed-effect model. When heterogeneity was substantial ($p < 0.10$ and $I^2 > 50\%$), a random-effects model was used.

The pooled estimates were displayed as forest plots. Where substantial heterogeneity was found for pain, CRC, MRC, or KTW, its possible sources were explored through subgroup analysis. The subgroups were defined by flap design (coronally advanced flap versus tunnel technique) and by the type of graft or substitute used. A p-value below 0.05 was considered statistically significant.

Results

Search Outcomes

The electronic search of the databases identified 264 potentially relevant records. After 40 duplicates were removed, both reviewers, A.K. and A.Y., independently screened the titles and abstracts of the remaining 224 records. Of these, 175 records were excluded, and 49 articles were retained for full-text evaluation.

After a detailed reading of the complete publications, both reviewers found that 17 articles did not fulfil the eligibility criteria, because they were case series, case reports, or non-randomized clinical trials, or did not meet the inclusion criteria. As a result, 32 articles were included in the qualitative synthesis, and 27 of them provided data suitable for the quantitative synthesis (meta-analysis). The included articles were published between 2010 and 2020, and all of them were randomized controlled trials. The selection process is shown in Fig. 1.

Risk of Bias in Included Studies

The judgements for each included trial are shown in Figure 1, and the proportion of studies in each risk category for every domain is shown in Figure 2.

Random sequence generation was adequately described in most trials (29 of 33; 87.9%). It was unclear in three trials (9.1%) and judged to carry a high risk in one trial (3.0%). Allocation concealment was the domain most frequently compromised: it was rated low risk in 17 trials (51.5%), unclear in 9 (27.3%), and high risk in 7 (21.2%).

Because the surgical procedures being compared, particularly those involving palatal graft harvesting, differ visibly to both patients and operators, blinding of participants and personnel was often not possible. This domain was rated low risk in 20 trials (60.6%), unclear in 6 (18.2%), and high risk in 7 (21.2%). Blinding of outcome assessment was rated low risk in 18 trials (54.5%), unclear in 9 (27.3%), and high risk in 6 (18.2%).

All 33 trials (100%) were judged to be at low risk of attrition bias and reporting bias. Other sources of bias were judged low risk in 22 trials (66.7%), unclear in 4 (12.1%), and high risk in 7 (21.2%).

Overall, 13 trials (39.4%) were rated as having a low risk of bias in every domain, 12 trials (36.4%) had an unclear risk, and 8 trials (24.2%) were judged to be at high risk of bias in at least one domain.

Primary Outcome

The primary outcome was patient morbidity, expressed as self-reported postoperative pain or discomfort. It was analysed in two ways, according to flap design and according to graft type, and the results are shown in the forest plots. Because the trials used different pain scales, the standardized mean difference (SMD) was calculated, and a random-effects model was used throughout because of the high heterogeneity.

(1) Patient morbidity according to flap design: Nine data sets were included in this meta-analysis, and considerable heterogeneity was found ($I^2 = 89\%$). A statistically significant reduction in morbidity was observed when CAF + biomaterial was compared with CAF + CTG (SMD = -0.16 , 95% CI -0.29 to -0.04 , $p = 0.01$; $I^2 = 0\%$), and when the tunnel technique with a biomaterial was compared with the tunnel technique with a CTG (SMD = -0.94 , 95% CI -1.27 to -0.61 , $p < 0.00001$). In contrast, CAF + CTG resulted in significantly greater morbidity than CAF alone (SMD = 1.82 , 95% CI 1.28 to 2.37 , $p < 0.00001$). No significant differences were found between the tunnel technique and CAF, whether combined with a CTG ($p = 0.40$) or with a biomaterial ($p = 0.28$), or between CAF + biomaterial and CAF alone ($p = 0.14$). However, the overall comparison did not show a statistically significant difference (SMD = -0.06 , 95% CI -0.40 to 0.28 , $p = 0.73$) (Figure 4).

(2) Patient morbidity according to graft type: Eight data sets were included, with considerable heterogeneity ($I^2 = 91\%$). The subgroup analysis showed that XCM was associated with significantly less postoperative morbidity than the CTG (SMD = -0.37 , 95% CI -0.69 to -0.04 , $p = 0.03$), and that adding EMD to a CTG reduced morbidity compared with CTG alone (SMD = -0.41 , 95% CI -0.73 to -0.09 , $p = 0.01$). The CTG produced significantly more morbidity than the flap alone (SMD = 1.82 , $p < 0.00001$), whereas PRF ($p = 0.30$) and XCM ($p = 0.26$) did not differ significantly from the flap alone. However, the overall comparison did not show a

statistically significant difference (SMD = -0.11, 95% CI -0.46 to 0.24, $p = 0.54$) (Figure 5).

