Are Surgical Root Coverage Procedures Effective for Controling Cervical Dentin Hypersensibility? A Systematic Review and Meta-analysis

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Abstract

Aim: The aim of this study was to review the efficacy of surgical root coverage for reducing cervical dentin hypersensitivity (CDH), when associated with gingival recession.

Materials and methods: The PubMed, Scopus, Web of Science, Cochrane Library and Virtual Health Library databases were searched until September 2020. Randomized clinical trials related to dentinal hypersensitivity, before and after surgery, were included. The methodological quality of the studies was determined through an assessment based on Consolidated Reporting Standards. Meta-analyses were conducted for dichotomous and continuous data to consider the frequency and amount of CDH, respectively, at baseline and the post-surgical root coverage technique.

Results: A total of 886 studies were evaluated, and twenty articles were included. Surgical interventions reduced the chance of CDH, compared to no technique applied at baseline (OR = 0.14, 95% CI = [0.08, 0.25], I2 = 73%); and were also effective in reducing the scores of Visual Analogic Scale (VAS) (MD = -2.64, 95% CI = [-3.11, -2.16], I2 = 0%).

Conclusions: Root coverage of Miller Classification type I and II gingival recessions, or Cairo Classification RT1, reduced dentin hypersensitivity and highlighted the advantages of the use of surgical procedures.

Keywords: Tooth sensitivity; recession; gingival recession; periodontal surgery

Introduction

Gingival recession (GR) is a condition that may affect an isolated tooth or a group of teeth, defined as an apical displacement of the gingival margin, in relation to the cement-enamel junction (CEJ) (American Academy of Periodontology, 1992), and its prevalence represents up to 100% of the population above 50 years old (Susin *et al.*, 2004). The apical migration of the gingival margin exposes the cementum to the oral environment, causing cervical dentin hypersensitivity (CDH), esthetic complaints, susceptibility to cervical caries and non-carious cervical lesions (NCCL), food impaction, pain during mastication or toothbrushing, and difficulty in managing the oral biofilm (Cairo *et al.*, 2016; Goldstein *et al.*, 2002; Chambrone and Tatakis *et al.*, 2016; Bignozzi *et al.*, 2014). Of the problems that arise from gingival recession, cervical dentin hypersensitivity is one of the biggest concerns, as it has a mean prevalence in the population of around 33.5% (Favaro *et al.*, 2019) and significantly affects the patient's quality of life (Douglas de Oliveira *et al.*, 2018).

The main symptom of CDH is acute, short-lived pain, which arises in response to thermal, tactile, osmotic, chemicals or, even, evaporative processes and may not be attributed to any other type of dental defect or

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pathology (West *et al.*, 2013). The hydrodynamic theory is a currently accepted hypothesis that postulates that dentin hypersensitivity might be caused by the movement of the dentinal tubules (Clark and Levin, 2016). The rapid shift in external fluids causes pressure changes on dentin, which distorts fibers through a mechanic-receptor action, and leads to acute pain in the tooth. Several treatment approaches to dentin hypersensitivity aim to occlude the dentinal tubules in order to block the hydrodynamic mechanism and, consequently, block neural transmission in the pulp. Strontium chloride, oxalate salts, hydroxyapatite gel, lasers, sodium phosphate, calcium chloride, calcium hydroxide, fluorides, and restorative materials are suggested as minimally invasive techniques (Moraschini *et al.*, 2018).

Conversely, surgical procedures can also be used as treatment, with the aim of treating gingival recession by covering the root tooth and increasing the amount of keratinized tissue. Techniques include the free gingival graft (Agudio *et al.*, 2016, Agudio *et al.*, 2017) and subepithelial connective tissue graft (Pini Prato *et al.*, 2018), which have been widely used with different types of flaps and have demonstrated complete root coverage (Tatakis *et al.*, 2015; Chambrone and Tatakis *et al.*, 2015; Cairo, 2017).

A previous systematic review (Douglas de Oliveira *et al.*, 2013b) reported that scientific evidence was insufficient to conclude that surgical root coverage provides a decrease in CDH, since most of the studies reviewed at that time had a high bias risk and CDH was evaluated as a secondary result. Since then, other studies have been published to evaluate the efficacy of root coverage procedures to improve clinical, esthetic, and patient-centered outcomes. In this context, the aim of the present study was to verify if the procedure of root coverage surgery reduced CDH in patients with gingival recession, when compared with the baseline, and update the available evidence.

Materials and methods

This systematic review was carried out in accordance with the statement of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher *et al.*, 2009) and the recommendations of the Cochrane Handbook. The protocol was previously registered in the International Prospective Registry of Systematic Reviews, where it is available for consultation (PROSPERO: CRD42020151524).

Criteria for considering studies for inclusion in this review

Research Question

Do root coverage surgical procedures result in reduced CDH in patients?

Eligibility criteria

To be included in the review, studies were required to be randomized controlled trials (RCTs) that evaluated hypersensitivity symptoms before and after surgery, as well as the clinical parameters resulting from root coverage surgery. Participants were 18 years of age or older, with CDH due to root surface exposure. The authors excluded studies reporting on Miller's classes III and IV or Cairo's Classes RT2 and RT3. Conference abstracts, letters to Editors, case reports, *in vitro* studies, abstracts, and annals of events were also excluded.

Type of intervention

The surgical interventions of interest were those related to Miller Class I and II root coverage procedures and Cairo's Class RT1, such as a) free gingival graft; b) laterally-positioned flap (LPF); c) coronally-advanced flap (CAF); d) subepithelial connective tissue (SCTG) grafts alone, or combined with CAFs or LPF; e) guided tissue regeneration; f) enamel matrix protein; g) semilunar flaps; h) acellular dermal matrix grafts and i) modified coronally advanced flap (M-CAF).

Primary outcomes

Primary results included changes in hypersensitivity symptoms, reported before and after treatment, in response to the most commonly used assessment parameters for sensitivity diagnosis (thermal, tactile, and evaporative stimulation) or obtained by assessing the patient's opinion of hypersensitivity during your daily activities after root coverage procedures.

