ACTA ODONTOLOGICA SCANDINAVICA, 2018
VOL. 76, NO. 2, 135–140
https://doi.org/10.1080/00016357.2017.1392602

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Selective versus non-selective removal for dental caries: a systematic review and meta-analysis

Ti Li, Xiangkai Zhai, Feifei Song and Hongguang Zhu

Department of Dentistry, People's Hospital of Weifang, Weifang, Shandong Province, P.R. China

ABSTRACT

Objective: Selective and non-selective methods for caries removal were controversial so far, thus we aimed to compare the efficacy of selective and non-selective caries removal by conducting meta-analysis of randomized controlled trials (RCTs).
Materials and methods: Eligible RCTs studies comparing selective caries removal with non-selective caries removal were retrieved by searching PubMed, EMBASE and Cochrane Library till 15 July 2017. The pooled odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for outcome indictors, including pulpal exposure, pulpal symptoms and failure using Inverse variance-random effects or Mantel-Haenszel-fixed effects models.
Results: Totally, seven studies were eligible for the meta-analysis. Compared with the non-selective caries removal group, the risk of pulpal exposure was significantly reduced in the selective caries removal group (OR = 0.11, 95% CI: 0.04–0.30). No significant difference was observed in pulpal symptoms (OR = 0.79, 95% CI: 0.30–2.12) and failure (OR = 1.40, 95% CI: 0.69–2.84) between the groups.
Conclusions: The efficacy of selective caries removal appears comparable to that of non-selective caries removal in children, with similar pulpal symptoms and failure, but selective caries removal may result in a low incidence of pulpal exposure. However, larger-scale RCTs with long-term follow-up are required to confirm this conclusion.

ARTICLE HISTORY
Received 12 April 2017
Revised 27 September 2017
Accepted 5 October 2017

KEYWORDS
Meta-analysis; dental caries; selective caries removal; non-selective caries removal

Introduction

Dental caries, one of the most common chronic oral diseases worldwide, is characterized by acid demineralization and degeneration of organic matrix on the tooth surface that can result in the cavities formation [1,2]. Caries can cause pain and chewing difficulties, as well as decrease the overall health and quality of life [3]. Global epidemiological data have demonstrated that despite a decline in the prevalence of dental caries over the last four decades, it is a prominent oral health problem in all age groups [4]. Therefore, the treatment of dental caries is of importance.

The interventions for dental caries mainly involve both non-operative measures (e.g. plaque and diet control, and fluoride application) and operative techniques (e.g. selective caries removal, stepwise removal and non-selective caries removal). Operative techniques are effective in facilitating plaque control and restoring tooth form and function if decay progresses [5]. The traditional management strategy for carious lesions is non-selective caries removal, which aims to avoid further cariogenic activity and to offer a well-mineralized base of dentin for restoration [6]. However, there are several disadvantages to non-selective caries removal, such as the risk of injury to the tooth nerve, toothache or weakening of the tooth structure [5,7]. A growing body of evidence suggests that selective caries removal is preferable to non-selective caries removal [8,9].

Although several meta-analyses regarding caries removal have been reported, only one has compared the effects of selective caries removal with non-selective caries removal for the management of dentinal caries, but its sample size was limited [5]. Therefore, an updated meta-analysis with larger sample size was performed to compare the efficacy of selective caries removal compared with non-selective caries removal.

Materials and methods

The present meta-analysis was designed and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, http://www.prisma-statement.org/) guidelines [10]. The Population, Intervention, Comparison, Outcome (PICO) framework was used to illuminate our clinical questions. Population with carious teeth that underwent selective caries removal or non-selective caries removal was evaluated, and the outcome indicators, such as pulpal exposure, pulpal symptoms and failure were compared between the two groups.

CONTACT Hongguang Zhu huang9500708858@163.com Shandong Provincial Key Laboratory of Oral Tissue Regeneration, School of Stomatology of Shandong University, Jinan 250012, P.R. China; Department of Dentistry, People's Hospital of Weifang, No. 151 Guangwen Street, Kuiwen District, Weifang, Shandong Province 261041, P.R. China

Search strategy

A systematic literature search was conducted using PubMed, Excerpta Medica Database (EMBASE) and Cochrane Library to identify relevant articles published in English till 15 July 2017. The search terms were as follows: ('selective OR non-selective OR partial OR complete') AND ('excavation OR remove OR removal') AND ('caries OR carious OR decayed tooth') AND ('controlled clinical trial OR randomized OR randomly'). Reference lists of included trials were also screened. Two authors (ZXK and SFF) independently retrieved the studies while screening the citations, and disagreements were resolved by discussion.

