



Partial or total removal of carious tissue: a current approach

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Abstract

Considering extensive caries lesions, a variety of techniques are used for caries removal. However, there are controversies in literature about the real need for the total removal of this tissue, since the inner portion of dentin, affected by dental caries, is able to remineralize when suitable cavity sealing is carried out. Since, sealing promotes the disruption of metabolic circuit of remaining microorganisms, preventing the progression of the lesion, many studies have recommended the partial removal of carious tissue. Therefore, the aim of this study was to present the scientific evidence in literature on the clinical applicability of total or partial caries removal and to discuss the variants that influence the results of each one of these treatments.

Key words: Alternative restorative treatment; dental caries; dentin; dental restoration; stepwise excavation

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Remoção parcial ou total do tecido cariado: uma abordagem atual

Resumo

Considerando as lesões extensas de cárie, uma grande variedade de técnicas é utilizada para a remoção do tecido cariado. Entretanto, existem controvérsias na literatura quanto a real necessidade da remoção total desse tecido, tendo em vista que, quando um adequado selamento da cavidade é realizado, a porção mais interna da dentina afetada pela cárie é passível de remineralização. Por isso, muitos estudos preconizam a técnica de remoção parcial por promover a interrupção do circuito metabólico dos micro-organismos remanescentes, impedindo a progressão da lesão de cárie. Assim, o objetivo do presente estudo foi apresentar evidências científicas da literatura sobre a aplicabilidade clínica de se remover completa ou parcialmente o tecido cariado e discutir as variantes que influenciam os resultados de cada um desses tratamentos.

Palavras-chave: Preparo da cavidade dentária; cárie dentária; dentina; restauração dentária; tratamento expectante

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Introduction

The treatment of extensive caries lesions, in teeth with vital pulp, is a challenge for dentists given that the technique used for the mechanical removal of decayed tissue increases the risk of cavity extension and pulp exposure, becoming difficult to determine how much carious dentin must be removed [1,2].

When restorative treatment is indicated, conventional dentistry recommends the total removal of carious dentin to avoid lesion progression [3,4]. This technique is usually performed in two stages in order to reduce the risk of pulp exposure during first excavation and to promote physiological reactions in the pulp-dentin organ for the deposition of tertiary dentine [4].

Since the evidence that a less invasive approach determines a more favorable condition for pulp repair, eliminating drawbacks of a two-sessions treatment, with the possibility of pulp exposure in subsequent clinical section, an alternative technique has been proposed: partial removal of decayed tissue and final restoration in a single session [5]. Furthermore, in the partial removal technique, the deepest and little infected layer of the carious dentin is maintained, without compromising the treatment success [6,7]. Some studies have shown that the inactivation of carious lesions is likely to be achieved by sealing the remaining tissue, once it impairs the communication between bacteria and the oral environment, promoting the breakage of substrates [8,9].

However, the correct diagnosis of the pulp condition prior to the removal of dentin tissue from extensive caries lesions is crucial, since the success of any therapy depends on a favorable pulp response. Thus, regardless of the technique (total or partial removal), clinical vitality criteria should be rigorously evaluated and teeth with indicative signs of irreversible pulp inflammation, with history of spontaneous pain or with radiographic evidence of periapical involvement or pulp degeneration, should be excluded [1].

Retrospective [10-12] and prospective [13,14] observational studies have shown that the partial removal of carious tissue does not prevent remineralization of the remaining carious dentin, which has been detected by microhardness tests [15] and radiographic analysis [16]. However, even if the partial removal of the decayed tissue demonstrates high success rates, there are still doubts regarding which is the best technique for the treatment of extensive caries lesions. This is because, in the partial removal technique, not all the decayed tissue is removed from the cavity floor and the axial walls during the cavity preparation, representing areas of reduced adhesion due to the formation of gaps, which would lead to the impairment of definitive restorative treatment [1].

