Review

Root coverage with the restoration of non-carious cervical lesions: A systematic review and meta-analysis

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Abstract

The progression of non-carious cervical lesions (NCCLs) leads to gingival recession (GR), which is restored with restorative materials, using different periodontal plastic surgery procedures. There is no consensus on which technique is superior to others. Therefore, the present systematic review aimed to assess the effectiveness of root coverage (RC) procedures in the restored and unrestored NCCLs in terms of clinical and patient-centered outcomes.

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) while searching 5 databases in addition to the gray literature. The Medical Subject Headings (MeSH) terms and keywords in the title and abstract fields, as well as in headings, were used to search the existing literature for the relevant publications on the effectiveness of RC procedures with the restoration of NCCLs over the past 3 decades (January 1990–July 2021). After applying the inclusion and exclusion criteria, 13 articles were read in full and critically analyzed. The quality analysis was performed using the Cochrane RevMan software.

A total of 222 potentially relevant titles and abstracts were found after the initial electronic and manual search, and after removing duplicates. Applying the inclusion and exclusion criteria yielded 23 publications that were further analyzed for relevance and applicability. Following critical analysis, 13 publications were used for validity assessment and data extraction.

In the teeth with NCCLs and GR, the restoration of NCCLs does not affect the percentage RC. However, it significantly decreases dentin hypersensitivity, and the patients' perception of esthetics and satisfaction.

Keywords: gingival recession, root coverage, non-carious cervical lesions, periodontal plastic surgery, mucogingival surgery

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Introduction

Due to the reduction of caries prevalence in worldwide populations, the teeth are functional for more extended periods.[1] This may expose the teeth to conditions other than caries, such as non-carious cervical lesions (NCCLs). Non-carious cervical lesions are saucer- or wedge-shaped defects present at the cementoenamel junction (CEJ), characterized by a gradual, slow loss of mineralized dental tissue in the absence of dental caries. The progression of NCCLs causes the loss of CEJ, leading to crown and root involvement.[2] Most of the NCCL coronal zone may be formed by the exposed dentin of the anatomical crown, and the apical zone involves the dentin of the anatomical root. Furthermore, the apical shift of the gingival margin with the exposure of the root surface leads to gingival recession (GR).[3] Non-carious cervical lesions are restored with various materials, like glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC) or composites. These restorations reduce dentinal hypersensitivity, but do not provide root coverage (RC) and improve esthetics.[4]

The successful treatment of NCCLs associated with GR is based on clinically predictable periodontal plastic surgery procedures with the restoration of NCCLs. Periodontal plastic surgery procedures may comprise the coronally advanced/positioned flap or the connective tissue graft (CTG) over the restored root surfaces. Various studies have shown that GR associated with NCCLs can be successfully treated with a restorative procedure combined with a periodontal plastic surgery procedure to obtain optimal functional and esthetic results. The restoration of NCCLs followed by mucogingival surgery is indicated when cervical abrasion is associated with GR of more than 3 mm.[5–7]

The RC of the restored surfaces depends on the extent of NCCL and GR, the amount of interdental bone and soft tissue loss, the type of restoration used, and the periodontal procedure performed.[8]

Several RC procedures have been demonstrated to correct GR, but there is no consensus on which is superior. Regarding the restorations, various materials have been shown to effectively restore NCCLs, claiming superiority over one another. However, there is no consensus on which treatment is better at correcting this complex lesion of RC associated with GR. Therefore, the present systematic review was undertaken to assess the effectiveness of RC procedures in the restored and unrestored NCCLs in terms of clinical and patient-centered outcomes.

The focused question was: What is the success rate of root coverage procedures in patients with GR associated with NCCLs?

Material and methods

Report and protocol

This review was prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement,[9] the Cochrane Collaboration guidelines, and used a review checklist based on the proposed focused question. It was registered with PROSPERO (https://www.crd.york.ac.uk/PROSPERO) under the registration number CRD42021258035.

Inclusion and exclusion criteria

The inclusion criteria for this systematic review were based on the PICOS acronym:

– (P) types of participants: patients suffering from GR defects associated with NCCLs;
– (I) types of interventions: any type of NCCL restoration followed by any RC procedure;
– (C) comparisons between interventions: all possible comparisons among the groups, including the restored and unrestored NCCL with RC procedures;
– (O) type of outcome measures:
  • primary outcome: recession height (RH); keratinized tissue thickness (KTT); and keratinized tissue height (KTH);
  • secondary outcome: probing depth (PD); clinical attachment loss (CAL); plaque index (PI); and gingival index (GI);
– (S) types of studies: only randomized controlled trials (RCTs) with at least 6 months of follow-up and including at least 15 patients in each arm.

The exclusion criteria were as follows: non-randomized controlled trials; defects other than NCCLs; and less than 6 months of follow-up.

Search strategy

An initial search strategy with no restrictions regarding the status or publication language was performed to identify relevant studies published up to and including July 31, 2021, that met the inclusion criteria. The studies selected for the review were RCTs with at least a 6-month follow-up that utilized tooth-colored restorative materials for NCCLs and RC procedures.

The keywords used: 'non-carious cervical lesions'; 'cervical abrasion'; 'cervical restoration'; 'tooth-colored restorative materials'; 'root coverage'; 'gingival recession'; 'periodontal plastic surgery'; 'coronally advanced flap'; 'laterally displaced flap'; 'denuded root surface'; 'abfraction'; 'subepithelial connective tissue graft'; and 'mucogingival surgery'.

Electronic search

The MEDLINE (via PubMed) search strategy relied on the Cochrane Highly Sensitive Search Strategy for identifying randomized trials in MEDLINE: Sensitivity-maximizing version (2008 revision); PubMed format.[10] The following electronic databases were searched: MEDLINE via PubMed; Scopus; the Cochrane Central Register of Controlled Trials (CENTRAL); Embase; and the Web of Science.

Hand-searching and the gray literature

The following leading journals were hand-searched twice by the 2 review authors (KC and LG): "Journal of Periodontology"; "Journal of Clinical Periodontology"; "Journal of Periodontal Research"; "International Journal of Periodontics and Restorative Dentistry'; and "Journal of Indian Society of Periodontology".

The gray literature was explored using the Conference Proceedings Citation Index (CPCI) within the Web of Science, the System for Information on Grey Literature in Europe (SIGLE) database, and the Scopus Web and Patent results sets. Dissertations and theses were searched using the ProQuest Dissertations & Theses Global (PQDT)™ full-text database. To locate unpublished and ongoing trials related to the review question, the Current Controlled Trials (www.controlled-trials.com) and ClinicalTrials.gov (www.clinicaltrials.gov) trial registries were consulted.

The review authors checked twice the bibliographies of all the RCTs and relevant review articles included.

Each study identified by at least one review author through the various search strategies was involved in the next stage (study selection).

Study selection

The titles and abstracts (when available) of all reports (222 articles) identified through the electronic and manual search were screened independently by the 2 review authors. The full texts were obtained if the studies appeared to meet the inclusion criteria or if there was insufficient data in the title and abstract to make a clear decision. The complete reports obtained from all electronic sources and with other searching methods were assessed independently by the 2 review authors to establish whether or not the studies met the inclusion criteria. The 2 review authors discussed any disagreement to resolve conflicts. Initially, 23 articles were selected after screening, and 10 not meeting the criteria were excluded, with the reasons for exclusion after the full-text analysis recorded.[11–20] Thirteen studies meeting the inclusion criteria were then included, and underwent validity assessment and data extraction. The screening and selection of articles are depicted in Fig. 1.

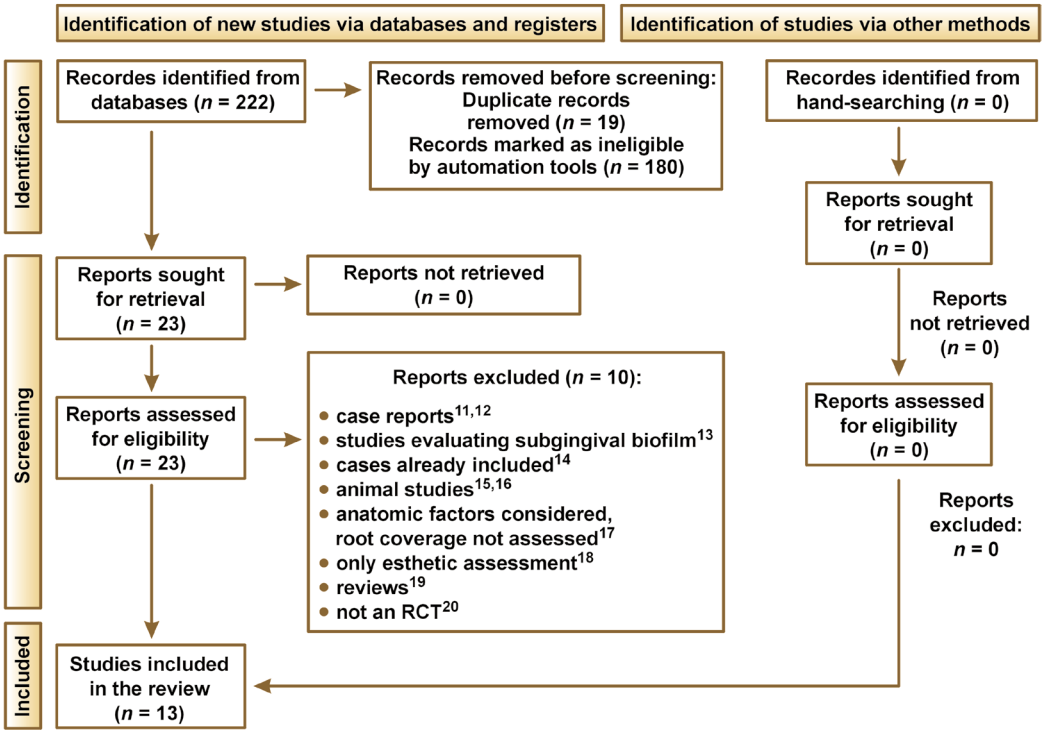

Fig. 1. Flow chart for the screening and selection of articles

RCT – randomized clinical trial.