Inclusion and exclusion criteria

Studies were included if they met all the following criteria: (1) the studies were randomized controlled trials (RCTs); (2) the studies had compared selective caries removal (a one-step procedure also referred to as incomplete or selective excavation seals carious dentin, with the aim of leaving carious dentin until the definitive restoration) with non-selective caries removal (one-step/direct complete caries removal) techniques in humans with dentin caries; (3) evaluated any of clinical outcomes, such as pulpal exposure during treatment; postoperative pulpal symptoms (clinical or radiological pulp symptoms such as pain, irreversible pulpitis and loss of vitality), and failure (technical or biological complications demanding intervention such as restorations lost, need for replacement, pulpitis and non-restorable teeth); and (4) the study could provide the case numbers for pulpal exposure, pulpal symptoms and failure of the above approaches.

Exclusion criteria were as follows: (1) articles lack the aforementioned data, including numbers of participants, treated teeth and analysed teeth in each group, as well as data about pulp exposure, pulp symptoms and follow-up in both group; (2) the studies were retrospective studies, reviews, letters or animal studies.

Data extraction and quality assessment

Two investigators (LT and ZHG) independently extracted the following data from all included studies: name of first author, publication year, sample size, research region, caries extension, numbers of participants, treated teeth and analysed teeth in each group, the relevant data about treatment in each group including pulp exposure and pulp symptoms, age of participants and follow-up duration. Any discrepancies were resolved by discussion during the course of data extraction and literature quality assessment.

In addition, the risk of bias for each included study was estimated using the Cochrane risk of bias assessment tool [11].

Statistical analysis

Pooled odds ratio (OR) with its 95% confidence interval (CI) for each effect indicator was calculated using a random effects model or fixed effects model depending on the level of heterogeneity. Heterogeneity among studies was examined using Cochrane's Q statistic and the I^2 statistic [12]. A Mantel-Haenszel-fixed effects model was selected to calculate the pooled effect size if the homogeneity test was not significant for the outcomes ($p \geq .05$ and $I^2 < 50\%$), otherwise an inverse variance-random effects model was applied for significant heterogeneous outcomes ($p < .05$ or $I^2 \geq 50\%$). Data analyses were performed with Review Manger 5.2 version software (Cochrane Library Software, Oxford, UK). For all tests, a p value of $<.05$ was considered statistically significant.

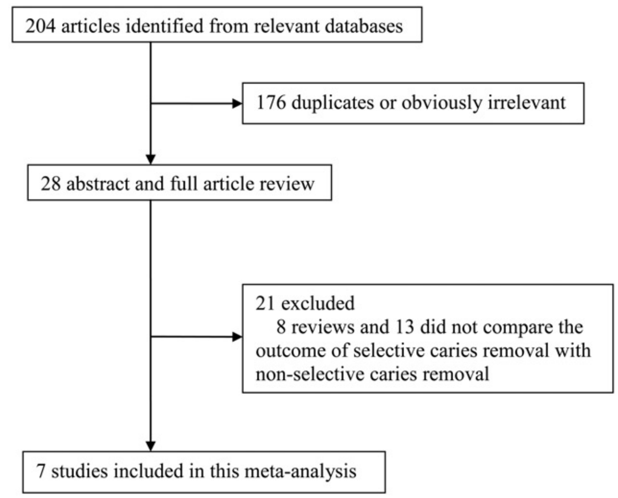

Figure 1. Flowchart showing selection of the included studies.

Publication bias analysis

Begg's test in statistical R software was employed to evaluate publication bias. A p value less than .05 were deemed as statistically significant, indicating obvious publication bias among the studies.