In this context, the aim of this study was to present scientific evidence, based on controlled clinical trials carried out during the last 20 years (Table 1), regarding the clinical applicability to totally or partially caries removal. In addition, this study aimed to discuss the variables that may influence the results of each of these treatments.

Table 1. Characteristics of controlled clinical trials involving partial or total caries removal conducted over the past 20 years.

Author (Year)	Study design	Study population	Follow-up period	Results found
Leksell et al. ⁵ (1996)	Multicentre RCT in which 64 primary molars were submitted to expectant treatment (TE, 2 sessions) compared to the control group (n=70), whose treatment was complete caries removal	116 participants aged 6-16 years	24 weeks	(70%); 18% of teeth (ET) showed pulp exposure compared to the control group (70%)
Mertz-Fairhurst et al. ³³ (1998)	RCT in which 312 permanent teeth with caries only in enamel were submitted to partial caries removal in one session (n=156) and sealed with resin sealants; and the others (CG) were submitted to total caries removal and restored with amalgam (n=79) or with amalgam adhesive (n=77)	123 participants aged 8-52 years	10 years	14% of teeth that received sealant showed failures; 2% showed failures in restorations with adhesive amalgam and 17% showed failure when restored with amalgam
Ribeiro et al. ²² (1999)	RCT in which 48 primary molars were submitted to partial caries removal in one session (n=24) and total caries removal (n=24)	38 children aged 7-11 years	12 restorative treatment and after exfoliation of primary teeth	No statistical difference was observed in both groups
Foley et al. ²¹ (2004)	RCT comparing the effectiveness of alternative restorative materials: GIC (n=43) and copper-based cement (n=36, restored with both cements) submitted to partial caries removal in one session; and others (n=41) submitted to complete caries removal in a total of 120 teeth	44 children aged 4-9 years	24 months	Higher abscess formation in teeth treated with copper phosphate cement was observed; Therapy failure: 23% restored with GIC; 33% of those who received the copper phosphate cement and 22% of those submitted to treatment for complete caries removal

(continue)

Table 1 (conclusion)

Author (Year)	Study design	Study population	Follow-up period	Results found
Marchi et al. ¹⁵ (2006)	RCT in which 27 primary molars were treated by indirect pulp therapy in one session, and 12 received pulp protection with calcium hydroxide (G1) and 15 only restoration with Vitremer® (G2)	17 children aged 4-9 years	48 months	G1 showed a 88.8% success rate whereas G2 showed 93% success rate, with no statistical differences between them
Pinto et al. ³⁴ (2006)	CCT in which 42 primary molars received indirect pulp treatment in a single session: 20 received pulp protection with calcium hydroxide and 20 did not receive pulp protection	20 children aged 4-7 years	4-7 months	Evaluations were performed in 39 teeth by reopening after 4-7 months. Both groups showed reduction in bacterial counts, with no differences between them.
Falsteret al. ³⁵ (2002); Casagrande et al. ³⁶ (2009)	(n=25) RCT in which 48 primary molars were submitted to partial caries removal in one session, coated with calcium hydroxide (n=23) or coated with adhesive system (n=25)	21 children aged 4-11 years	48 months	83% of teeth treated with calcium hydroxide and 96% of teeth treated with adhesive system showed successful treatment after clinical and radiographic evaluation
Büyükgüral e Cehrelî ³⁷ (2008)	RCT in which 240 primary molars were submitted to partial caries removal in one session, and 180 received only restorations with resins and 60 received pulp protection with calcium hydroxide and amalgam	97 children aged 5-10 years	24 months	There was no difference between groups
Lula et al. ⁸ (2009)	RCT in which 36 primary molars were submitted to partial caries removal in one session (n=18) and total caries removal (CG, n=18)	30 children aged 5-8 years	6 months	It was observed that there was no failure in the treatment of the test group and 14% of control group showed treatment failure
Franzonet al. ³⁸ (2007); Casagrande et al. ^{39,40} (2008, 2010)	RCT em que 40 molares decíduos foram submetidos à terapia de remoção parcial de cárie em uma sessão; 21 deles receberam proteção pulpar com hidróxido de cálcio e restauração com compósito e 19 apenas a restauração com compósito	21 children aged 4-8 years	60 months	The success rate of therapy was 79.3%, with no statistical difference between groups
Orhanet al. ^{26,41} (2008; 2010)	TCR in which 154 teeth (94 primary and 60 permanent) were submitted to treatment for partial caries removal in one session (n=50); partial caries removal in two sessions (n=49); and others (n=55) to total caries removal (CG)	123 children aged 4-15 years	12 months	The authors concluded that indirect pulp therapy can be performed in one or two sessions in primary and permanent teeth, with no difference between them.
Björndal et al. ⁴² (2010)	RCT in which 314 permanent molars were submitted to partial caries removal in two sessions (TE, n=156) and total caries removal (CG, n=158)	314 participants over 18 years	12 months	17% of ET showed pulp exposure against 29% of CG; 10% of ET presented failures against 12% of CG
Phonghanyudhet al. ⁴³ (2012)	RCT in which 92 primary molars were submitted to partial caries removal in one session (TP) and 92 were submitted to TCR	276 participants aged 6-11 years	12 months	They observed: Pulp exposure in 0% of TP and 2% of TCR; Pulp symptoms in 1% of TP and 2% of TCR
Maltzet al. ^{44,9} (2012, 2013)	RCT in which 299 deep caries lesions were treated by partial removal in one session (n=152) or in 2 sessions (n=147)	233 participants aged 6-53 years	18 months	212 evaluations were carried out, indicating 99 and 86% success rates in groups of removal in one session and two sessions, respectively