Secondary results

Secondary outcomes included oral health impact on quality of life, use of analgesics, adverse effects, and postoperative complications. In addition to clinical parameters, percentage of root coverage (% RC) and Relative Gingival Recession (RGR).

Search Strategy

The studies included in this systematic review were obtained by searching the PubMed (MEDLINE), Scopus, Web of Science, Cochrane Library and Virtual Health Library (LILACS, IBECS, BIREME and SCIELO) databases. The keywords, DeCs (Health Sciences Descriptors) and MeSH (Medical Subject Headings) terms were: (dentin hypersensitivity OR cervical dentin hypersensitivity OR dentin sensitivity) AND (gingival recession OR gingival recession Therapy OR gingival recession treatment OR root coverage). There were no limitations on the publication date and language. Electronic searches were performed selecting indexed articles until September 2020.

To identify studies of interest for this review, a general search strategy was adapted to the characteristics of each database. References contained in all of the studies and systematic reviews included were checked by an additional manual search.

Study Selection

For this systematic review, we selected RCTs that met the inclusion criteria, in the respective databases. Inclusion was based on the analysis of the title and abstract in accordance with the eligibility criteria.

Review Method

For the selection of studies, the Rayyan Qatar Computing Research Institute (QCRI) application was employed and was initially performed by two reviewers (GCBF and LVFC), in two phases. In the first phase, the two reviewers independently identified all relevant studies by electronically searching the titles based on the inclusion criteria. The agreement among the review authors was calculated as 85.36%. In the second phase, the pre-selected studies were analyzed by the same two authors. Disagreements between the review authors were resolved through consensus between the two reviewers and a third reviewer (LCNM). Each researcher qualitatively evaluated the studies using an evaluation form for the study. The following data were collected: 1) Author; 2) year of publication; 3) parameters measured; 4) study design; 5) methods; and 6) results according to CDH (Table 1).

Risk of bias assessment

A methodological assessment of trial quality was performed based on the revised recommendations of the Consolidated Standards of Reporting Trials Statement (Moher *et al.*, 2010) and two previous systematic reviews (Douglas de Oliveira *et al.*, 2013b; Sgolastra *et al.*, 2011). The criteria used to assess quality of the papers are listed in Table 2. The risk of bias (low, high, or moderate) from each included study was assessed using the Cochrane domain-based two-part tool as described in the Cochrane Handbook for Systematic Reviews Intervention (Cochrane Handbook for Systematic Reviews of Interventions): 1) Low risk of bias (when all criteria have been met); 2) moderate risk of bias (when ≥ 1 partially met criterion); and 3) high risk of bias (when ≥ 1 criterion not met) (Table 3).

Data Analysis/ Synthesis

The meta-analyses were conducted in R software, version 3.6.2, using meta and metafor packages. The odds ratio (OR) was reported for dichotomous data for the frequency of CDH at baseline (before surgical intervention) and post-surgical root coverage technique, presented in the RCTs. The mean difference (MD) was reported for continuous data related to CDH presented in terms of Visual Analogue Scale (VAS). The I^2 test was used to evaluate the heterogeneity of outcomes. When I^2 was ≤ 30%, we used the fixed effects model to estimate the pooled estimates and related 95% confidence intervals (95% CI), while if significant heterogeneity was present (I^2> 30%), the random effects model was used.

Results

Study Selection

A total of 886 studies, published until September 2020, were evaluated following the initial electronic search of the major databases, with the aid of the Rayyan QCRI application. After removing duplicates, 637 articles remained. After reading the title and abstracts, 543 articles were excluded. Of the 94 articles selected for full-text reading, 74 articles were excluded. Twenty articles were included in the qualitative analysis (Pini Prato *et al.*, 2000; McGuire and Nunn, 2003; Bittencourt *et al.*, 2006; Bittencourt *et al.*, 2007; Santamaria *et al.*, 2008; Bittencourt *et al.*, 2009; Cortellini *et al.*, 2009; Santamaria *et al.*, 2009; Bittencourt *et al.*, 2012; McGuire *et al.*, 2012; Fernandes-Dias *et al.*, 2015; Santamaria *et al.*, 2016; Rocha Dos Santos *et al.*, 2017; Santamaria *et al.*, 2017; Santamaria *et al.*, 2018; Rasperini *et al.*, 2018; Damante *et al.*, 2019; Dursun *et al.*, 2018; Ramireddy *et al.*, 2018, Nahas *et al.*, 2019), and twelve were included in meta-analyses. No articles were found during the manual search (Figure 1).

Study Characteristics

Cervical dentin hypersensitivity (CDH) was evaluated in six studies using the Visual Analog Scale (VAS) (Fernandes-Dias *et al.*, 2015; Santamaria *et al.*, 2017, Santamaria *et al.*, 2018; Rocha Dos Santos *et al.*, 2017; Damante *et al.*, 2019; Nahas *et al.*, 2019). Additionally, ten RCTs reported on CDH as present or absent (Pini Prato *et al.*, 2000; Bittencourt *et al.*, 2007; Santamaria *et al.*, 2008; Cortellini *et al.*, 2009; Santamaria *et al.*, 2009; Bittencourt *et al.*, 2012; McGuire *et al*, 2012; Santamaria *et al.*, 2016; Dursun *et al.*, 2018; Ramireddy *et al.*, 2018), while CDH was measured on a qualitative scale in the other RCTs (McGuire and Nunn, 2003; Bittencourt *et al.*, 2006; Bittencourt *et al.*, 2009). One study (Rasperini *et al.*, 2018) reported the use of an air spray, but without mentioning the manner in which data were collected. One study (Rocha Dos Santos *et al.*, 2017) used the Schiff Scale in addition to the Visual Analog Scale, and observed significant differences only for the intra-group analysis and not for the inter-group analysis at the follow-up times. Five studies did not present the sample calculation (Pini Prato *et al.*, 2000; Bittencourt *et al.*, 2009; McGuire *et al.*, 2012; Damante *et al.*, 2019; Dursun *et al.*, 2018). All studies presented appropriate statistical calculation. The period of evaluation of the