Results

Eligible studies

The process of study selection is shown in Figure 1. A total of 204 articles (Pubmed: 73, EMBASE: 64, Cochrane Library: 67) were retrieved by the search terms, 176 of which were excluded as duplicates or obviously irrelevant, and total 28 articles were reminded. Subsequently, through reviewing the abstract and full article of those 28 articles, eight reviews and 13 articles that did not compare selective caries removal with non-selective caries removal were further excluded. Finally, a total of seven RCTs were included in the present meta-analysis [13–19].

Characteristics of included studies

The characteristics of included studies are summarized in Table 1. Studies were conducted in Brazil, UK, Turkey or

Table 1. Characteristics of studies included in the meta-analysis.

Study	Country	No. of participants (age) and treated teeth	Caries extension	No. of analysed teeth (PR vs. CR)	Follow-up (months)	No. of outcomes (PR vs. CR)		
						PE	PS	F
Franzon 2014 [13]	Brazil	51 (3–8) 124 primary molars	Deep caries	66 vs. 54	24	1 vs. 15	5 vs. 2	5 vs. 2
Lula 2009 [14]	Brazil	30 (5–8) 36 primary molars	Caries >1/2 dentin	16 vs. 16	6	0 vs. 4	0 vs. 2	0 vs. 2
Orhan 2010 [15]	Turkey	123 (4–15) 154 (94 deciduous and 60 permanent) molars	Caries >3/4 dentin	50 vs. 55 for PE 47 vs. 43 for PS/F	12	3 vs. 12	0 vs. 2	0 vs. 2
Rando-Meirelles 2013 [16]	Brazil	11 (12–17) 18 permanent molars	Caries ≥1/3 dentin	8 vs. 8	24	NA	1 vs. 0	0 vs. 0
Ribeiro 1999 [17]	Brazil	38 (7–11) 48 primary molars	Dentin caries	24 vs. 24	12	NA	0 vs. 1	0 vs. 1
Foley 2004 [18]	UK	6.8 (3.7–9.5) 86 molar pairs	Deep caries	59 vs. 27	24	NA	**NA**	21 vs. 3
Phonghanyudh 2011 [19]	Switzerland	6–11 179 primary molars	Deep caries	90 vs. 89	6	NA	NA	1 vs. 2

PR: partial removal; CR: complete removal; PE: pulp exposure; PS: pulp symptoms; F: failure; NA: not available.

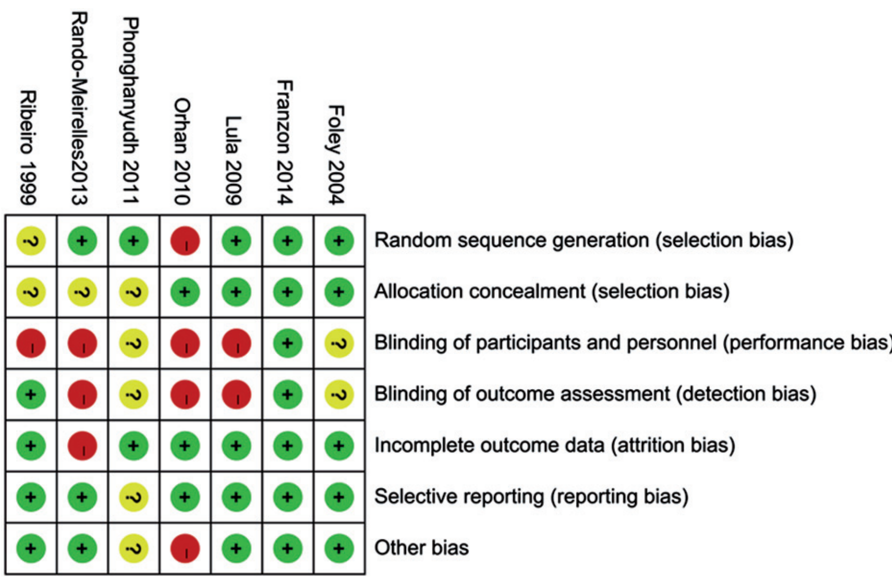

Figure 2. Quality assessments of the included studies. '+' indicates a low risk of bias; '?' represents an unclear risk of bias; '–' represents a high risk of bias.

Switzerland from 1999 to 2014, with a follow-up ranging from 6 to 24 months. Patients were children or adolescents aged 3–17 years. Both primary and permanent teeth were treated.