Overall, the procedures associated with the lowest patient morbidity were those that avoided palatal graft harvesting, particularly the use of a collagen matrix with either CAF or the tunnel technique.

Secondary Outcomes

The secondary outcomes were complete root coverage (CRC), mean root coverage (MRC), and gain in keratinized tissue width (KTW). All outcomes are shown in the forest plots.

(1) CRC: CRC was analysed as a risk ratio (RR) with a random-effects model. In the flap-based analysis, 22 data sets were included, with considerable heterogeneity ($I^2 = 83\%$). A statistically significant benefit was found for CAF + CTG compared with CAF alone (RR = 1.66, 95% CI 1.20 to 2.31, $p = 0.002$), and for CAF + biomaterial compared with CAF alone (RR = 1.21, 95% CI 1.04 to 1.42, $p = 0.02$). However, the CTG was superior to the biomaterial with both flap designs: CAF + biomaterial versus CAF + CTG (RR = 0.75, 95% CI 0.66 to 0.84, $p < 0.00001$), and tunnel + biomaterial versus tunnel + CTG (RR = 0.42, 95% CI 0.23 to 0.76, $p = 0.004$). There was no significant difference between the tunnel technique and CAF with a CTG ($p = 0.78$) or with a biomaterial ($p = 0.35$). The overall comparison did not show a statistically significant difference (RR = 0.86, 95% CI 0.72 to 1.02, $p = 0.08$) (Figure 6).

In the graft-based analysis of 17 data sets ($I^2 = 85\%$), the CTG (RR = 1.66, $p = 0.002$) and ADM (RR = 1.67, 95% CI 1.08 to 2.58, $p = 0.02$) achieved CRC significantly more often than the flap alone. XCM (RR = 0.42, $p = 0.004$) and EMD alone (RR = 0.29, 95% CI 0.13 to 0.65, $p = 0.002$) were inferior to the CTG. PRF gave results similar to the CTG ($p = 0.99$) and to the flap alone ($p = 0.44$). The overall comparison was not statistically significant (RR = 0.89, 95% CI 0.72 to 1.10, $p = 0.28$) (Figure 7).

(2) MRC: In the flap-based analysis, 18 data sets were included, with considerable heterogeneity ($I^2 = 89\%$). The subgroup analysis showed significantly greater MRC with CAF + biomaterial than with CAF alone (SMD = 0.53, 95% CI 0.30 to 0.76, $p < 0.00001$). The tunnel technique with a biomaterial gave significantly lower MRC than the tunnel technique with a CTG (SMD = -0.61, 95% CI -1.03 to -0.18, $p = 0.005$). The remaining comparisons were not significant, and the overall result did not show a statistically significant difference (SMD = -0.09, 95% CI -0.43 to 0.24, $p = 0.59$) (Figure 8).

In the graft-based analysis of 13 data sets ($I^2 = 89\%$), ADM (SMD = 0.90, $p = 0.003$) and XCM (SMD = 0.59, 95% CI 0.28 to 0.89, $p = 0.0002$) produced significantly greater MRC than the flap alone. XCM (SMD = -0.61, $p = 0.005$) and EMD alone (SMD = -2.18, 95% CI -3.06 to -1.31, $p < 0.00001$) gave significantly lower MRC than the CTG. There was no significant difference between EMD + CTG and

CTG alone ($p = 0.47$). The overall comparison was not statistically significant (SMD = -0.24, 95% CI -0.59 to 0.11, $p = 0.19$) (Figure 9).

(3) KTW: In the flap-based analysis, 23 data sets were included, with considerable heterogeneity ($I^2 = 90\%$). The subgroup analysis showed a significantly greater KTW gain with CAF + CTG than with CAF alone (SMD = 1.71, 95% CI 1.26 to 2.17, $p < 0.00001$), and with CAF + biomaterial than with CAF alone (SMD = 0.47, 95% CI 0.07 to 0.87, $p = 0.02$). When combined with a biomaterial, the tunnel technique produced significantly less KTW gain than CAF (SMD = -0.82, 95% CI -1.29 to -0.35, $p = 0.0007$). There was no significant difference between CAF + biomaterial and CAF + CTG ($p = 0.50$). The overall comparison was not statistically significant (SMD = 0.09, 95% CI -0.20 to 0.38, $p = 0.54$) (Figure 10).