Table 1. Characteristics of studies included in the present systematic review

Study	Study Design	Follow-up	Participants (sex, age range)	Miller Class	Intervention	Primary Measurements	Hypersensitivity Measurement	Hypersensitivity Outcome
Pini Prato *et al.*, 2000	RCT, split-mouth	3 months	11 patients (4 males, 7 females), 22 to 41 years	I	Control: CAF without tension Test: CAF with tension	REC, PD, CAL, WKT, AC	Present or absent (unclear method)	12 of 22 teeth with baseline root hypersensitivity; 5 of 22 postoperatively CAF with tension 6 of 22 teeth with baseline root hypersensitivity; 3 of 22 postoperatively.
McGuire and Nunn, 2003	RCT, split-mouth	12 months	20 patients (10 males, 10 females), 23 to 62 years	II	Control: CAF + EMD Test: CAF + SCTG	REC, WKT, PD, CAL, inflammation, GM position	None, moderate, or severe (air evaporative stimuli)	10 of 20 teeth with baseline root hypersensitivity; 1 of 17 postoperatively CAF + SCTG 8 of 20 teeth with baseline root hypersensitivity; 0 of 17 postoperatively.
Bittencourt *et al.*, 2006	RCT, split-mouth	6 months	17 patients (6 males, 11 females), 21 to 52 years	I	Control: SCTG Test: SCPF	REC, WKT, RW, PD, CAL, TKT	None, low, moderate, or severe (patient opinion)	7 of 17 patients reported baseline root hypersensitivity; 0 of 17 postoperatively.
Bittencourt *et al.*, 2007	RCT, split-mouth	6 months	15 patients (9 males, 6 females), 22 to 59 years	I	Control: SCRF Test: SCRF + EDTA	REC, WKT, RW, PD, CAL, TKT	Present or absent (patient opinion)	9 of 15 teeth reported baseline root hypersensitivity; 0 of 15 postoperatively SCRF + EDTA 9 of 15 teeth reported baseline root hypersensitivity; 3 of 15 postoperatively.
Santamaria *et al.*, 2008	RCT, split-mouth	6 months	19 patients (9 males, 10 females), 24 to 58 years	I	Control: CAF Teste: CAF + R	PD, REC, CAL, HCL, WKT, TKT	Present or absent (patient opinion)	13 of 19 teeth with baseline root hypersensitivity; 1 of 19 postoperatively CAF 13 of 19 teeth with baseline root hypersensitivity; 9 of 19 postoperatively.
Bittencourt *et al.*, 2009	RCT, split-mouth	30 months	17 patients (6 males, 11 females), 21 to 52 years	I	Control: SCTG Test: SCPF	REC, WKT, RW, PD, CAL, TKT	None, low, moderate, or severe (patient opinion)	7 of 17 teeth reported baseline root hypersensitivity; 0 of 17 postoperatively SCPF 7 of 17 teeth reported baseline root hypersensitivity; 3 of 17 postoperatively.
Cortellini *et al.*, 2009	RCT, parallel	6 months	85 patients (37 males, 48 females), 20 to 59 years	I, II	Control: CAF Test: CAF + CTG	PD, REC, RW, CAL, WKT	Present or absent (air evaporative stimuli)	17 of 43 teeth with baseline root hypersensitivity; 5 of 43 postoperatively CAF + CTG 18 of 42 teeth with baseline root hypersensitivity; 5 of 42 postoperatively.

Table 1 continued overleaf...

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Santamaria *et al.*, 2009	RCT, parallel	6 months	30 patients (21 males, 19 females), 19 to 71 years	I	Control: CTG Test: CTG + R	PD, REC, CAL, HCL, WKT, TKT	Present or absent (patient opinion)	12 of 20 teeth with baseline root hypersensitivity; 7 of 20 postoperatively CTG + R 14 of 20 teeth with baseline root hypersensitivity; 1 of 20 postoperatively.
Bittencourt *et al.*, 2012	RCT, split-mouth	12 months	24 patients (13 males, 11 females), 19 to 71 years	I, II	Control: SCTG without operative microscope Test: SCTG with operative microscope	REC, WKT, RW, PD, CAL, TKT	Present or absent (patient opinion)	11 of 24 teeth reported baseline root hypersensitivity; 0 of 24 postoperatively SCTG without operative microscope 11 of 24 teeth reported baseline root hypersensitivity; 3 of 24 postoperatively.
McGuire *et al.*, 2012	RCT	10 years	9 patients (4 males and 5 females), 44 to 74 years (mean age: 55.4 years)	I, II	Control: CAF + CTG Test: CAF + EMD	PD, CAL, WKT, %RC, DH, CRC, TEXTURE, CONTOUR, PACIENTE SATISFACTION	Present or absent (air evaporative stimulus 3s)	Moderate root dentin hypersensitivity continued to exist in a minority of the test (n=3) and control (n=1) sites, although the majority of sites exhibited no sensitivity to a conventional 3-second blast of air to the root surface.
Fernandes-Dias *et al.*, 2014	RCT, parallel group, double-blind	6 months	40 patients (20 males, 20 females), older than 18 years	I, II	Control: CTG Test: CTG + L	PI, BOP, PD, RGR, CAL, GR, WKT, TKT, DS	VAS, 5s (air evaporative stimulus)	13 out of 20 subjects with baseline root hypersensitivity, 2 out of 20 after 6 months 15 out of 20 subjects with baseline root hypersensitivity, 2 out of 20 after 6 months
Santamaria *et al.*, 2016	RCT, parallel group, single-blind	12 months	36 patients (19 males, 17 females)	I, II	Control: CTG Test: CTG + RC	PI, BOP, PD, RGR, CAL, CDH, WKT, TKT, DS	Present or absent (air evaporative stimulus, 5s)	17 out of 18 sites with baseline root hypersensitivity, 8 out of 18 after 6 months 16 out of 18 sites with baseline root hypersensitivity, 1 out of 18 after 6 months
Dursun *et al.*, 2017	RCT	12 months	36 patients (28 females, 8 males), mean age 41.65+/- 12.26 years	I	Control: CAF + SCTG Test 1: CAF + SCTG + NIC Test 2: CAF + SCTG + RMGIC	HGR, WGH, CAL, GI, BOP, PI, PD, HKT, TKT, HCL, WCL, DS, ES	Present or absent (thermal and tactile stimuli)	41 defects (11 from RMGIC, 17 from NIC, and 13 from control groups) (75.1%) had DS at baseline. When compared with baseline, a significant reduction in DS was seen in all groups at follow-up visits. Only 1 patient in the RMGIC group still complained about DS at 12 months
Santamaria *et al.*, 2017	RCT, parallel, double-blind	6 months	42 patients (27 females, 15 males), 40.2+/- 9.6 years; range 24–59	I, II	Control: CAF + CTG Test: TUN + CTG	PI, BOP, PD, KTT, RGR, RCAL, GRD, CRC, WKT, RES, DH	VAS, 5s (air evaporative stimulus)	13 out of 21 sites with baseline root hypersensitivity, 2 out of 21 after 6 months 14 out of 21 sites with baseline root hypersensitivity, 2 out of 21 after 6 months