Quality assessment of the selected studies

The risk of bias of included studies is summarized in Figure 2. The majority of studies had a low risk of selection bias. Meanwhile, six of seven studies had a relatively low risk of reporting bias and attrition. However, the risk of performance bias was high in four studies [14–17] and was unclear in two studies [18,19]. Additionally, only two studies had a low risk of detection bias [13,17]. Overall, the included studies appeared to have a moderate risk of bias.

Outcome: pulpal exposure

A total of three included studies [13–15] compared pulpal exposure between groups. No obvious heterogeneity was detected among these studies ($I^2 = 5\%$, $p = .35$), thus the fixed effects model was used for analysis. The results revealed that occurrence of pulpal exposure was significantly lower in the selective caries removal group compared with non-selective caries removal group (OR = 0.11, 95% CI: 0.04–0.30) (Figure 3).

Outcome: pulpal symptoms

Five studies examined the post-operative pulpal symptoms (clinical or radiological) [13–17], and no striking heterogeneity ($I^2 = 4\%$, $p = .38$) was detected between the studies. Therefore, a fixed effects model was employed. In addition, the results indicated that pulpal symptoms was similar in selective and non-selective caries removal groups (OR = 0.79, 95% CI: 0.30–2.12) (Figure 4).

Outcome: failure

All seven studies performed clinical and radiographic follow-up [13–19], and no obvious heterogeneity was detected

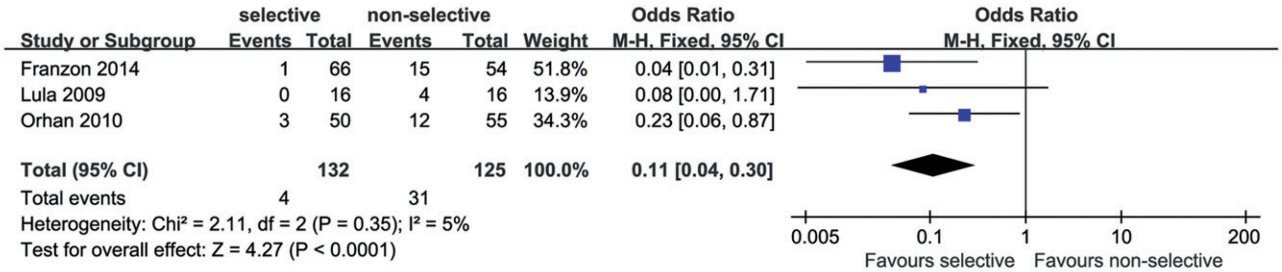

Figure 3. Forest plot of pulpal exposure in the selective and non-selective caries removal groups. Squares denote study-specific outcome estimates, and the size of the square represents the study-specific weight. Horizontal lines and figures in parentheses represent 95% CIs. Diamonds indicate the pooled effect sizes with corresponding 95% CIs. CI: confidence interval.

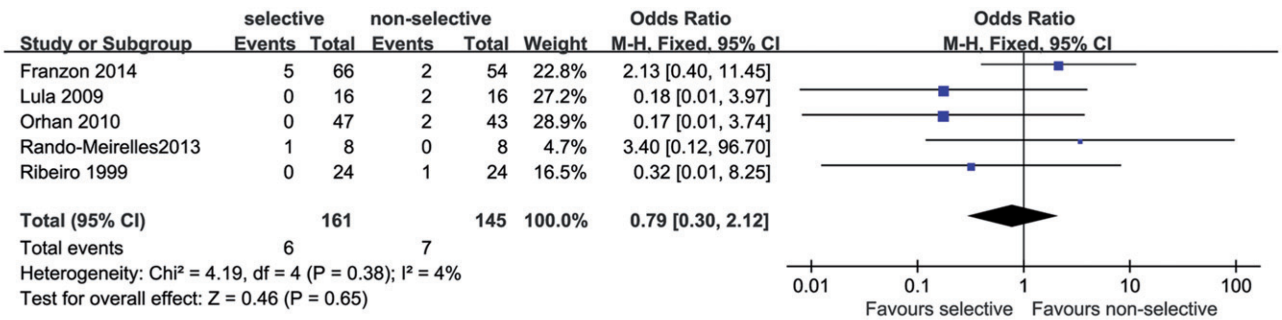

Figure 4. Forest plot of pulpal symptoms in the selective and non-selective caries removal groups. Squares denote the study-specific outcome estimates, and the size of the square represents the study-specific weight. Horizontal lines and figures in parentheses represent 95% CIs. Diamonds indicate the pooled effect size with corresponding 95% CIs. CI: confidence interval.