In the graft-based analysis of 19 data sets ($I^2 = 91\%$), ADM (SMD = 1.99, 95% CI 1.28 to 2.69, $p < 0.00001$) and the CTG (SMD = 1.71, $p < 0.00001$) increased KTW significantly more than the flap alone. XCM ($p = 0.41$), PRF ($p = 0.88$), EMD + CTG ($p = 0.53$), and EMD alone ($p = 0.18$) did not differ significantly from the CTG. The overall comparison was not statistically significant (SMD = 0.17, 95% CI -0.17 to 0.50, $p = 0.33$) (Figure 11).

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Ahmedbeyli et al., 2014	●	●	●	●	●	●	●
Alexiou et al., 2017	●	●	●	●	●	●	●
Aroca et al., 2010	●	●	●	●	●	●	●
Aroca et al., 2013	●	●	●	●	●	●	●
Azaripour et al., 2016	●	●	●	●	●	●	●
Barootchi et al., 2019	●	●	●	●	●	●	●
bozkurt et al., 2015	●	●	●	●	●	●	●
Cairo et al., 2016	●	●	●	●	●	●	●
Cardaropoli et al., 2014	●	●	●	●	●	●	●
cetiner et al., 2018	●	●	●	●	●	●	●
Gobbato et al., 2016	●	●	●	●	●	●	●
Gorski et al., 2020	●	●	●	●	●	●	●
Gurlek et al 2019	●	●	●	●	●	●	●
Jaiswal et al., 2012	●	●	●	●	●	●	●
kuka et al., 2018	●	●	●	●	●	●	●
Nahas R et al., 2019	●	●	●	●	●	●	●
oncu et al 2017	●	●	●	●	●	●	●
Ozenci et al., 2015	●	●	●	●	●	●	●
Parween et al., 2020	●	●	●	●	●	●	●
Pelekos et al., 2019	●	●	●	●	●	●	●
Pietruska et al., 2019	●	●	●	●	●	●	●
Potey et al., 2019	●	●	●	●	●	●	●
prato et al., 2010	●	●	●	●	●	●	●
Rakasevic et al., 2020	●	●	●	●	●	●	●
Rotundo et al., 2019	●	●	●	●	●	●	●
Suzuki et al., 2020	●	●	●	●	●	●	●
Tavelli et al., 2019	●	●	●	●	●	●	●
Tonetti et al., 2018	●	●	●	●	●	●	●
Tunali et al., 2015	●	●	●	●	●	●	●
Uzun et al., 2017	●	●	●	●	●	●	●
Wegemund et al., 2016	●	●	●	●	●	●	●
zucchelli et al., 2014	●	●	●	●	●	●	●
Zuhr et al., 2014	●	●	●	●	●	●	●

Figure 2: Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

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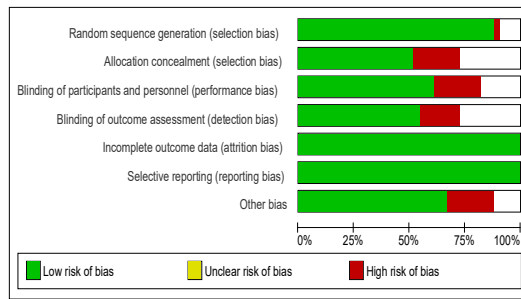


Figure 3: Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

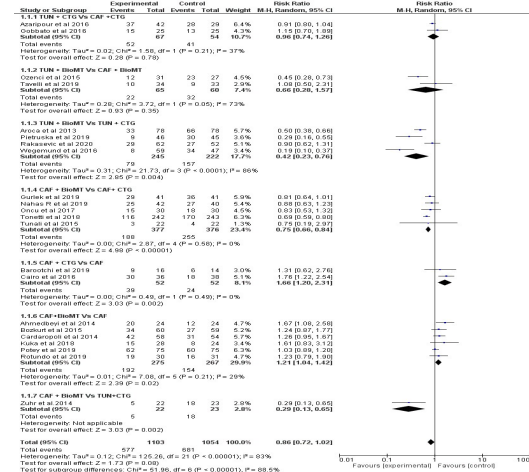
Discussion

This systematic review and meta-analysis looked at how patients experience surgery to cover several adjacent gingival recessions at once, alongside the clinical results of the different techniques. The aim was to find out which procedures cause the least postoperative pain and discomfort while still giving acceptable root coverage and keratinized tissue gain. Overall, the results point to a consistent trade-off. Using an autogenous connective tissue graft (CTG) gave the most predictable clinical results, but it also caused the most postoperative pain and discomfort. Graft substitutes reduced patient morbidity, but they usually came with some loss of clinical effectiveness.⁹

The main determinant of postoperative morbidity in this review was whether a palatal donor site was needed. Adding a CTG to the coronally advanced flap (CAF) markedly increased the pain patients reported, compared with CAF alone.