Table 1 continued overleaf...

Table 1 continued...

Santos *et al.*, 2017	RCT, double-blind	6 months	68 patients (42 females, 26 males), mean age 37.53 +/- 11.23 years	I, II	Control: CAF Test 1: CAF + CM Test 2: CAF + EMD Test 3: CAF + CM + EMD	FMPI, FMBI, GR, CDH, WKT, TKT, CAL, PD	VAS, 1s (air evaporative stimulus) SCHIFF	From baseline to six months, there were no inter-group differences concerning CDH-VAS and esthetics-VAS. At the end of the study, only 18 patients reported persistent CDH after the root coverage procedure.
Ramireddy *et al.*, 2018	RCT	180 days	20 patients (78 sites with NCCL), 24-58 years	I, II	Control: CAF + PRF Test: CAF + RmGIC.	KTT, PPD, RGR, RCAL, WKT, DS, NCCLH, NCCLW	Present or absent	28 out of 39 sites with baseline root hypersensitivity, 15 out of 28 after 6 months 29 out of 39 sites with baseline root hypersensitivity, 5 out of 29 after 6 months
Rasperini *et al.*, 2018	RCT, parallel, double-blind	9 years	25 patients	I, II	Control: CAF Test: CAF + CTG	PD, REC, CAL, WKT, DH	Air evaporative stimulus	3 out of 12 patients with baseline root hypersensitivity, 1 out of 12 after 6 months 6 out of 13 patients with baseline root hypersensitivity, 1 out of 13 after 6 months
Santamaria *et al.*, 2018	RCT, parallel	6 months	40 patients (mean age: 44.5 ± 10.6 years; range 22-60)	I, II	Control: CTG Test: CTG + PR	FMPI, FMBI, PD, RGR, RCAL, CDH, %CDC, %RC, WKT, TKT, DH, MRES.	VAS, 3s (air evaporative stimulus)	16 out of 20 patients with baseline dentin hypersensitivity, 9 out of 20 after 6 months 14 out of 20 with baseline dentin hypersensitivity, 2 out of 20 after 6 months
Damante *et al.*, 2019	RCT, double-blind	12 months	17 patients (60 recession defects; age (18–60 years old)	I, II	SRP + SCTG SCTG + SRP + CAT SCTG + SRP + aPDT	RD, %RC, WKT, STT, PD, CAL, HYPER, EST	VAS	All treatments promoted a decrease in dentin hypersensitivity from baseline to 12 months. A significant difference between groups was seen only at 6 months, with less hypersensitivity reported for aPDT and CAT groups in relation to control.
Nahas *et al.*8, 2019	RCT, split-mouth, single-blind	12 months	15 patients (82 recession defects; 8 females and 7 males; mean age of 32.7 ± 8.1.; range: 18–51	I	Control: mCAF + CTG Test: mCAF + CM	GRD, bacterial plaque index, PD, BOP, CAL, WKT, DH, postoperative pain and esthetics (VAS)	VAS	No difference between groups was detected for DH reductions at 12 months. After 12 months, there was a significant reduction in mean DH scores for both treatment groups ($p < 0.05$), with no difference between groups

CTG: connective tissue graft; CAF: coronally advanced flaps; TUN: coronally advanced tunnel; L: low-level laser therapy; PI: plaque index; BOP: bleeding on probing; PD: probing depth; RGR: relative gingival recession; CAL: clinical attachment level; GR: gingival recession; WKT: width keratinized tissue; TKT: thickness keratinized tissue; DS: dentin sensitivity; CDH: combined defect height; RC: resin composite to restore; RMGIC: resin-modified glass ionomer cement; NIC: nano-ionomer cements; SCTG: subepithelial connective tissue grafts; HGR: height of gingival recession; WGH: width of gingival recession; GI: gingival index; HKT: height of keratinized tissue; HCL: height of cervical lesion; WCL: width of cervical lesion; ES: esthetic score; DH: dentin hypersensitivity; RES: coverage esthetic score; CRC: complete root coverage; RCAL: relative clinical attachment level; GRD: gingival recession depth; EMD: enamel matrix derivative; CM: xenogeneic collagen matrix; CDH: cervical dentin hypersensitivity; FMPI: full-mouth visible plaque index; FMBI: full-mouth sulcus bleeding index; PPD: probing pocket depth; RmGIC: resin-modified glass-ionomer cement; NCCLH: noncarious cervical lesions height; NCCLW: noncarious cervical lesions width; REC/RD: recession depth; PR: partial restoration; MRES: modification of the Root Coverage Esthetic Score; SRP: scaling and root planing only; CAT: citric acid/tetracycline gel; aPDT: Antimicrobial photodynamic therapy; %RC: percentage of root coverage; STT: soft tissue thickness; EST: esthetic perception by patient; RW: recession width; GM: gingival marginal; mCAF: modified coronally advanced flap; CM: collagen matrix; VAS: Visual Analogic Scale.