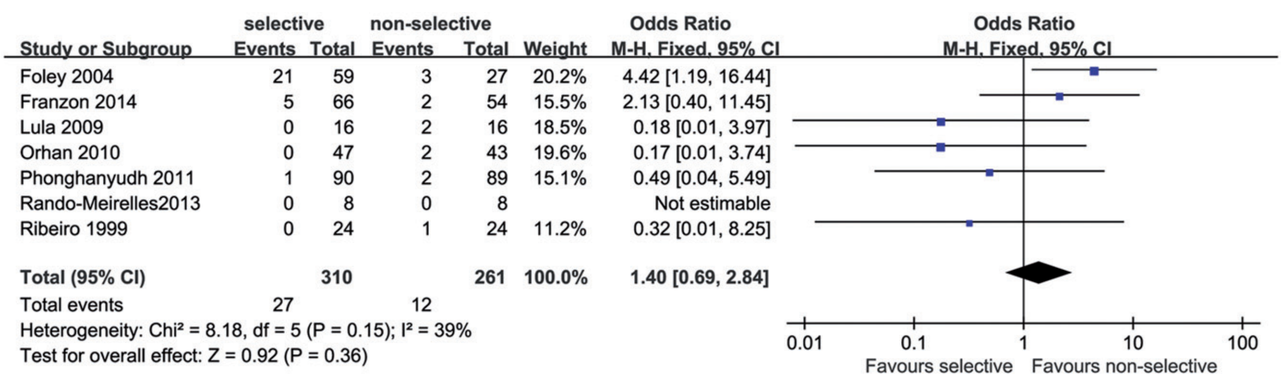

Figure 5. Forest plot of the risk of failure in the selective and non-selective caries removal groups. Squares denote study-specific outcome estimates, and the size of the square represents the study-specific weight. Horizontal lines and figures in parentheses represent 95% CIs. Diamonds indicate the pooled effect size with corresponding 95% CIs. CI: confidence interval.

among them ($I^2 = 39\%$, $p = .15$); thus, a fixed-effects model was used. No significant difference was observed in the risk of failure between selective and non-selective caries removal groups (OR = 1.4, 95% CI: 0.69–2.84) (Figure 5).

Publication bias analysis

Begg's test showed no obvious publication bias on the indicators pulpal exposure ($t = 0.2493$, $p = .8445$) and pulpal symptoms ($t = 0.8930$, $p = .4377$) among the studies. However, there was obvious publication bias for failure ($t = 7.0502$, $p = .002134$), thus, publication bias might have influenced the results for failure.

Discussion

In the present study, we compared the efficacy of selective caries removal with that of non-selective caries removal. The overall risk of pulpal exposure was significantly reduced by selective caries removal compared with that by non-selective caries removal, whereas the risk of pulpal symptoms was similar in the two caries removal groups. In addition, no obvious difference was observed in the risk of failure in between the two groups.

Reportedly, non-selective (formerly named complete) caries removal as conventional treatment for deep dental caries focuses on the eradication of bacteria and all infected dental biomass, as well as restoration of the cavity, but it may result in pulp exposure [20,21]. In recent years, with an improved understanding of disease pathogenesis and the need to minimize the risk of pulp exposure, more conservative approaches such as selective removal and stepwise excavation have been developed, and complete removal of all carious teeth is no longer considered as the standard treatment [22]. Accumulating evidence suggests that selective caries removal is a preferable method with similar effectiveness [6,23–25]. In addition, the selective caries removal is more cost-effective than non-selective removal while retaining deeply carious teeth and their vitality for longer [26]. In contrast to non-selective caries removal, selective caries removal only eliminates part of the affected dentin before sealing the cavity [27], thereby reducing the risk of pulp exposure, pulpal symptoms [9] and postoperative pulpal complications [28]. However, compared with non-selective caries removal, it does not cause any increased risk of failure [9]. In line with previous studies, the results of current study also found that the overall risk of pulp exposure was significantly reduced by selective caries removal compared with non-selective caries removal, without increased risk of pulpal symptoms. In addition, no obvious difference was observed in the failure between selective caries removal and non-selective caries removal. However, in recent surveys, most of surveyed dentists have expressed skepticism about selective excavation and have stated that they would first consider non-selective caries removal for deep dentin caries to avoid lesion progression and remaining sealed bacteria, even though pulp exposure is anticipated [29,30]. Notably, selective excavation is proposed for children and adolescents [28]. Therefore, the benefits of selective excavation should be emphasized to encourage minimally invasive techniques. However, additional clinical trials are needed to conclusively demonstrate the routine applicability of selective caries removal.