This finding was based on the trial by Cairo et al. (2016)¹⁰ and is in line with earlier reports that the palatal wound accounts for most of the pain, bleeding and discomfort after root coverage surgery.¹⁰ Treating multiple recessions needs a longer graft and a larger donor area, so this problem is likely to be greater than in single-tooth procedures. Replacing the CTG with a xenogeneic collagen matrix (XCM) significantly reduced morbidity, with both CAF and the tunnel technique.¹⁰ The largest benefit was seen in the trial by Aroca et al. (2013)¹¹, in which patients treated with the tunnel technique and a collagen matrix reported much less pain than those who received a CTG. These results support using soft tissue substitutes when keeping patient discomfort to a minimum is the priority, for example in patients who are anxious, have a thin palatal mucosa, or need treatment of many teeth.^{11,22,23} An interesting finding was that adding enamel matrix derivative (EMD) to a CTG reduced postoperative morbidity compared with CTG alone.^{12,16,17} This may be explained by the biological effects reported for EMD, such as faster early wound healing and less postoperative inflammation.^{13,14,15,18} However, this result comes from a single trial and needs to be confirmed in further studies. The flap design itself seemed to have

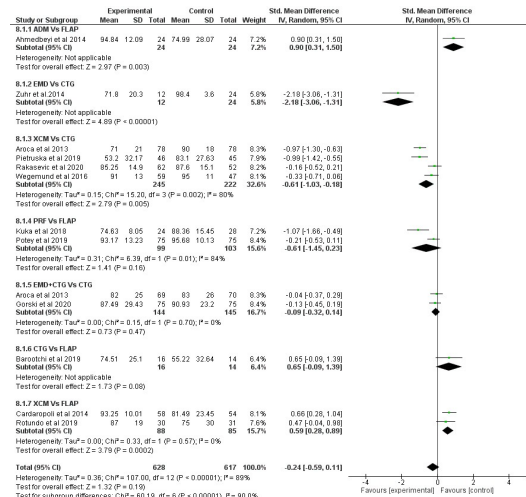
little effect on morbidity, as the tunnel technique and CAF produced similar levels of discomfort. This suggests that, once the donor site is taken into account, the type of recipient-site flap plays only a minor role in how patients experience the procedure. Similarly, platelet-rich fibrin (PRF) and the collagen matrix did not significantly change morbidity compared with the flap alone. This indicates that these materials add little or no discomfort to the basic flap procedure.



For complete root coverage (CRC), the CTG remained the most effective adjunct. CAF + CTG achieved CRC significantly more often than CAF alone, and the CTG did better than biomaterials with both flap designs. These findings agree with the widely held view of the CTG as the reference standard for root coverage. At the same time, adding a biomaterial to CAF improved CRC compared with CAF alone. This shows that substitutes still offer a clinical benefit over the flap without any graft.

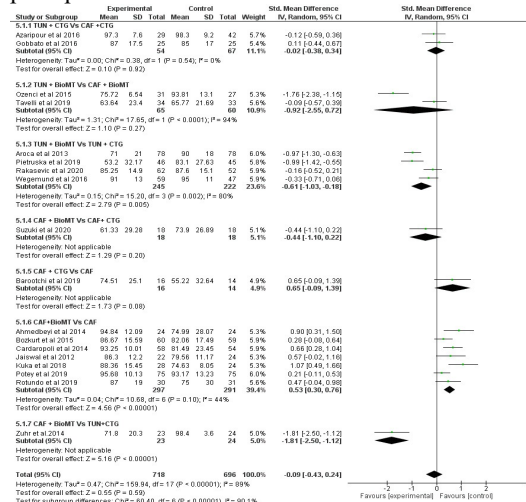
The results for mean root coverage (MRC) followed a similar pattern. The collagen matrix and acellular dermal matrix (ADM) produced greater root coverage than the flap alone, whereas the collagen matrix and EMD alone were less effective than the CTG. When both techniques were combined with a CTG, the tunnel technique and CAF gave comparable root coverage. This suggests that the choice between these two flap designs can be based on the clinician's experience and the anatomy of the site.

Patient morbidity outcomes following root coverage procedures in association with the treatment of multiple gingival recessions: A Systematic Review and Meta-analysis



The greatest gain in keratinized tissue width (KTW) was achieved with CAF + CTG, followed by CAF combined with a biomaterial. This agrees with the idea that the connective tissue of the palate can induce keratinization in the overlying epithelium. The tunnel technique combined with a biomaterial produced less KTW gain than CAF with the same biomaterial.