Table 2. Categories used to assess the quality of selected studies

Description	Grading
Sample-size calculation, estimating the minimum number of participants required to detect a significant difference among compared groups	0=did not exist/not mentioned/not clear 1=was reported but not confirmed 2=reported and confirmed
Allocation of concealment methods	0=clearly inadequate 1=possibly adequate 2=clearly adequate
Randomization	0=clearly inadequate 1=possibly adequate 2=clearly adequate
Losses (specified reasons for withdrawals and dropouts in each study group)	0=no/not mentioned/not clear 1=yes/no withdrawals or dropouts occurred
Presence of masking	0=no 1=unclear/not complete 2=yes
Appropriate statistical analysis	0=no 1=unclear/possibly not the best method applied 2=yes

studies varied between 6 to 12 months; however, one study reevaluated the patients after 9 years (Rasperini *et al*., 2018) and another after 10 years (McGuire *et al*. 2012). Mean root coverage rate was 82.44% and 81,66%, after 6 months and 12 months, respectively, without statistically significant differences between periods (p=0.285) (Table 4).

Only Rocha Dos Santos *et al*. (2017) studied the effect of the root coverage procedure on the oral health-related quality of life (OHRQoL) of patients with gingival recession. The OHIP-14 scores showed a positive correlation between physical pain dimension and CDH. Although some authors instructed patients to take analgesics as needed for pain (Fernandes-Dias *et al*., 2015; Santamaria *et al*., 2016; Santamaria *et al*., 2017; Santamaria *et al*., 2018; Rasperini *et al*., 2018; Damante *et al*., 2019; Nahas *et al*., 2019), only two (Fernandes-Dias *et al*., 2015; Santamaria *et al*., 2017) studies presented the number of analgesic pills consumed by the patients during the week after surgery.

All authors reported on adverse events (Fernandes-Dias *et al*., 2015; Santamaria *et al*., 2016, 2017; Dursun *et al*., 2018), stating that the surgeries were completed uneventful and that no adverse events occurred during follow-up. Postoperative complications were not addressed and only Dursun *et al*. (2018) mentioned that no patient experienced healing complications.

Results of the Meta-Analysis

Twelve of the twenty studies, comprising 662 patients, presented the frequency of patients reporting CDH at baseline and after the surgical root coverage technique. Surgical interventions related to Miller Class I and II or Cairo's Class RT1 root coverage procedures reduced the chance of CDH, compared to the use of no technique applied at baseline (before surgeries) (OR = 0.14, 95% CI = [0.08, 0.25], I^2 = 73%). Sensitivity analysis, pooling studies according to the follow-up period, revealed a significantly decreased chance of CDH after the intervention only considering six months follow-up (Figure 2).

Surgical root coverage techniques were effective in reducing the scores of VAS, in comparison with scores reported at baseline (MD = -2.64, 95% CI = [-3.11, -2.16], I^2 = 0%) (Figure 3). Fernandes-Dias *et al*. (2015), was not included in the meta-analysis because, despite referring to use VAS for pain assessment, the authors presented the results in frequency. Damante *et al*., 2019, was also not included in the meta-analysis because their outcomes were presented in graphs, making the data extraction not possible, even after attempting to contact the authors. In addition, Nahas *et al*. (2019) presented the follow-up results as CDH reduction. While Rocha Dos Santos *et al*. (2017) presented CDH values (mean ± SD) for all evaluated interventions in a single summary measure, Santamaria *et al*. (2017) and Santamaria *et al*. (2018) presented these results for each randomized group. Thus, each line for the Santamaria studies in Figure 3 represents a different root coverage procedure.

Discussion

To date, a number of systematic reviews have been performed in the field of periodontology to verify the effectiveness of surgical procedures for the treatment of gingival recession (Roccuzzo *et al*., 2002; Oates *et al*., 2003; Chambrone and Tatakis *et al*., 2009; Chambrone

Table 3. Evaluation of bias risk in the studies

Study	Sample Size	Allocation Concealment	Random Allocation	Losses	Assessor(s) Masking	Statistical Analysis	Judged Bias Risk
Pini Prato *et al.*, 2000	0	0	2	0	2	2	High
McGuire and Nunn, 2003	2	2	2	1	2	2	Low
Bittencourt *et al.*, 2006	2	0	2	1	2	2	High
Bittencourt *et al.*, 2007	2	0	2	1	2	2	High
Santamaria *et al.*, 2008	1	0	2	1	1	2	High
Bittencourt *et al.*, 2009	0	0	2	1	2	2	High
Cortellini *et al.*, 2009	2	2	2	1	2	2	Low
Santamaria *et al.*, 2009	2	1	1	1	0	2	High
Bittencourt *et al.*, 2012	2	0	2	1	2	2	High
McGuire *et al.*, 2012	0	0	0	1	2	2	High
Fernandes-Dias *et al.*, 2014	2	2	2	1	2	2	Low
Santamaria *et al*, 2016	2	2	2	1	0	2	Moderate
Dursun *et al.*, 2017	0	0	0	0	0	2	High
Santamaria *et al.*, 2017	2	2	2	1	2	2	Low
Santos *et al.*, 2017	2	2	2	1	2	2	Low
Ramireddy *et al.*, 2018	2	2	2	0	0	2	High
Rasperini *et al.*, 2018	1	2	2	1	0	2	High
Santamaria *et al.*, 2018	2	2	2	1	0	2	Moderate
Damante *et al.*, 2019	0	2	2	1	2	2	Low
Nahas *et al.*, 2019	2	1	2	1	2	2	Moderate

and Tatakis *et al.*, 2015). In general, all techniques reduced recession, and increased clinical attachment level and keratinized tissue. However, a previous systematic review suggested there was not enough evidence to conclude that surgical root coverage procedures reduce CDH (Douglas de Oliveira *et al.*, 2013a). The present study, which included recently published studies in this field, identified a lower chance for CDH after surgical root coverage procedures related to Miller Class I and II or Cairo's Class RT1, compared to baseline, especially considering a follow-up of six months.