Data extraction

The 2 review authors extracted data from the included studies independently, using the preferred data extraction forms. If necessary, trial authors were contacted for clarification or the missing information. For each trial included in the study, the following data was recorded:

– general information: year of publication; correspondence details; country of origin; and setting (university or clinical);
– methods: study design; and number of centers;
– participants: number of participants and their characteristics (age, gender and systemic health); and criteria for inclusion and exclusion;
– interventions and comparisons: number of intervention groups; types of intervention (restored or unrestored NCCLs); and surgical technique (type of RC procedure used – coronally advanced flap (CAF), CTG, or a combination);
– outcomes: details of the outcomes collected (types – RH, KTT, KTH, PD, CAL, PI, GI, time points, and patient-centered outcomes);
– results: number of participants allocated to each intervention group; dropouts; characteristics of patients in each group (age, gender and systemic health); and results for each outcome considered;
– study funding: information about the possible study funding.

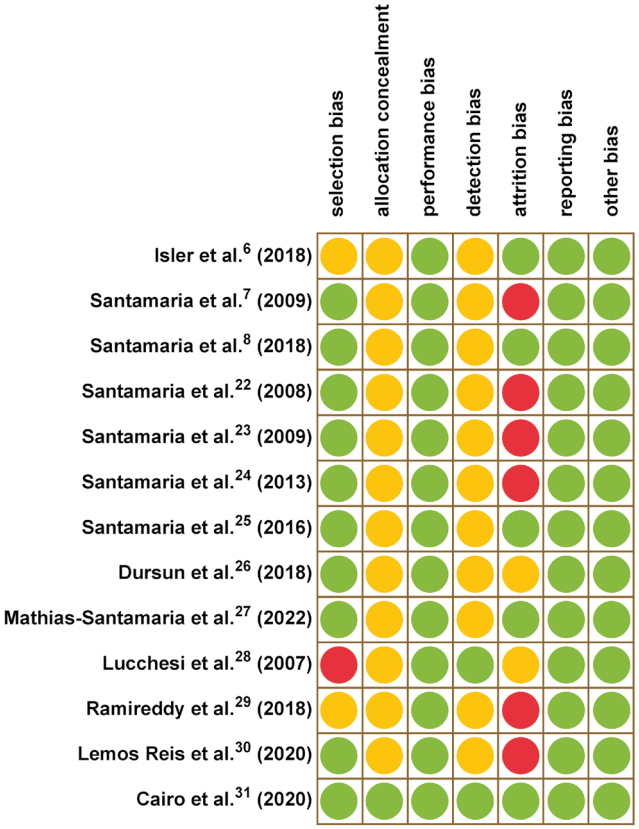

Fig. 2. Risk of bias assessment

Colors: green –low risk of bias; yellow – unclear risk of bias; red – high risk of bias.

Risk of bias assessment

The assessment of the risk of bias was carried out independently and in duplicate by the 2 review authors as part of the data extraction process, with any disagreement discussed between the same 2 review authors. It was conducted using the recommended approach for assessing the risk of bias in studies (Fig. 2) by the Cochrane Collaboration[21] and reported using the RevMan software, v. 5 (Copenhagen, Denmark: The Nordic Cochrane Centre, the Cochrane Collaboration).

Randomization

All trials were reported as RCTs, but not all of them reported randomization and allocation in detail.

Allocation

All trials presented an adequate method of allocation concealment except 2 studies.[6,22]

Masking

Examiner masking was not practical in most of the studies,[6,7,23–26,28–31] as it was easy to note whether the restoration was present. The investigators who recruited patients and the examiner were masked to the procedure in the study by Mathias-Santamaria et al.[27]

Data synthesis and reporting

This systematic review included 13 research articles that were analyzed for quantitative data. The literature analysis revealed that most studies were conducted from 2007 until now. Table 1 demonstrates the baseline characteristics of the RCTs included.

Table 2 reports the outcomes of the studies on which the meta-analysis was performed.

Statistical analysis

Data was extracted and coded using Microsoft Excel (Microsoft Corporation, Redmond, USA). The outcomes of interest were the mean RC, PD, KTH, keratinized tissue width (KTW), and CAL. The effect sizes and weights were calculated for each outcome from each study. The χ^2-based test of homogeneity was performed using Cochran's Q statistic. The I^2 statistic (<50%) indicated that there was homogeneity between the studies, hence a fixed effects model was considered. Forest plots were constructed for each outcome.

Table 1. Baseline characteristics of the included studies

Study	Year	Country	Setting	No. of centers	Study design	No. of participants	Age group [years]	External funding	Type of defect	Intervention		Primary and secondary outcomes	Follow-up
										test	control		
Isler et al.[6]	2018	Turkey	university	1	RCT	23	28–59	–	GR associated with NCCL	NRC +CTG RMGIC + CTG giomer + CTG	CTG	rRH, KTT, KTW, PD, rCAL	1 year
Santamaria et al.[7]	2009	Brazil	university/ college	1	RCT (split-mouth study – bilateral defects)	16	26–58	–	Miller's class I buccal GR associated with NCCL	R +CAF	CAF	KTT, KTW, PD, rCAL, BOP, RGR, CLH, DS	2 years
Santamaria et al.[8]	2018	Brazil	university/ college	1	RCT	40	22–60	–	Miller's class I or class II GR associated with NCCL (B+ tooth cervical defect)	PR +CTG	CTG + odontoplasty	KTT, KTW, PD, rCAL, PI, BOP, FMBI, RGR, CDH, CDC, RC	1 year
Santamaria et al.[22]	2008	Brazil	university/ college	1	RCT (split mouth study – bilateral defects)	19	24–58	–	Miller's class I buccal GR associated with NCCL	R + CAF	CAF	KTT, KTW, PD, BOP, RGR, CAL, CLH, DS	45 days, 2, 3, 6 months
Santamaria et al.[23]	2009	Brazil	university/ college	1	RCT	40	19–71	–	Miller's class I buccal GR associated with NCCL	R + CTG	CTG	KTT, KTW, PD, CAL, FMPI, BOP, FMBI, RGR, CLH	6 months
Santamaria et al.[24]	2013	Brazil	university/ college	1	RCT	36	19–71	–	Miller's class I buccal GR associated with NCCL	R + CTG	CTG	PD, CAL, BOP, RGR, CLH	2 years
Santamaria et al.[25]	2016	Brazil	university/ college	1	single-blind, parallel, equivalence RCT	36	–	–	Miller's class I or class II GR associated with NCCL (B+ tooth cervical defect)	RCom + CTG	CTG	KTT, KTW, PD, rCAL, FMPI, FMBI, RGR, CLH, DS	6 months, 1 year
Dursun et al.[26]	2018	Turkey	university	1	–	36	41.65 ±12.26 (*M* ±*SD*)	–	GR associated with NCCL	RMGIC + SCTG NIC + SCTG	–	KTH, WGR, HGR, CDH, DS	1 year
Mathias-Santamaria et al.[27]	2022	Brazil	university	1	double-blind, parallel RCT	62	>18	the State of São Paulo Research Foundation (FAPESP), Brazil (grants No. 2018/03284-3 and 2016/26154-2)	GR type 1 associated with class B+ or B– NCCL	CAF + CM	CAF	primary: CDC, RC secondary: KTT, KTW, PD, CAL, FMPI, FMGI, RGR, CDH, DH, mRES, VAS	baseline, 6 months, 1 year

Study	Year	Country	Setting	No. of centers	Study design	No. of participants	Age group [years]	External funding	Type of defect	Intervention		Primary and secondary outcomes	Follow-up
										test	control		
Lucchesi et al.[28]	2007	Brazil	university	1	–	59	23–65	–	root exposure with NCCL, root exposure without NCCL	test I: RMGIC + CPF test II: MRC + CPF (root exposure with NCCL)	CPF (root exposure without NCCL)	KTT, KTW, PD, PI, CALG, BOP, RR	6 months
Ramireddy et al.[29]	2018	India	university/ college	1	RCT	20 participants with 78 sites	24–58	–	Miller's class I or class II GR (single and multiple)	RMGIC + CAF	CAF + PRF	KTT, KTW, PD, rCAL, CLH, CLW, rGR, DS	6 months
Lemos Reis et al.[30]	2020	Brazil	university	1	controlled clinical trial (split-mouth study – bilateral defects)	17	24–65	the study was financially supported by the Coordination for the Improvement of Higher Education Personnel (CAPES), Brazil; the acellular dermal matrix was donated by BioHorizons Implant Systems, Inc., Birmingham, USA	test group – GR + NCCL control group – GR	CAF + ADMG	CAF + ADMG	KTT, KTW, PD, CAL, GR, RC	6 months
Cairo et al.[31]	2020	Italy	university	1	RCT	24 participants (12 – test group, 12 – control group)	>18	–	presence of NCCL associated with GR	CAF + CTG	CAF	KT, PD, CAL, GT, GR, IM–CEJr, IM–GM, IM–GM1, IM–MGJ, CEJr-BC, CRC, sens VAS, RES intra-operatory measurement	3, 6 months, 1 year

M – mean; *SD* – standard deviation; GR – gingival recession; NCCL – non-carious cervical lesion; NRC – nanofilled resin composite; CTG – connective tissue graft; RMGIC – resin-modified glass ionomer cement; R – restoration; CAF – coronally advanced flap; PR – partial restoration; RCom – resin composite; SCTG – subepithelial connective tissue graft; NIC – nano-ionomer cement; CM – collagen membrane; CPF – coronally positioned flap; MRC – microfilled resin composite; ADMG – acellular dermal matrix graft; PRF – platelet-rich fibrin; (r)RH – (relative) recession height; KTT – keratinized tissue thickness; KTH – keratinized tissue height; PD – probing depth (PD); CAL – clinical attachment loss; BOP – bleeding on probing; RGR – relative gingival recession; CLH – cervical lesion height; DS – dentin sensitivity; PI – plaque index; FMBI – full-mouth bleeding index; CDH – combined defect height; CDC – combined defect coverage; RC – root coverage; FMPI – full-mouth plaque index; KTH – keratinized tissue height; WGR – width of gingival recession; HGR – height of gingival recession; FMGI – full-mouth gingival index; mRES – modified root coverage esthetic score; VAS – visual analog scale; CALG – clinical attachment level gain; RR – recession reduction; CLW – cervical lesion width; KT – keratinized tissue; GT – gingival thickness; IM–CEJr – distance from the incisal margin (IM) to the restored cementoenamel junction (CEJ) level; IM–GM – distance from the gingival margin (GM) to IM; IM–GM1 – distance from GM to IM after suturing; IM–MGJ – distance from IM to the mucogingival junction (MGJ); CEJr–BC – distance from the restored CEJ to the bone crest after flap elevation; CRC – complete root coverage; sens VAS – VAS score for DS; RES – root coverage esthetic score.