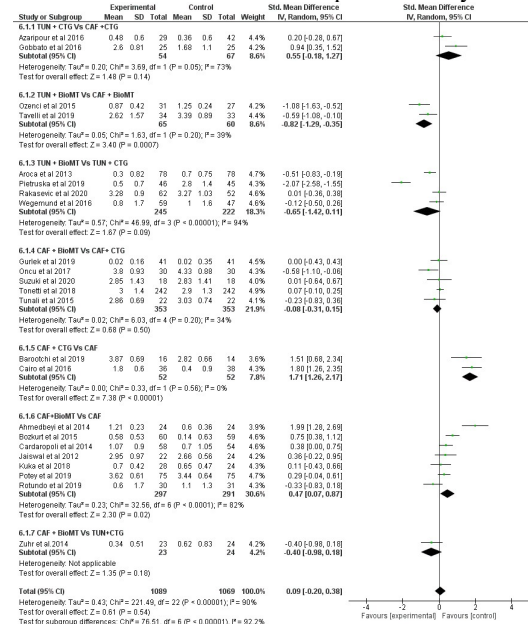
This may be because the tunnel technique does not move the mucogingival junction coronally in the same way. Esthetic outcomes were better with the collagen matrix than with the CTG. This may reflect the better colour and texture match that substitutes can give, compared with the bulky appearance sometimes seen with autogenous grafts. Taken together, these results suggest that no single procedure is best in every respect for treating multiple gingival recessions. When complete root coverage and an increase in keratinized tissue are the main goals, especially at sites with a thin phenotype or little keratinized tissue, CAF or the tunnel technique combined with a CTG is still the most predictable choice. However, this comes with more postoperative discomfort.



When patient comfort, or avoiding a second surgical site, matters more, a collagen matrix or another

substitute is a reasonable alternative, provided the patient understands that root coverage may be somewhat less complete. Clinicians should therefore discuss these trade-offs with patients and include patient-reported outcomes in their treatment decisions.

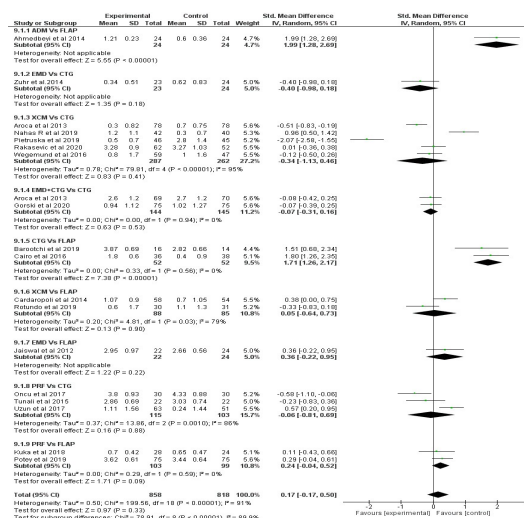
A main strength of this review is that it used patient-reported morbidity as the primary outcome, rather than treating it as a secondary finding, and that it included only randomized controlled trials. Several limitations should nevertheless be taken into account. Heterogeneity was considerable for most outcomes. It reflects differences in surgical technique, graft materials, recession characteristics, follow-up time and how outcomes were measured. Several comparisons were based on only one or two trials, which limits how reliable those estimates are. The trials measured morbidity with different scales and at different time points after surgery, which makes the results harder to interpret clinically.



About one-third of the included trials were judged to be at high risk of bias, mainly because allocation concealment and blinding were inadequate. Blinding patients is especially difficult when only one group has a palatal graft taken, and this may have influenced the pain scores they reported. In addition, several trials reported outcomes per treated site rather than per patient, and the review was limited to articles published in English.

Future trials should report patient morbidity in a standard way: a validated 0–10 scale, measurements at set time points, separate reporting of donor-site and recipient-site pain, and data on analgesic use. Trials with longer follow-up are also needed, to find out whether the clinical results of substitute materials remain stable over time.

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Conclusion

In conclusion, within the limitations of this review, procedures that avoided palatal graft harvesting, particularly those using a xenogeneic collagen matrix with CAF or the tunnel technique, were associated with the lowest patient morbidity. Procedures that included a CTG gave the highest rates of complete root coverage and the greatest gain in keratinized tissue width, but caused more postoperative discomfort. Choosing a technique for multiple gingival recessions should therefore involve weighing the expected clinical benefit against what the patient will experience after surgery.

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