Although selective caries removal is an option to avoid pulp exposure, the tactile hardness test should be considered along with the evaluation of lesion depth and clinical symptoms [31]. Additionally, the frequency of pulp exposure during caries excavation may vary from caries with at least half dentin remaining to deep caries [32]. However, of the three included studies assessing pulp exposure in both groups, one study included subjects with deep caries, second included subjects with caries lesions $>1/2$ dentin and third included subjects with caries $\geq 1/3$ dentin [13–15], but these studies still consistently found that the occurrence of pulpal exposure was significantly low in the selective caries removal group. Nonetheless, additional more future studies with large sample permitting subgroup analysis of participants with different caries lesion depths are required to determine whether this advantage of selective caries removal is limited or can be broadly applied.

The results of this meta-analysis should be cautiously interpreted owing to some limitations in this study. First, the number of included studies was relatively small, which might lead to unreliable results. Second, the follow-up duration varied among enrolled studies from 6 to 24 months, the incidence of failure might have increased with time. Therefore, the authenticity of the results may be influenced. Third, considerable risk of bias was found in most studies and publication bias was detected among studies that compared failure risk between groups. Fourth, we only included studies involving children and adolescents, the subgroup analysis with different age sections were not conducted, so it is uncertain whether these conclusions will apply to adults. Fifth, randomization procedures were not clarified, and allocation was usually accomplished before caries excavation. Thus, the operator was aware of the allocation and subsequently may have removed different amounts of caries.

In conclusion, results from this meta-analysis demonstrated that the efficacy of selective caries removal might be comparable to that of non-selective caries removal in children and adolescents with no significant difference of pulpal symptoms and failure, but a decreased pulp exposure risk, even though pulp exposure can be accepted and treated. However, larger-scale RCTs with long-term clinical trials follow-up are required to confirm these conclusions.

Disclosure statement

The authors declare no conflicts of interest.

References

[1] Lin P-Y, Lyu H-C, Hsu C-YS, et al. Imaging carious dental tissues with multiphoton fluorescence lifetime imaging microscopy. Biomed Opt Express. 2011;2:149–158.

[2] Hillman JD. Compositions and methods for the maintenance of oral health. Google Patents; 2011.

[3] Kramer PF, Feldens CA, Ferreira SH, et al. Exploring the impact of oral diseases and disorders on quality of life of preschool children. Community Dent Oral Epidemiol. 2013;41:327–335.

[4] Frencken JE, Sharma P, Stenhouse L, et al. Global epidemiology of dental caries and severe periodontitis – a comprehensive review. J Clin Periodontol. 2017;44:S94–S105.

[5] Ricketts D, Lamont T, Innes NP, et al. Operative caries management in adults and children. Cochrane Database Syst Rev. 2013;3:CD003808.

[6] Thompson V, Craig RG, Curro FA, et al. Treatment of deep carious lesions by complete excavation or partial removal: a critical review. J Am Dent Assoc. 2008;139:705–712.

[7] Innes NP, Frencken JE, Bjørndal L, et al. Managing carious lesions: consensus recommendations on terminology. Adv Dent Res. 2016;28:49–57.

[8] Fontana M. Limited evidence for main reason for failure of partially excavated and restored teeth. Evid Based Dent. 2014;15:16–17.

[9] Schwendicke F, Dorfer CE, Paris S. Incomplete caries removal: a systematic review and meta-analysis. J Dent Res. 2013;92:306–314.

[10] Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151:264–269.