Until now, several classifications have been proposed to classify and to facilitate the diagnosis of gingival recession. Miller's classification of gingival recession was

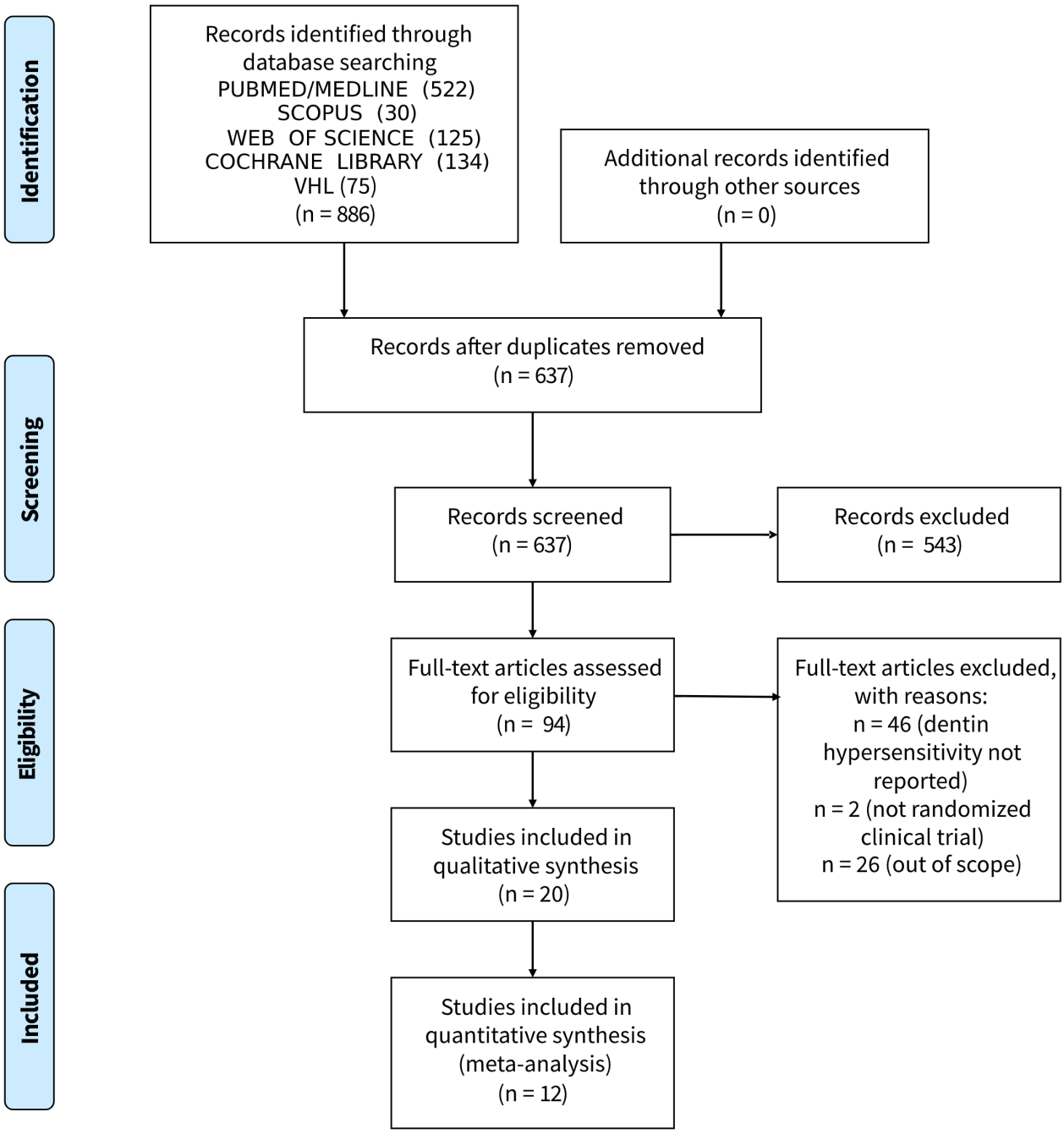

Figure 1. Flowchart for search results.

the most widely used by the included studies because of the year of publication. However, a classification system, which specifies the type of recession according to inter-dental clinical attachment level as an identification criterion and the amount of loss promotes more accurate information, should be preferred in future studies. According to the recent classification of periodontal and peri-implant diseases, using the Cairo classification for the diagnosis of gingival recessions, the studies included Miller's class I and II recessions as equivalent to RT1 in Cairo's classification (Cairo *et al.* 2011; Jepsen *et al.*, 2018).

Pain relief is the main objective of CDH treatment; VAS is an important tool for assessing the degree of dentin sensitivity, and was used by six studies included in this review (Fernandes-Dias *et al.*, 2015; Santamaria *et al.*, 2017, 2018; Rocha Dos Santos *et al.*, 2017; Damante *et al.*, 2019; Nahas *et al.*, 2019). Overall, reductions in VAS pain intensity scores in the postoperative group, compared to controls, were found in all studies. Thus, our results indicate a reduction of 2.64 points in the VAS scale within six months of the intervention. It is likely that covering exposed root with gingival tissue can impair transmission of stimulus to dentin, which would generate fluid dislocation and further activation of the nervous fiber responsible for acute pain. Future studies should consider measuring CDH using the VAS scale at other follow-up times.

Table 4. Data from percentage of root coverage (%) at 6 and 12 months after surgical treatment.