Table 2. Outcomes of the studies included in the meta-analysis

Study	Year	Fully restored/ partially restored	Restoration used	Intervention	Follow-up	Outcome assessed													
						PI [%]	GI/ BOP [%]	PD [mm]	rCAL/ CAL [mm]	CALG [mm]	rRH/ RGR [mm]	RGR reduction [mm]	KTH / KTW	KTT [mm]	RR	RC [%]	CLH [mm]	CLH [%]	CDC [%]
Lucchesi et al.[28]	2007	fully restored	RMGIC + MRC	root exposure with NCCL treated with RMGI + CPF	baseline	–	–	1.5 ±0.5	–	–	–	–	3.58 ±0.94	0.83 ±0.37	–	–	–	–	–
					3 months	–	–	1.4 ±0.5	2.2 ±1.0	–	–	–	3.55 ±0.94	0.90 ±0.38	2.4 ±1.0	–	–	–	–
					6 months	–	–	1.4 ±0.5	2.2 ±1.0	–	–	–	3.70 ±0.98	0.93 ±0.37	2.4 ±1.0	–	–	–	–
				root exposure with NCCL treated with MRC + CPF	baseline	–	–	1.3 ±0.5	–	–	–	–	3.37 ±1.01	0.92 ±0.25	–	–	–	–	–
					3 months	–	–	1.4 ±0.8	2.3 ±0.8	–	–	–	3.05 ±0.71	0.92 ±0.25	2.3 ±0.7	–	–	–	–
					6 months	–	–	1.3 ±0.6	2.2 ±0.7	–	–	–	3.32 ±0.82	0.92 ±0.25	2.2 ±0.6	–	–	–	–
				root exposure without NCCL treated with CPF	baseline	–	–	1.4 ±0.5	–	–	–	–	3.81 ±0.91	0.9 3±0.34	–	–	–	–	–
					3 months	–	–	1.3 ±0.6	2.4 ±1.0	–	–	–	3.05 ±0.76	0.90 ±0.31	2.2 ±0.7	–	–	–	–
					6 months	–	–	1.2 ±0.5	2.4 ±1.0	–	–	–	3.40 ±0.94	0.88 ±0.28	2.2 ±0.7	–	–	–	–
Santamaria et al.[22]	2008	fully restored	RMGIC	R + CAF	baseline	–	–	1.18 ±0.40	12.12 ±1.13	–	10.94 ±1.32	–	–	–	–	–	2.63 ±0.57	–	–
					45 days	–	–	1.12 ±0.34	10.66 ±1.19†	–	9.54 ±1.21†	–	–	–	–	–	–	–	–
					2 months	–	–	1.06 ±0.44	10.57 ±1.21†	–	9.51 ±1.23†	–	–	–	–	–	–	–	–
					3 months	–	–	1.00 ±0.36	10.54 ±1.22†	–	9.54 ±1.25†	–	–	–	–	–	–	–	–
					6 months	–	–	1.00 ±0.36	10.54 ±1.20†	1.52 ±0.66	9.54 ±1.25†	1.39 ±0.29	–	–	–	–	–	56.14 ±11.74	–
				CAF	baseline	–	–	1.25 ±0.44	11.82 ±0.80	–	10.57 ±0.94	–	–	–	–	–	2.60 ±0.39	–	–
					45 days	–	–	1.50 ±0.51	10.43 ±0.90†	–	8.93 ±1.00†	–	–	–	–	–	–	–	–
					2 months	–	–	1.43 ±0.51	10.42 ±1.17†	–	8.99 ±0.89†	–	–	–	–	–	–	–	–
					3 months	–	–	1.37 ±0.50	10.40 ±1.10†	–	9.03 ±0.87†	–	–	–	–	–	–	–	–
					6 months	–	–	1.31 ±0.47	10.32 ±1.03†	1.50 ±0.73	9.01 ±0.83†	1.50 ±0.30	–	–	–	–	–	59.78 ±11.11	–

Study	Year	Fully restored/ partially restored	Restoration used	Intervention	Follow-up	Outcome assessed													
						PI [%]	GI/ BOP [%]	PD [mm]	rCAL/ CAL [mm]	CALG [mm]	rRH/ RGR [mm]	RGR reduction [mm]	KTH / KTW	KTT [mm]	RR	RC [%]	CLH [mm]	CLH [%]	CDC [%]
Santamaria et al.[7]	2009	fully restored	RMGIC	R + CAF	baseline	–	–	1.25 ±0.44	11.73 ±1.15	–	10.48 ±1.09	–	3.16 ±0.85	1.16 ±0.13	–	–	–	–	–
					6 months	–	–	1.00 ±0.36	10.14 ±0.95*	–	9.14 ±1.00*	–	–	–	–	–	–	–	–
					1 year	–	–	1.12 ±0.50	10.30 ±1.26*	–	9.17 ±0.99*	–	–	–	–	–	–	–	–
					2 years	–	–	1.25 ±0.44	10.42 ±1.00*	–	9.17 ±1.00*	–	3.11 ±0.91	1.07 ±0.20	–	80.37 ±25.44	2.54 ±0.50	51.57 ±17.20	–
				CAF	baseline	–	–	1.31 ±0.47	11.56 ±0.72	–	10.25 ±0.81	–	3.24 ±0.40	1.12 ±0.16	–	–	–	–	–
					6 months	–	–	1.37 ±0.50	10.21 ±.83*	–	8.84 ±0.77*	–	–	–	–	–	–	–	–
					1 year	–	–	1.50 ±0.51	10.37 ± 0.95*	–	8.87 ±0.81*	–	–	–	–	–	–	–	–
					2 years	–	–	1.50 ±0.50	10.36 ±0.97*	–	8.86 ±0.80*	–	3.25 ±0.56	1.04 ±0.33	–	83.46 ±20.79	2.58 ±0.42	53.87 ±12.60	–
Santamaria et al.[23]	2009	fully restored	RMGIC	R + CTG	baseline	18.5	14.0	1.10 ±0.44	–	–	11.79 ±1.09	–	2.54 ±1.17	0.85 ±0.19	–	–	3.27 ±0.68	–	–
					45 days	–	–	1.90 ±0.64*	–	–	9.50 ±0.87	–	–	–	–	–	–	–	–
					2 months	–	–	2.00 ±0.56*	–	–	9.51 ±0.88	–	–	–	–	–	–	–	–
					3 months	–	–	2.00 ±0.56*	–	–	9.57 ±0.89	–	–	–	–	–	–	–	–
					6 months	–	–	2.15 ± 0.67*	–	1.26 ±0.90	9.48 ±0.82	2.31 ±0.74	3.34 ±0.91	1.95 ±0.42	–	88.64 ±11.90	–	70.00 ±13.85	–
				CTG	baseline	19.4	18.0	1.15 ±0.48	–	–	11.70 ±2.01	–	2.38 ±1.22	0.90 ±0.23	–	–	3.22 ±0.52	–	–
					45 days	–	–	1.98 ±0.60	–	–	9.12 ±1.55	–	–	–	–	–	–	–	–
					2 months	–	–	2.00 ±0.45	–	–	9.15 ±1.46	–	–	–	–	–	–	–	–
					3 months	–	–	2.15 ±0.48	–	–	9.12 ±1.52	–	–	–	–	–	–	–	–
					6 months	–	–	2.10 ±0.55	–	1.58 ±0.74	9.17 ±1.53	2.53 ±0.78	3.05 ±1.11	1.93 ±0.53	–	91.91 ±70.76	–	77.59 ±20.15	–