[11] Higgins J, Green S. Cochrane handbook for systematic reviews of interventions Version 5.1.0. The Cochrane Collaboration; 2011 [cited March 2011]. Available from: www.cochrane-handbook.org 2012.

[12] Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. BMJ. 2003;327:557–560.

[13] Franzon R, Guimarães LF, Magalhães CE, et al. Outcomes of one-step incomplete and complete excavation in primary teeth: a 24-month randomized controlled trial. Caries Res. 2014;48:376–383.

[14] Lula ECO, Monteiro-Neto V, Alves CMC, et al. Microbiological analysis after complete or partial removal of carious dentin in

primary teeth: a randomized clinical trial. Caries Res. 2009;43:354–358.

[15] Orhan AI, Oz FT, Orhan K. Pulp exposure occurrence and outcomes after 1- or 2-visit indirect pulp therapy vs complete caries removal in primary and permanent molars. Pediatr Dent. 2010;32:347–355.

[16] Rando-Meirelles M, Tôrres L, Sousa M. Twenty-four months of follow-up after partial removal of carious dentin: a preliminary study. Dentistry. 2013;3:1122–2161.

[17] Ribeiro C, Baratieri L, Perdigão J, et al. A clinical, radiographic, and scanning electron microscopic evaluation of adhesive restorations on carious dentin in primary teeth. Quintessence Int (Berlin, Germany: 1985). 1999;30:591–599.

[18] Foley J, Evans D, Blackwell A. Partial caries removal and cariostatic materials in carious primary molar teeth: a randomised controlled clinical trial. Br Dent J. 2004;197:697–701.

[19] Phonghanyudh A, Phantumvanit P, Songpaisan Y, et al. Clinical evaluation of three caries removal approaches in primary teeth: a randomised controlled trial. Community Dent Health. 2012; 29:173–178.

[20] Mattos J, Soares GM, Ribeiro Ade A. Current status of conservative treatment of deep carious lesions. Dent Update. 2014;41:452–454.

[21] Schwendicke FF, Frencken JE, Bjørndal L, et al. Managing carious lesions: consensus recommendations on carious tissue removal. Adv Dent Res. 2016;28:58–67.

[22] Opal S, Garg S, Dhindsa A, et al. Minimally invasive clinical approach in indirect pulp therapy and healing of deep carious lesions. J Clin Pediatr Dent. 2014;38:185–192.

[23] Oliveira EF, Carminatti G, Fontanella V, et al. The monitoring of deep caries lesions after incomplete dentine caries removal: results after 14–18 months. Clin Oral Invest. 2006;10:134–139.

[24] Ritter AV, Browning WD, Swift J, et al. Critical appraisal. Partial caries excavation. J Esthet Restor Dent. 2012;24:148–152.

[25] Maltz M, Moura M, Jardim JJ, et al. Partial caries removal in deep lesions: 19–30 months follow-up study. Rev Facul Odontol Porto Alegre. 2010;51:20–23.

[26] Schwendicke F, Stolpe M, Meyer-Lueckel H, et al. Cost-effectiveness of one- and two-step incomplete and complete excavations. J Dent Res. 2013;92:880–887.

[27] Casagrande L, Bento LW, Dalpian DM, et al. Indirect pulp treatment in primary teeth: 4-year results. Am J Dent. 2010;23: 34–38.

[28] Schwendicke F, Meyer-Lueckel H, Dörfer C, et al. Attitudes and behaviour regarding deep dentin caries removal: a survey among German dentists. Caries Res. 2013;47:566–573.

[29] Oen KT, Thompson VP, Vena D, et al. Attitudes and expectations of treating deep caries: a PEARL Network survey. Gen Dent. 2007;55:197–203.

[30] Schwendicke F, Stangvaltaite L, Holmgren C, et al. Dentists' attitudes and behaviour regarding deep carious lesion management: a multi-national survey. Clin Oral Investig. 2010;5:1–8.

[31] Alaçam T. Evaluation of a tactile hardness test in indirect pulp capping. Int Endod J. 1985;18:274–276.

[32] Bjørndal L, Demant S, Dabelsteen S. Depth and activity of carious lesions as indicators for the regenerative potential of dental pulp after intervention. J Endodont. 2014;40:S76–S81.