Study	Groups	GR (mm) at Baseline	%RC 6 months (Mean ± SD)	%RC 12 months (Mean ± SD)	*p-value*
Pini Prato *et al.*, 2000	CAF without tension CAF with tension	2.68 2.82			0.3911
McGuire and Nunn, 2003	CAF + EMD CAF + SCTG	4.25 4.25	NR	95.1 93.8	0.281**
Bittencourt *et al.*, 2006	SCTG SCPF	2.15 2.20	96.10 90.95	NR	<0.05*
Bittencourt *et al.*, 2007	SCRF SCRF + EDTA	1.79 1.86	90.1 ± 18 70.2 ± 30.5	NR	
Santamaria *et al.*, 2008	CAF CAF + R	10.57 10.94	97.48 ± 15.36 88.02 ± 19.45	NR	>0.05*
Bittencourt *et al.*, 2009	SCTG SCPF	2.15 2.20	96.30 90.95	NR	>0.05*
Cortellini *et al.*, 2009	CAF CAF + CTG	2.4 2.7	62.5 74.1	NR	<0.0001*
Santamaria *et al.*, 2009	CTG CTG + R	11.7 11.79	91.91 ± 17.76 88.64 ± 11.9	NR	0.74*
Bittencourt *et al.*, 2012	SCTG without operative microscope SCTG with operative microscope	2.53 2.51	NR	88.3 98.0	<0.05**
Mcguire *et al.*, 2012	CAF + CTG CAF + EMD	4.00 4.00	NR	96.3 ± 11.1 94.4 ± 11.0	NR
Fernandes – Dias *et al.*, 2014	CTG CTG + L	3.33 3.09	89.38 ± 22.38 91.84 ± 22.5	NR	0.661*
Santamaria *et al.*, 2016	CTG CTG + RC	NR	NR	82.16 ± 16.1 73.84 ± 19.2	0.14**
Dursun *et al.*, 2017	CAF + SCTG CAF + SCTG + RmGIC CAF + SCTG + NIC	3.17 3.5 3.13	NR	96.22 ± 10.75 89.49 ± 18.15 90.12 ± 16.58	0.13**
Santamaria *et al.*, 2017	CAF + CTG TUN + CTG	3.2 3.0	87.2 ± 27.1 77.4 ± 20.4	NR	0.02*
Santos *et al.*, 2017	CAF CAF + CM CAF + EMD CAF + CM + EMD	NR	68.04 ± 24.11 87.20 ± 15.01 88.77 ± 20.66 91.59 ± 11.08	NR	<0.05*
Ramireddy *et al.*, 2018	CAF + PRF CAF + RmGIC	NR	NR	72.48 72.01	0.401**
Rasperini *et al.*, 2018	CAF CAF + CTG	2.4 2.4	38.5 58.3	30.8 58.3	0.320* 0.165**
Santamaria *et al.*, 2018	CTG CTG + PR	NR	NR	92.2 ± 28.4 93.0 ± 26.1	0.7**
Damante *et al.*, 2019	SRP SRP + CAT SRP + aPDT	2.73 2.18 2.45	NR	57.7 ± 28.2 81.6 ± 29.6 82.1 ± 28.2	<0.05**
Nahas *et al.*, 2019	CTG CM	2.8 2.7	89.28 74.07	82.14 77.78	0.233**
MEAN		3.68	82.44	81.66	0.285

**p* value, 6 months; ***p* value, 12 months; NR: not reported; CTG: connective tissue graft; CAF: coronally advanced flaps; EMD: enamel matrix derivative; RC: resin composite to restore; RmGIC: resin-modified glass-ionomer cement; TUN: coronally advanced tunnel; L: low-level laser therapy; aPDT: Antimicrobial photodynamic therapy; CAT: citric acid/tetracycline gel; SCTG: subepithelial connective tissue grafts; CM: xenogeneic collagen matrix; PR: partial restoration; SRP: scaling and root planing only; PRF: platelet-rich fibrin; GR: gingival recession; RC: root coverage.