Study	Year	Fully restored/ partially restored	Restoration used	Intervention	Follow-up	Outcome assessed													
						PI [%]	GI/ BOP [%]	PD [mm]	rCAL/ CAL [mm]	CALG [mm]	rRH/ RGR [mm]	RGR reduction [mm]	KTH / KTW	KTT [mm]	RR	RC [%]	CLH [mm]	CLH [%]	CDC [%]
Santamaria et al.[24]	2013	fully restored	RMGIC	R + CTG	baseline	18.5	14.0	1.10 ±0.44	12.89 ±1.09	–	11.79 ±1.09	–	2.54 ±1.17	0.85 ±0.19	–	–	–	–	–
					6 months	–	–	2.15 ±0.67*	11.63 ±1.08*	–	9.48 ±0.82*	–	3.34 ±0.91*	1.95 ±0.42*	–	–	–	–	–
					1 year	–	–	2.12 ±0.56*	11.51 ±1.15*	–	9.51 ±0.88*	–	3.38 ±1.46*	1.81 ±0.50*	–	–	–	–	–
					2 years	–	–	2.11 ±0.78*	11.57 ±1.12*	–	9.57 ±0.81*	–	3.56 ±1.46*	1.87 ±0.72*	–	–	–	–	–
				CTG	baseline	19.4	18.0	1.15 ±0.48	12.85 ±2.06	–	11.70 ±2.01	–	2.38 ±1.22	0.90 ±0.23	–	–	–	–	–
					6 months	–	–	2.10 ±0.55*	11.27 ±1.17*	–	9.17 ±1.53*	–	3.05 ±1.11*	1.93 ±0.53*	–	–	–	–	–
					1 year	–	–	2.00 ±0.45*	11.15 ±1.72*	–	9.15 ±1.46*	–	3.17 ±1.50*	1.90 ±0.77*	–	–	–	–	–
					2 years	–	–	2.00 ±0.34*	11.27 ±1.70*	–	9.12 ±1.52*	–	3.20 ±1.00*	1.82 ±0.44*	–	–	–	–	–
Santamaria et al.[25]	2016	fully restored	NRC	RC + CTG	baseline	–	–	1.11 ±0.47	13.84 ±1.65	–	12.73 ±1.56	–	2.27 ±0.86	0.90 ±0.24	–	–	3.73 ±0.50	–	–
					6 months	–	–	2.77 ±0.42*	12.88 ±1.36*	–	10.10 ±1.29*	–	2.59 ±0.76*	2.00 ±0.30*	–	–	–	–	–
					1 year	–	–	2.66 ±0.48*	12.67 ±1.30*	1.17 ±0.89	10.01 ±1.30*	2.72 ±0.69	2.73 ±0.75*	1.97 ±0.26*	–	73.84 ±19.20	–	–	–
				CTG	baseline	–	–	1.16 ±0.38	13.41 ±2.00	–	12.24 ±1.90	–	2.41 ±1.20	0.90 ±0.23	–	82.16 ±16.10	3.39 ±0.57	–	–
					6 months	–	–	2.10 ±0.47	11.40 ±1.70*	–	9.31 ±1.60*	–	2.88 ±0.96*	1.87 ±0.47*	–	–	–	–	–
					1 year	–	–	2.00 ±0.48*	11.42 ±1.60*	1.98 ±0.81*	9.42 ±1.50*	2.82 ±0.74	3.00 ±0.90*	1.81 ±0.44*	–	82.16 ±16.10	–	–	–

Study	Year	Fully restored/ partially restored	Restoration used	Intervention	Follow-up	Outcome assessed														
						PI [%]	GI/ BOP [%]	PD [mm]	rCAL/ CAL [mm]	CALG [mm]	rRH/ RGR [mm]	RGR reduction [mm]	KTH / KTW	KTT [mm]	RR	RC [%]	CLH [mm]	CLH [%]	CDC [%]
Isler et al.[6]	2018	fully restored	NRC + RMGIC + giomer	NRC + CTG	baseline	–	–	1.13 ±0.34	12.5 ±0.88	–	11.37 ±0.73	–	3.17 ±1.15	0.89 ±0.12	–	–	3.07 ±1.13	–	71.31 ±21.73
					3 months	–	–	1.26 ±0.45	10.64 ±0.65	–	9.38 ±0.45	–	4.02 ±1.25	1.82 ±0.40	–	–	1.03 ±0.86	–	71.31 ±21.73
					6 months	–	–	1.30 ±0.47	10.79 ±0.66	–	9.40 ±0.45	–	3.76 ±1.02	1.70 ±0.38	–	–	1.03 ±0.81	–	69.86 ±20.82
					1 year	–	–	1.43 ±0.66	10.83 ±0.85	–	9.39 ±0.48	–	3.78 ±1.15	1.63 ±0.36	–	–	1.04 ±0.89	–	71.18 ±23.16
				RMGIC + CTG	baseline	–	–	1.13 ±0.46	12.48 ±0.89	–	11.35 ±0.73	–	3.30 ±0.99	0.89 ±0.12	–	–	2.89 ±1.20	–	
					3 months	–	–	1.13 ±0.34	10.63 ±0.63	–	9.50 ±0.43	–	3.87 ±0.98	1.82 ±0.41	–	–	1.04 ±1.08	–	68.85 ±21.19
					6 months	–	–	1.09 ±0.29	10.54 ±0.56	–	9.46 ±0.42	–	3.80 ±1.07	1.69 ±0.35	–	–	0.96 ±1.09	–	71.93 ±21.78
					1 year	–	–	1.17 ±0.39	10.59 ±0.62	–	9.41 ±0.39	–	3.83 ±1.10	1.68 ±0.33	–	–	1.00 ±1.04	–	71.33 ±22.33
				giomer + CTG	baseline	–	–	1.04 ±0.21	12.35 ±0.71	–	11.26 ±0.62	–	3.04 ±0.99	0.88 ±0.10	–	–	2.83 ±0.97	–	
					3 months	–	–	1.22 ±0.52	10.70 ±0.66	–	9.55 ±0.39	–	3.96 ±1.16	1.84 ±0.38	–	–	1.10 ±0.87	–	66.62 ±22.89
					6 months	–	–	1.22 ±0.42	10.79 ±0.74	–	9.53 ±0.37	–	3.72 ±1.16	1.71 ±0.33	–	–	1.10 ±0.86	–	65.79 ±22.09
					1 year	–	–	1.30 ±0.47	10.76 ±0.60	–	9.54 ±0.33	–	3.61 ±1.18	1.69 ±0.32	–	–	1.11 ±0.81	–	64.23 ±20.33
Santamaria et al.[8]	2018	partially restored vs. odontoplasty	RCom	PR + CTG	baseline	–	–	1.2 ±0.5	9.3 ±1.5	–	8.7 ±1.4	–	2.7 ±1.3	1.0 ±0.5	–	–	–	–	–
					6 months	–	–	2.5 ±0.5	8.8 ±1.0	–	6.3 ±1.7	–	4.1 ±0.9	2.1 ±0.6	–	–	–	–	–
					1 year	–	–	2.6 ±0.7	8.8 ±1.8	0.5 ±1.3	6.2 ±1.8	2.5 ±1.0	4.2 ±1.7	2.0 ±0.7	–	93.0 ±26.1	–	–	75.3 ±22.7
				CTG + odonto-plasty	baseline	–	–	1.3 ±0.5	10.5 ±1.5	–	9.2 ±2.5	–	2.9 ±0.9	0.9 ±0.2	–	–	–	–	–
					6 months	–	–	2.1 ±0.6	8.7 ±1.4	–	6.7 ±1.3	–	4.1 ±0.8	2.0 ±0.6	–	–	–	–	–
					1 year	–	–	2.0 ±0.5	8.8 ±2.0	1.7 ±1.4	6.8 ±1.9	2.4 ±1.1	4.1 ±1.1	1.9 ±0.6	–	92.2 ±28.4	–	–	74.6 ±31.5

Study	Year	Fully restored/ partially restored	Restoration used	Intervention	Follow-up	Outcome assessed													
						PI [%]	GI/ BOP [%]	PD [mm]	rCAL/ CAL [mm]	CALG [mm]	rRH/ RGR [mm]	RGR reduction [mm]	KTH / KTW	KTT [mm]	RR	RC [%]	CLH [mm]	CLH [%]	CDC [%]
Dursun et al.[26]	2018	fully restored	RMGIC + NIC	RMGIC + SCTG	baseline	0.17 ±0.25	0.23 ±0.23	1.73 ±0.64	3.16 ±0.65	–	3.50 ±1.04	–	2.83 ±1.85	1.22 ±0.54	–	–	–	–	–
					3 months	0.18 ±0.32*	0.06 ±0.14	1.63 ±0.40	1.47 ±0.76	–	0.44 ±0.70*	–	4.94 ±1.89*	–	–	–	–	–	–
					6 months	0.20 ±0.27	0.09 ±0.17	1.61 ±0.35	1.41 ±0.75	–	0.44 ±0.70	–	4.89 ±1.84*	–	–	–	–	–	–
					1 year	0.18 ±0.26*	0.06 ±0.17	1.88 ±0.29	1.76 ±0.76	1.66 ±0.76	0.44 ±0.70*	3.22 ±0.66	4.89 ±1.84*	2.30 ±0.08*	–	89.49 ±18.15	–	–	–
				NIC + SCTG	baseline	0.26 ±0.19	0.18 ±0.33	1.21 ±0.03	3.03 ±0.78	–	3.13 ±0.68	–	3.28 ±1.56	1.06 ±0.23	–	–	–	–	–
					3 months	0.42 ±0.33*	0.17 ±0.35	1.45 ±0.56	1.53 ±1.04	–	0.24 ±0.56*	–	5.92 ±1.44*	–	–	–	–	–	–
					6 months	0.40 ±0.28	0.14 ±0.28	1.37 ±0.43	1.53 ±0.96	–	0.24 ±0.56*	–	5.62 ±0.96*	–	–	–	–	–	–
					1 year	0.48 ±0.39*	0.12 ±0.27	1.28 ± 0.39	1.51 ± 0.86	1.61 ± 0.47	0.41 ± 0.71*	3.08 ± 0.71	5.62 ± 0.96*	2.16 ± 0.16*	–	90.12 ±16.58	–	–	–
				SCTG (control – RC without NCCL)	baseline	0.37 ±0.52	0.34 ±0.40	1.45 ±0.61	2.67 ±0.63	–	3.17 ±0.85	–	2.62 ±1.19	1.28 ±0.57	–	–	–	–	–
					3 months	0.35 ±0.34	0.26 ±0.33	1.50 ±0.55	1.16 ±0.64	–	0.06 ±0.23*	–	5.12 ±1.16*	–	–	–	–	–	–
					6 months	0.34 ±0.47	0.18 ±0.32	1.43 ±0.44	1.15 ±0.77	–	0.06 ±0.23*	–	5.12 ±1.16*	–	–	–	–	–	–
					1 year	0.25 ±0.31	0.12 ±0.22	1.48 ±0.41	1.25 ±0.57	1.35 ±0.76	0.06 ±0.23*	3.16 ±0.20	5.12 ±1.16*	2.36 ±0.18*	–	96.22 ±10.75	–	–	–
Ramireddy et al.[29]	2018	fully restored	RMGIC + PRF	RMGIC + CAF	baseline	–	–	1.21 ±0.41	11.74 ±1.25	–	10.54 ±1.29	–	2.23 ±0.43	2.13 ±0.11	–	–	–	–	–
					3 months	–	–	0.26 ±0.44	7.87 ±1.38	–	7.64 ±1.37	–	6.10 ±0.60	2.15 ±0.22	–	–	–	–	–
					6 months	–	–	0.21 ±0.41	7.77 ±1.40	–	7.59 ±1.39	–	6.18 ±0.68	2.19 ±0.12	–	–	–	–	–
				CAF + PRF	baseline	–	–	1.23 ±0.43	11.62 ±1.18	–	10.54 ±1.29	–	2.23 ±0.43	2.13 ±0.10	–	–	–	–	–
					3 months	–	–	0.23 ±0.43	7.92 ±1.21	–	7.69 ±1.15	–	6.00 ±0.76	2.66 ±0.14	–	–	–	–	–
					6 months	–	–	0.18 ±0.39	7.82 ±1.14	–	7.64 ±1.06	–	6.03 ±0.84	2.95 ±0.18	–	–	–	–	–

Study	Year	Fully restored/ partially restored	Restoration used	Intervention	Follow-up	Outcome assessed														
						PI [%]	GI/ BOP [%]	PD [mm]	rCAL/ CAL [mm]	CALG [mm]	rRH/ RGR [mm]	RGR reduction [mm]	KTH / KTW	KTT [mm]	RR	RC [%]	CLH [mm]	CLH [%]	CDC [%]
Lemos Reis et al.[30]	2020	fully restored	ADMG	CAF + ADMG (control)	baseline	–	–	1.5 ±0.6	4.4 ±1.1	–	3.1 ±0.2	–	2.8 ±0.6	1.0 ±0.5	–	–	–	–	–
					6 months	–	–	1.5 ±0.5	2.5 ±0.7	1.9 ±1.3	0.9 ±0.6	2.2 ±0.5	3.4 ±1.2	1.5 ±0.4	–	69.5 ±19.0	–	–	–
				CAF + ADMG (test)	baseline	–	–	1.5 ±0.6	4.8 ±1.3	–	3.3 ±0.4	–	2.6 ±0.8	1.0 ±0.4	–	–	–	–	–
					6 months	–	–	1.5 ±0.6	2.6 ±0.9	2.1 ±1.2	0.9 ±0.6	2.4 ±0.5	3.3 ±1.2	1.5 ±0.5	–	72.2 ±16.5	–	–	–
Cairo et al.[31]	2020	fully restored	composite	CAF	baseline	–	–	1.1 ±0.3	–	–	3.2 ±0.5	–	3.1 ±0.5	0.80 ±0.09	–	–	–	–	–
					6 months	–	–	1.1 ±0.3	–	–	0.3 ±0.5	–	3.3 ±0.5	–	2.9 ±0.7	69	–	–	–
					1 year	–	–	1.2 ±0.4	–	–	0.5 ±0.5	–	3.3 ±0.7	0.86 ±0.16	2.7 ±0.6	50	–	–	–
				CAF + CTG	baseline	–	–	1.1 ±0.3	–	–	3.4 ±0.6	–	2.9 ±1.1	0.78 ±0.12		–	–	–	–
					6 months	–	–	1.2 ±0.4	–	–	0.1 ±0.3	–	4.6 ±0.6	–	3.3 ±0.7	93	–	–	–
					1 year	–	–	1.1 ±0.3	–	–	0.3 ±0.5	–	4.6 ±0.5	1.38 ±0.09	3.1 ±0.7	71	–	–	–
Mathias-Santamaria et al.[27]	2022	partially restored	composite	CAF	baseline	–	–	1.5 ±0.5	11.8 ±1.7	–	3.2 ±0.5	–	2.1 ±1.0	1.0 ±0.5	–	–	–	–	–
					6 months	–	–	1.5 ±0.4	9.8 ±1.7	–	0.3 ±0.5	–	2.5 ±1.3	1.1 ±0.5	2.9 ±0.7	69	–	–	–
					1 year	–	–	1.5 ±0.4	9.8 ±1.6	–	0.5 ±0.5	–	2.5 ±1.2	1.1 ±0.4	2.7 ±0.6	50	–	–	–
				CAF + CM	baseline	–	–	1.5 ±0.4	12.6 ±1.6	–	3.4 ±0.6	–	2.4 ±1.5	1.0 ±0.6	–	–	–	–	–
					6 months	–	–	1.6 ±0.4	10.8 ±1.6	–	0.1 ±0.3	–	3.0 ±1.3	1.5 ±0.5	3.3 ±0.7	93	–	–	–
					1 year	–	–	1.6 ±0.4	10.8 ±1.5	–	0.3 ±0.5	–	3.3 ±1.2	1.7 ±0.6	3.1 ±0.7	71	–	–	–

* † statistical significance.

Table 3 and Fig. 3 show the forest plot of the studies included in the meta-analysis. The point estimate is the effect size of PD between the interventions administered to the treatment and control arms. As can be observed from the figure, Isler et al.,[6] Santamaria et al.,[7,23,24] Dursun et al.,[26] Lucchesi et al.,[28] and Ramireddy et al.[29] reported a significant difference in the PD value between the 2 arms in their experiments.

Table 4 and Fig. 4 show the forest plot of the studies included in the meta-analysis. The point estimate is the effect size of KTH/KTT between the interventions administered to the treatment and control arms. As can be observed from the figure, Isler et al.,[6] Lucchesi et al.,[28] Ramireddy et al.,[29] and Lemos Reis et al.[30] reported a significant difference in the KTH/KTW value between the 2 arms in their experiments.

Table 5 and Fig. 5 show the forest plot of the studies included in the meta-analysis. The point estimate is the effect size of relative CAL(rCAL)/CAL between the interventions administered to the treatment and control arms. As shown in the figure, Isler et al.,[6] Santamaria et al.[7] and Ramireddy et al.[29] reported a significant difference in the rCAL/CAL value between the 2 arms in their experiments.

Table 6 and Fig. 6 show the forest plot of the studies included in the meta-analysis. The point estimate is the effect size of relative RH (rRH)/relative GR (RGR) between the interventions administered to the treatment and control arms. As seen in the figure, Isler et al.,[6] Santamaria et al.[7,23,24] and Ramireddy et al.[29] reported a significant difference in the rRH/RGR value between the 2 arms in their experiments.

Table 7 and Fig. 7 show the forest plot of the studies included in the meta-analysis. The point estimate is the effect size of the percentage RC between the interventions administered to the treatment and control arms.

Table 8 tabulates dentin sensitivity (DS) for the evaluation of patient-centered outcomes.

Table 9 and Fig. 8 show the effect size for the esthetic scores (ESs) obtained from the studies outlined in the meta-analysis. Changes in the visual analog scale (VAS) score for the esthetic outcome were observed for both treatment groups, and the differences between the effect sizes were used to compare the outcomes between the studies analyzed in the meta-analysis. As shown in Table 9, the summary score calculated showed a statistically significant difference in ES between the 2 groups assessed in each study.

Table 3. Forest plot of the effect size in the difference between the interventions in terms of pocket depth (PD) at 6 months

Study	PD (95% *CI*)	Weight
Isler et al.[6] (giomer + CTG)	0.47 (0.372–0.568)	10.2
Isler et al.[6] (RMGIC + CTG)	0.17 (0.134–0.205)	28.2
Santamaria et al.[7]	0.09 (0.067–0.112)	44.4
Santamaria et al.[8]	0.67 (0.564–0.776)	9.4
Santamaria et al.[22]	0.66 (0.508–0.811)	6.6
Santamaria et al.[23]	0.74 (0.623–0.857)	8.5
Santamaria et al.[24]	0.09 (0.075–0.105)	66.7
Santamaria et al.[25]	1.42 (1.183–1.667)	4.2
Dursun et al.[26] (RMGIC + SCTG)	0.41 (0.342–0.478)	14.6
Dursun et al.[26] (NIC + SCTG)	0.14 (0.117–0.163)	42.9
Mathias-Santamaria et al.[27]	0.10 (0.087–0.113)	78.7
Lucchesi et al.[28] (RMGIC + CPF)	0.40 (0.348–0.452)	19.2
Lucchesi et al.[28] (MRC + CPF)	0.20 (0.174–0.226)	38.4
Ramireddy et al.[29]	0.07 (0.059–0.093)	58.8
Cairo et al.[31]	0.33 (0.263–0.397)	14.8
Effects summary	0.42 (0.345–0.493)	–
Z-score (*p*-value)	0.254 (0.400)	–

CI – confidence interval.