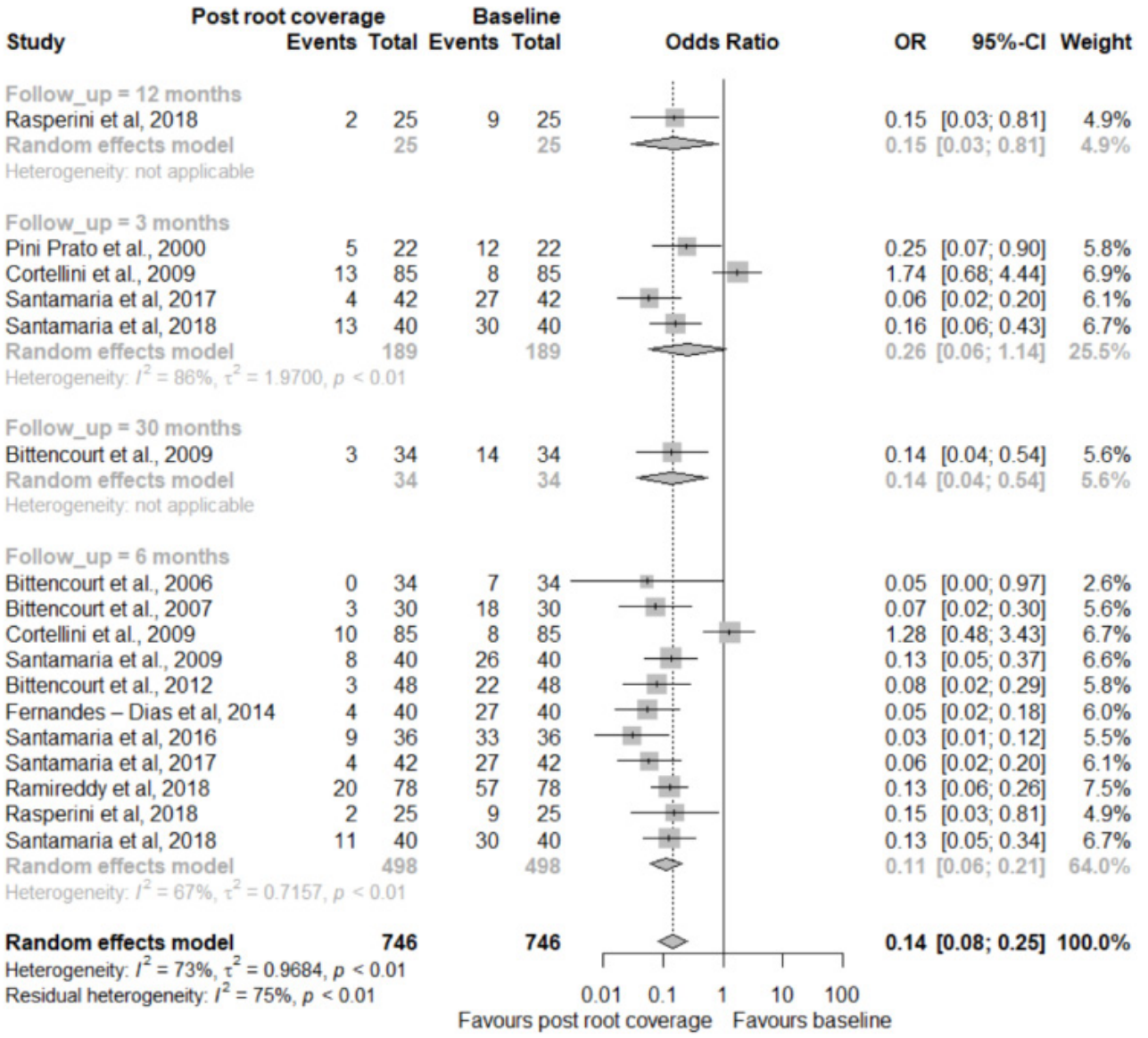

Figure 2. Odds ratio (OR) and confidence intervals (CI) calculated from studies reporting CDH at baseline and after the surgical root coverage technique.

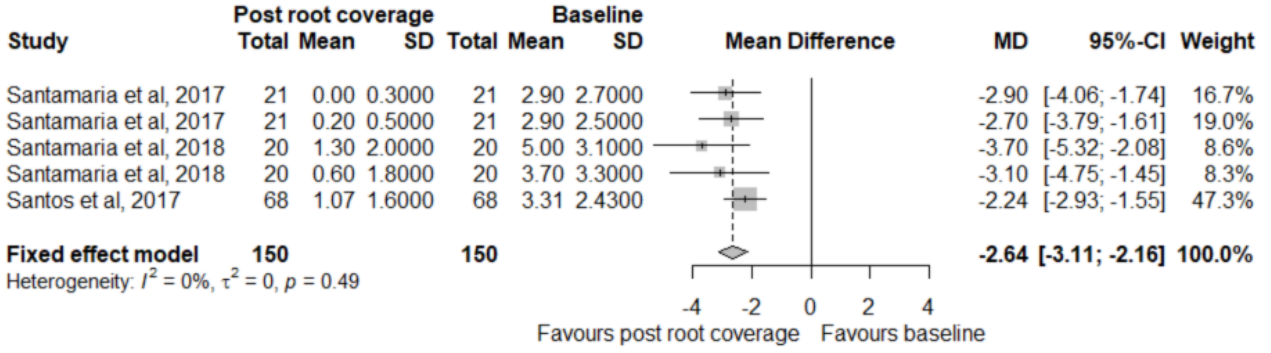

Figure 3. Mean difference (MD) and confidence intervals (CI) calculated from studies reporting the scores of VAS at baseline and after the surgical root coverage technique.

For pain assessment, different protocols and types of devices were used for stimulus application to determine the tooth sensitivity level in the included studies. All hypersensitivity measurements were based on patient opinion and were noted through the VAS scale, present or absent pain sensation, or on a categorical scale considering none, moderate, or severe pain sensation. However, few studies detailed the stimuli used to assess CDH (McGuire and Nunn, 2003; Cortellini *et al*., 2009; McGuire *et al*., 2012; Fernandes-Dias *et al*., 2014; Santamaria *et al*., 2016; Dursun *et al*., 2017; Santamaria *et al*., 2017; Rocha Dos Santos *et al*., 2017; Santamaria *et al*., 2018). Holland *et al.* (1997) suggested the use of at least two different stimuli, including tactile, thermal, and evaporative air stimuli, for testing CDH. Among the studies included in this review, only Dursun *et al* (2018) used more than one stimulus (thermal and tactile).

A previous non-randomized trial reported that surgical procedures resulted in a reduction in CDH and an improvement in quality of life, irrespective of the defect coverage rate (Douglas de Oliveira *et al*., 2013). Although it is important to evaluate whether CDH treatments improve the OHRQoL of patients (Lima *et al*., 2016), only one randomized study investigated the effects of the root coverage of localized Miller Class I/II gingival recession defects with the coronally advanced flap (CAF) plus xenogeneic collagen matrix (CM), and/or enamel matrix derivative (EMD), on CDH (Rocha Dos Santos *et al*., 2017). There was a significant improvement in total OHIP-14 score, when comparing baseline and six months after surgeries. The pain caused by dentin exposure can have a negative impact on patients' oral health, compromising daily activities related to social interaction, food and drink intake. Once the treatment for CDH is completed, individuals no longer experience negative impact on their activities and, therefore, describe an improvement in the quality of life (Favaro *et al*., 2019).

With regard to postoperative analgesic use, the most prevalent recommendation to the patients was to take 500 mg sodium dipyrone, every 8 h, as needed, for pain, besides using an antimicrobial rinse (0.12% chlorhexidine, twice daily for 2 weeks) for biofilm control, and avoid any mechanical plaque control for 2 weeks (Santamaria *et al*., 2016, 2018; Rocha Dos Santos *et al*., 2017).

Although the authors did not report the amount of analgesics consumed by patients, these results do not influence our findings regarding CDH, since we evaluated this outcome in meta-analyzes considering six months after the intervention. Thus, root coverage techniques appear to have a positive impact on reducing CDH after six months and adverse events appear not to be a problem, since none were reported during the follow-up in the included studies.

A limitation of this review was that different treatment options were employed for covering the exposed root surface, related to gingival recession defects, in the RCTs included herein. The range of surgical methods reported reveals heterogeneity in relation to the type of intervention, making quantitative analysis unviable. In the same sense, substantial heterogeneity was observed across studies included in the dichotomous meta-analysis. Other limitations of the present review include the high risk of bias of some primary studies. Future clinical trials with greater methodological rigor that follow the CONSORT guidelines are important for improving scientific evidence in this field.

Conclusion

It may be concluded that root coverage procedures for Cairo's Class RT1 or Miller's Class I and II can reduce CDH in adult patients, especially after a period of six months of follow-up. Thus, this study highlighted the advantages of the use of surgical procedures to reduce CDH. Considering the presented limitations of this study, we suggest further clinical trials with low risk of bias and evaluating the patients with longer periods of follow-up to provide better and specific evidence. Comparing the efficacy of different procedures was not the aim of this systematic review.

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