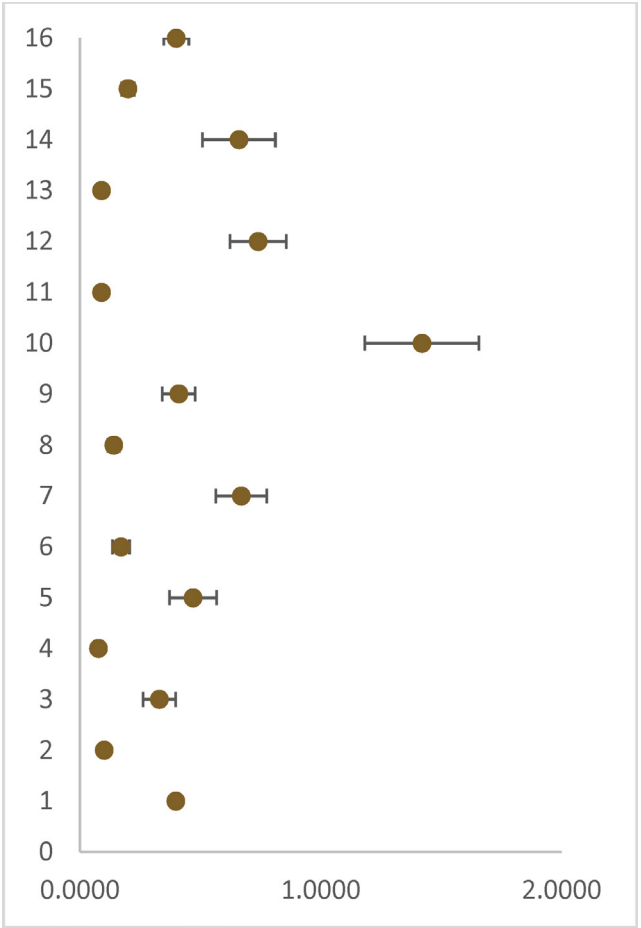

Fig. 3. Forest plot of the effect size in the difference between the interventions in terms of pocket depth (PD) at 6 months

Table 4. Forest plot of the effect size in the difference between the interventions in terms of keratinized tissue height (KTH)/keratinized tissue width (KTW) at 6 months

Study	KTH/KTW (95% *CI*)	Weight
Isler et al.[6] (RMGIC + CTG)	0.04 (0.032–0.048)	119.9
Isler et al.[6] (giomer + CTG)	0.04 (0.032–0.048)	119.9
Lucchesi et al.[28] (MRC + CPF)	0.14 (0.122–0.158)	54.9
Santamaria et al.[7]	0.26 (0.195–0.325)	15.4
Santamaria et al.[24]	0.26 (0.217–0.303)	23.1
Santamaria et al.[25]	0.30 (0.250–0.350)	20.0
Dursun et al.[26] (RMGIC + SCTG)	0.90 (0.750–1.050)	6.7
Dursun et al.[26] (NIC + SCTG)	0.43 (0.358–0.507)	14.0
Mathias-Santamaria et al.[27]	0.20 (0.174–0.225)	39.4
Ramireddy et al.[29]	0.18 (0.140–0.220)	24.8
Lemos Reis et al.[30]	0.08 (0.061–0.099)	51.5
Cairo et al.[31]	2.17 (1.727–2.613)	2.3
Effects summary	0.43 (0.347–0.507)	–
Z-score (*p*-value)	0.240 (0.405)	–

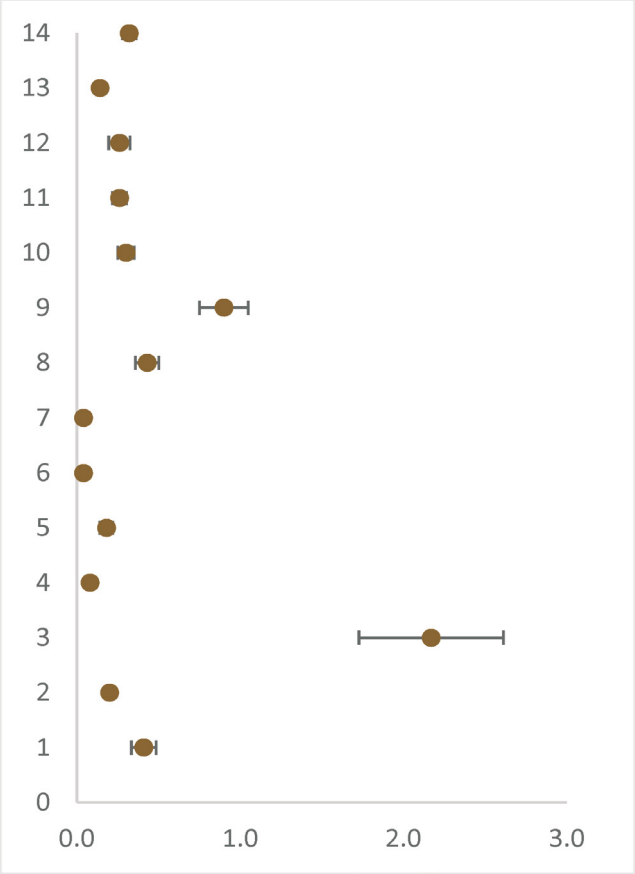

Fig. 4. Forest plot of the effect size in the difference between the interventions in terms of keratinized tissue height (KTH)/keratinized tissue width (KTW) at 6 months

Table 5. Forest plot of the effect size in the difference between the interventions in terms of relative clinical attachment loss (rCAL)/CAL at 6 months

Study	rCAL/CAL (95% *CI*)	Weight
Isler et al.[6] (RMGIC + CTG)	0.07 (0.059–0.081)	90.4
Isler et al.[6] (giomer + CTG)	0.38 (0.301–0.459)	12.6
Santamaria et al.[7]	0.08 (0.067–0.092)	79.1
Santamaria et al.[22]	0.21 (0.162–0.258)	20.8
Santamaria et al.[24]	0.21 (0.175–0.245)	28.6
Santamaria et al.[25]	0.87 (0.725–1.015)	6.9
Dursun et al.[26] (RMGIC + SCTG)	0.34 (0.283–0.397)	17.6
Dursun et al.[26] (NIC + SCTG)	0.49 (0.408–0.572)	12.2
Mathias-Santamaria et al.[27]	0.20 (0.175–0.225)	39.4
Lucchesi et al.[28] (MRC + CPF)	0.20 (0.174–0.226)	38.4
Ramireddy et al.[29]	0.04 (0.031–0.049)	111.8
Effects summary	0.28 (0.232–0.329)	–
Z-score (*p*-value)	0.261 (0.397)	–

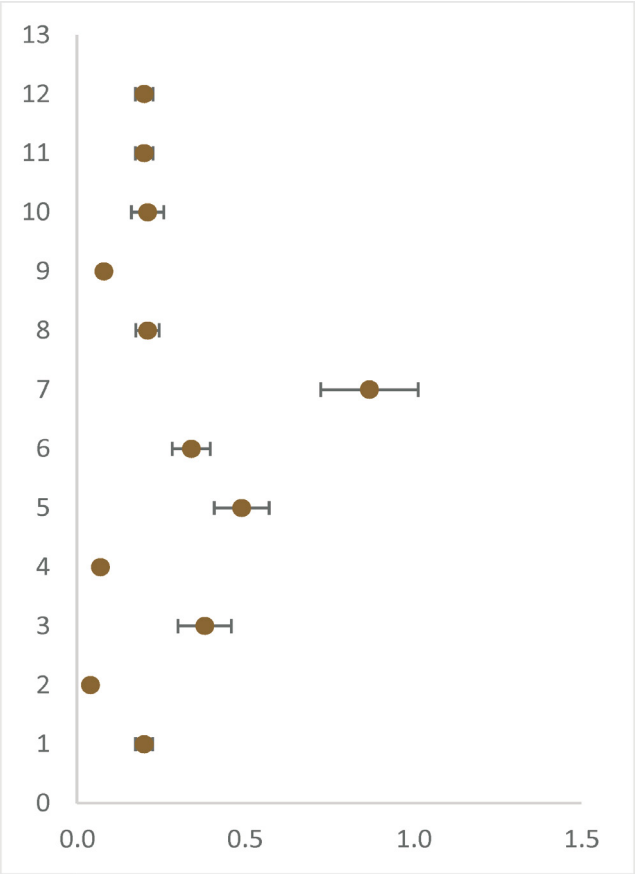

Fig. 5. Forest plot of the effect size in the difference between the interventions in terms of relative clinical attachment loss (rCAL)/CAL at 6 months

Table 6. Forest plot of the effect size in the difference between the interventions in terms of relative recession height (rRH)/relative gingival recession (RGR) at 6 months

Study	rRH/RGR (95% *CI*)	Weight
Isler et al.[6] (RMGIC + CTG)	0.13 (0.102–0.157)	36.9
Isler et al.[6] (giomer + CTG)	0.29 (0.229–0.35)	16.5
Santamaria et al.[7]	0.20 (0.15–0.25)	20.0
Santamaria et al.[8]	0.31 (0.26–0.359)	20.4
Santamaria et al.[23]	0.00 (0.003–0.004)	1,581.1
Santamaria et al.[24]	0.20 (0.166–0.233)	30.0
Santamaria et al.[25]	0.49 (0.408–0.571)	12.2
Dursun et al.[26] (RMGIC + SCTG)	1.65 (1.375–1.925)	3.6
Dursun et al.[26] (NIC + SCTG)	0.78 (0.65–0.91)	7.7
Mathias-Santamaria et al.[27]	0.40 (0.349–0.451)	19.7
Ramireddy et al.[29]	0.05 (0.038–0.061)	89.4
Effects summary	0.43 (0.353–0.510)	–
Z-score (*p*-value)	0.245 (0.403)	–

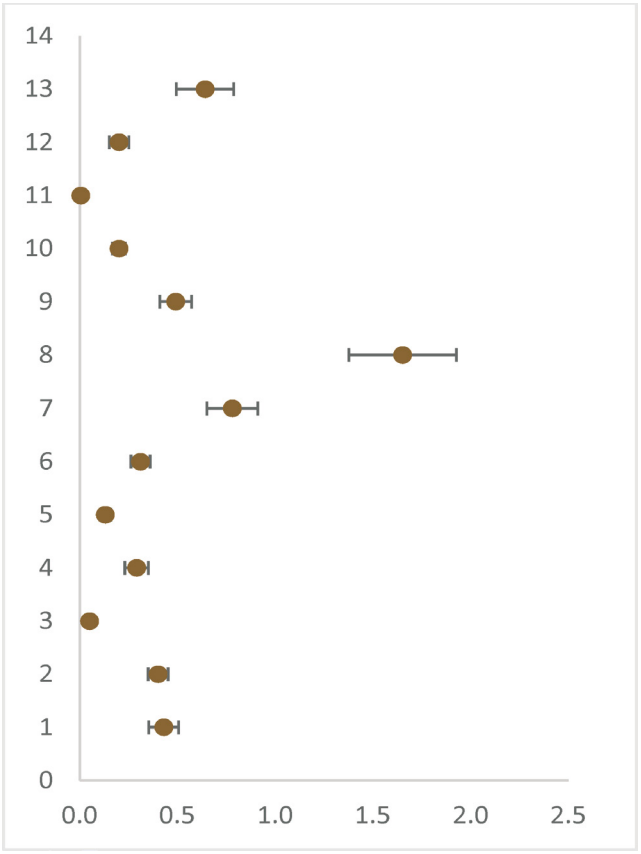

Fig. 6. Forest plot of the effect size in the difference between the interventions in terms of relative recession height (rRH)/relative gingival recession (RGR) at 6 months

Table 7. Forest plot of the effect size of the percentage root coverage (RC)

Study	%RC (95% *CI*)	Weight
Santamaria et al.[7]	0.064 (0.05–0.08)	62.1
Santamaria et al.[8]	0.029 (0.02–0.03)	215.6
Santamaria et al.[23]	0.133 (0.11–0.15)	47.6
Santamaria et al.[25]	0.470 (0.39–0.55)	12.8
Dursun et al.[26] (RMGIC + SCTG)	0.451 (0.38–0.53)	13.3
Dursun et al.[26] (NIC + SCTG)	0.437 (0.37–0.51)	14.5
Lemos Reis et al.[30]	0.152 (0.11–0.19)	27.2
Cairo et al.[31]	2.100 (1.67–2.53)	2.3
Effects summary	0.248 (0.20–0.29)	–
Z-score (*p*-value)	0.231 (0.408)	–

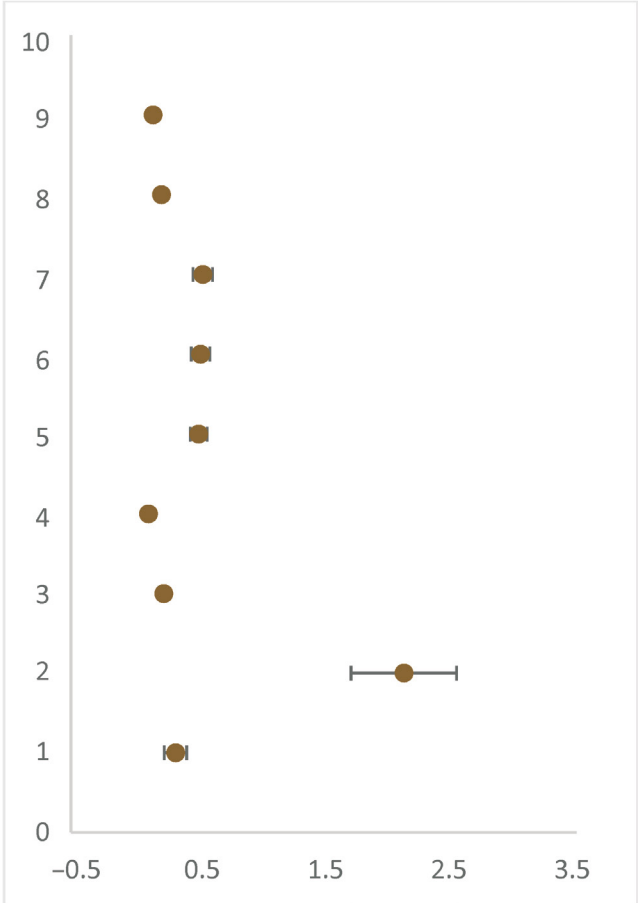

Fig. 7. Forest plot of the effect size of the percentage root coverage (RC)

Table 8. Dentin sensitivity (DS) in the included studies

Study	Year	Intervention	Follow-up	DS [%]	DS (VAS) *M* ±*SD*
Santamaria et al.[7]	2009	R + CAF	baseline	70	–
			6 months	5	–
		CAF	baseline	60	–
			6 months	35	–
Santamaria et al.[8]	2018	PR + CTG	baseline	–	3.7 ±3.3
			6 months	–	0.6 ±1.8
		CTG	baseline	–	5.0 ±3.1
			6 months	–	1.3 ±2.0
Santamaria et al.[22]	2008	R + CAF	baseline	68.42	–
			6 months	5.26	–
		CAF	baseline	68.42	–
			6 months	47.36	–
Santamaria et al.[25]	2016	RC + CTG	baseline	88	–
			6 months	6	–
		CTG	baseline	94	–
			6 months	44	–
Dursun et al.[26]	2018	RMGIC + SCTG	baseline	75.1 (n = 11)	–
			1 year	complain of sensitivity after 11 year (n = 1)	–
		NIC + SCTG	baseline	75.1 (n = 17)	–
			1 year	0	–
		SCTG (control – RC without NCCL)	baseline	75.1 (n = 13)	–
			1 year	0	–
Mathias-Santamaria et al.[27]	2022	CAF	baseline	–	4.9 ±3.6
			6 months	–	1.1 ±1.8
		CAF + CM	baseline	–	3.8 ±3.3
			6 months	–	1.1 ±2.3
Ramireddy et al.[29]	2018	RMGIC + CAF	6 months	83	–
		CAF + PRF	6 months	46	–
Cairo et al.[31]	2020	CAF	baseline	–	24.9 ±28.7
			6 months	–	1.4 ±5.5
			1 year	–	3.6 ±7.3
		CAF + CTG	baseline	–	29.1 ±29.6
			6 months	–	0.0 ±0.0
			1 year	–	1.9 ±4.9

Table 10 and Fig. 9 show the effect size for DS from the studies outlined in the meta-analysis. Changes in the VAS score for DS were observed for both treatment groups, and the differences between the effect sizes were used to compare the outcomes between the studies. Table 10 summarizes the score calculated from the studies and shows a statistically significant difference in DS between the 2 groups assessed in each study.

A summary of ESs is recorded in Table 11.

Table 12 and Fig. 10 show the risk ratio for DS obtained from the studies outlined in the meta-analysis. Change in the proportion of cases with DS were observed for both treatment groups, and the differences between the risk ratios were used to compare the outcomes between the studies. As seen in Table 12, the summary score calculated for the studies showed a statistically significant difference in DS between the 2 groups assessed in each study.

Table 9. Forest plot of the effect size in the difference between the interventions in terms of esthetic score (ES) after 1 year

Study	ES (95% *CI*)
Isler et al.[6] (RMGIC + CTG)	1.37 (1.08–1.66)
Isler et al.[6] (giomer + CTG)	1.32 (1.04–1.59)
Santamaria et al.[8]	0.10 (0.08–0.12)
Mathias-Santamaria et al.[27]	0.40 (0.35–0.45)
Effects summary	0.93 (0.74–1.12)
Z-score (*p*-value)	4.90 (0.500)

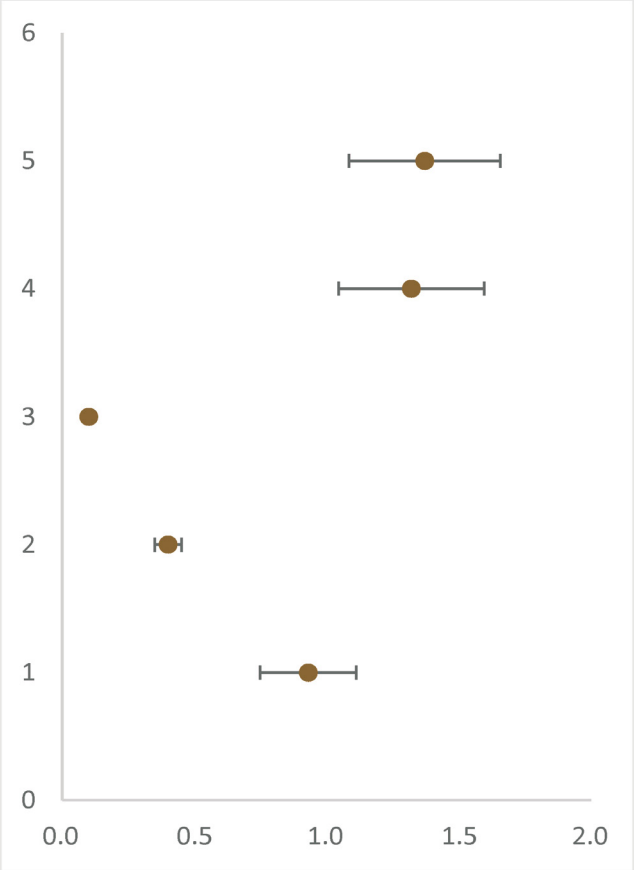

Fig. 8. Forest plot of the effect size in the difference between the interventions in terms of esthetic score (ES) after 1 year

Table 10. Forest plot of the effect size in the difference between the interventions in terms of dentin sensitivity (DS) – VAS (visual analog scale) score – after 1 year

Study	DS (VAS) (95% *CI*)
Isler et al.[6] (RMGIC + CTG)	0.56 (0.44–0.67)
Isler et al.[6] (giomer + CTG)	0.89 (0.71–1.08)
Santamaria et al.[8]	0.24 (0.20–0.28)
Mathias-Santamaria et al.[27]	1.10 (0.96–1.24)
Cairo et al.[31]	0.39 (0.31–0.47)
Effects summary	0.52 (0.41–0.62)
Z-score (*p*-value)	4.95 (0.500)

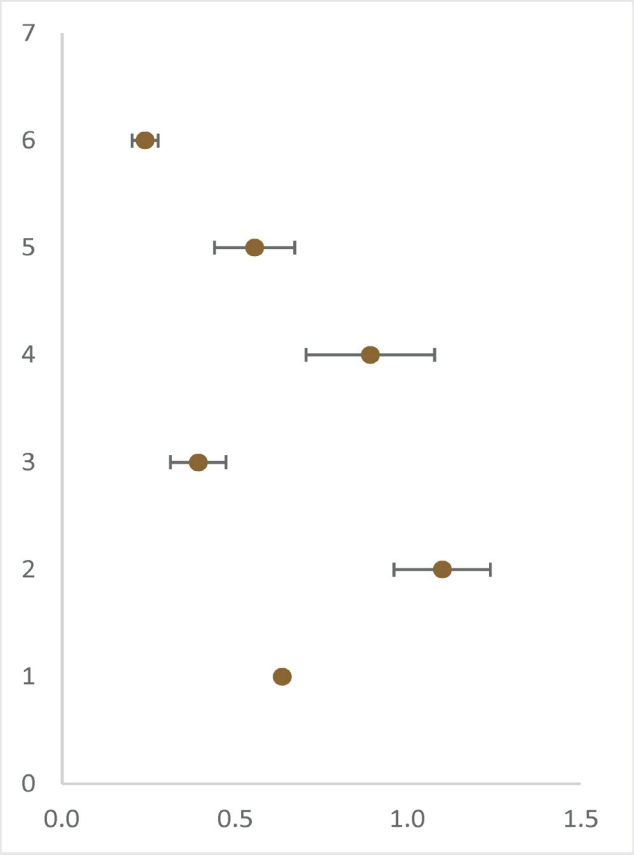

Fig. 9. Forest plot of the effect size in the difference between the interventions in terms of dentin sensitivity (DS) – VAS (visual analog scale) score – after 1 year

Table 11. Esthetic scores (ESs) in the included studies

Study	Year	Intervention	Follow-up	ES (VAS)	Satisfaction (VAS)
Isler et al.[6]	2018	NRC	baseline	3.02 ±1.24	–
			1 year	8.93 ±1.11	–
		RMGIC	baseline	3.65 ±1.33	–
			1 year	8.52 ±1.33	–
		giomer	baseline	3.36 ±1.28	–
			1 year	8.57 ±1.53	–
Santamaria et al.[8]	2018	CTG	baseline	4.1 ±2.9	–
			6 months	9.0 ±2.3	–
			1 year	9.2 ±1.1	–
		PR + CTG	baseline	4.6 ±2.3	–
			6 months	9.1 ±2.2	–
			1 year	9.1 ±1.0	–
Mathias-Santamaria et al.[27]	2022	CAF	baseline	3.4 ±2.6	–
			6 months	8.9 ±1.1	–
			1 year	9.0 ±0.9	–
		CAF + CM	baseline	3.9 ±2.7	–
			6 months	9.0 ±1.2	–
			1 year	9.2 ±1.1	–
Cairo et al.[31]	2020	CAF	baseline	–	–
			6 months	–	–
			1 year	91.2 ±9.8	95.4 ±6.0
		CAF + CTG	baseline	–	–
			6 months	–	–
			1 year	88.6 ±10.4	90.9 ±10.7

Table 12. Forest plot of the effect size in the difference between the interventions in terms of dentin sensitivity (DS) – risk ratios – after 1 year

Study	Risk ratio for DS (95% *CI*)
Santamaria et al.[7]	12.29 (9.22–15.36)
Santamaria et al.[22]	11.57 (8.92–14.22)
Santamaria et al.[25]	12.55 (10.46–14.64)
Effects summary	12.14 (9.53–14.74)
Z-score (*p*-value)	4.26 (<0.001)

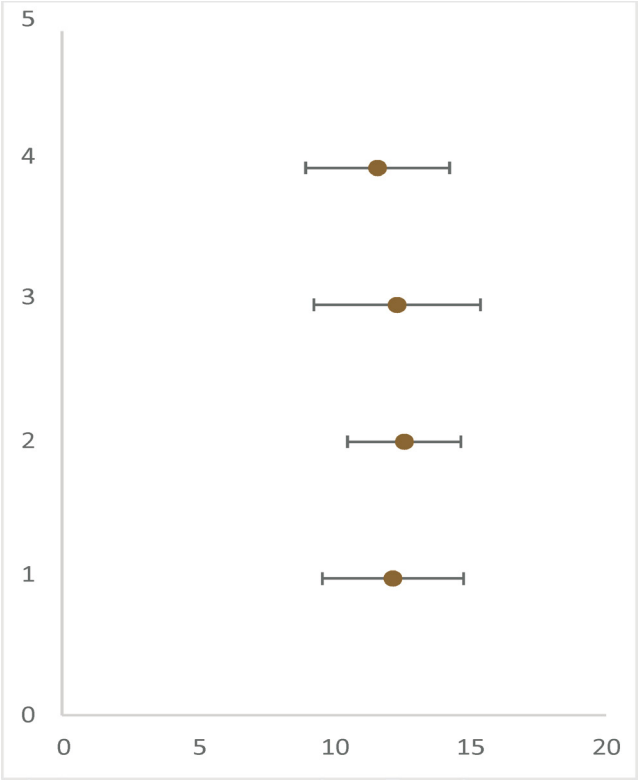

Fig. 10. Forest plot of the effect size in the difference between the interventions in terms of dentin sensitivity (DS) – risk ratios – after 1 year

Results

A total of 222 potentially relevant papers were identified through the search strategy, of which 199 were excluded after screening the titles and abstracts. The full texts of 23 papers were assessed based on the inclusion and exclusion criteria, with 13 articles fulfilling the eligibility criteria and included in the review. The reasons for the exclusion of 10 articles are shown in Fig. 1.

Included studies

A total of 428 patients were enrolled in the 13 included articles, 12 studies[6,7,8,22,23,25–31] completed the follow-up periods and 1 RCT[24] reported dropouts. The characteristics of the studies are shown in Table 1.

Age groups

The age of patients ranged from 19 to 71 years. Four RCTs[7,22–24] included participants with Miller's class 1 GR, 3 RCTs[8,25,29] included Miller's class 1 and 2 GR, and 5 studies[6,26,28,30,31] did not mention the GR classification. One study by Mathias-Santamaria et al.[27] included GR based on a different classification system[32] (a single recession type (RT)-1[32] associated with class B+ or B– NCCL,[33] forming a combined defect on a vital canine or premolar).

Follow-up

The maximum follow-up period for 5 RCTs[7,22,28–30] was 6 months, 6 RCTs[6,8,25–27,31] followed up for 1 year, and Santamaria et al.[23] and Santamaria et al.[24] for 2 years.

Study design

Three studies[22,23,30] had a split-mouth design, while the others used a parallel group design. Eleven RCTs[6,7,22–26,28–31] performed complete NCCL restoration, whereas 2 – by Santamaria et al.[8] and Mathias-Santamaria et al.[27] employed partial restoration.

Type of material used

Various materials were used for NCCL restoration, with 4 studies[6,26,28,29] using RMGIC, and others employing giomer,[6] nano-ionomer cement (NIC),[26] micro-filled resin composite (MRC),[28] or nano-filled resin composite (NRC) alone[25,27] or in combination.[6,26] However, no evidence suggested that the material type affected the surgical outcome.

Type of surgical root coverage procedure

Seven studies[7,22,27–31] performed the coronally advanced/positioned flap and 6 studies[6,8,23–26] used CTG for RC.

Esthetic scores

Five studies[6,8,26,27,31] recorded ES and reported that the restoration of NCCLs in combination with any RC procedure provided better esthetic results. Dursun et al.[26] also reported that ES was similar in the RMGIC and NIC groups (9.06 ±1.43). Two studies involved professional esthetic assessment by recording the root coverage esthetic score (RES)[26,31] and the modified root coverage esthetic score (mRES).[27]

Dentin hypersensitivity

Three of the RCTs[6,27,31] recorded the VAS scores for DS and reported decreased dentin hypersensitivity as perceived by the patient. Cairo et al.[31] recorded the VAS scores for patient satisfaction at 1 year and reported no significant difference between the 2 groups.

Six studies[7,22,25,26,29,31] reported the percentage of sites with DS. All of these studies reported a statistically significant difference in the percentage of dentin hypersensitivity, and there was a more significant decrease in the percentage of dentin hypersensitivity in the restored NCCL group.

Discussion

From among the 13 included studies, only 3 RCTs[6,7,29] compared the restored NCCLs with the unrestored NCCLs. All 13 studies demonstrated that the restoration of NCCLs had a significant impact on PD, rCAL/CAL and rRH/RGR.

Complete root coverage (CRC) was the most used and indicated primary outcome, as it is the main objective of RC procedures. Nonetheless, there was no significant difference in RC when comparing GR without NCCL with the GR of the root surface with NCCL, suggesting that root surface restoration did not markedly affect the outcome of the surgical procedure.

In RC procedures using soft tissue augmentation, such as platelet-rich fibrin (PRF),[29] CTG[6,8,23–26] or the acellular dermal matrix,[30] there was an increase in KTT. However, there was no significant difference in the outcome of the surgical procedure in terms of RC.

No data indicated the sequence of restoration, or whether restoration should be complete or partial, with only one study analyzing partial restoration.[27] Most of the studies employed restoration before surgical procedures, maybe due to better isolation conditions.

The risk of bias is an indicator of the methodological quality of the studies included. As shown in Fig. 2, the studies had a low risk of bias. In these studies, it was not possible to attain blinding or masking, as it was easy to notice if the NCCL was restored.

Conclusions

In the teeth with NCCLs and GR, the restoration of NCCL does not affect the percentage RC. However, it significantly decreases dentin hypersensitivity, and the patient's perception of esthetics and satisfaction.

Ethics approval and consent to participate

Not applicable.

Data availability

All data generated and/or analyzed during this study is included in this published article.

Consent for publication

Not applicable.

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