Note: RCT (Randomized Controlled Trial); ET (Expectant treatment, partial removal in two sessions); CG (control group); GIC (glass ionomer cement); G1 (Group 1); CCT (Controlled Clinical Trial); TCR (Total Caries Removal Therapy).

Literature review

Traditionally, the procedure used for the treatment of dentin caries is the total removal of the infected tissue, thereby stopping the cariogenic activity, leaving a well-mineralized dentine base ready to receive the restorative material. In some cases, carious tissue removal procedure may expose the pulp. Thus, treatment has a low predictability, requiring interventions such as indirect pulp capping [11].

Conventional indirect pulp capping technique or expectant treatment is the removal of decayed tissue in two clinical sessions. In the first session, initial excavation is carried out aiming to partially remove the softened dentin from the central portion of the lesion and to completely remove the tissue located in the peripheral region. Then, the cavity is temporarily sealed from 45 days to two years [17], in which, the formation of reparative dentin and sclerosis of the affected dentin tubules will occur, so that definitive restorative treatment will be carried out by reopening the cavity to remove all demineralized tissue [10,12].

In a clinical trial conducted by Maltz et al. [16], it was observed that dentin remaining from cavities submitted to caries partial removal in an initial clinical session showed color change, becoming darker and harder in approximately 68.75% of the cases. There was also a significant decrease of *Lactobacilli* and *Streptococci mutans* in the lesion [16], which reduced acid production, greatly contributing to the stoppage of the caries lesion progression.

Leksell et al. [5] found in their study that, in 40% of the single-clinical sessions, with complete-removal cases, there was pulp exposure. While only 17.5% of teeth submitted to expectant treatment showed such an outcome.

Although expectant treatment is considered a conservative treatment, the possibility of pulp exposure when removing the remaining demineralized dentin in a second excavation is imminent. Furthermore, there is the disadvantage of submitting the patient to a new clinical procedure with this technique [2]. More recent studies [7,18,19] propose the treatment of deep caries lesions by partial carious tissue removal, without reopening the cavity, which is called ultraconservative treatment.

The ultraconservative treatment of caries removal is a method where the dentist removes most, but not all, affected dentin and conduces the definitive restoration in the same clinical session. In this procedure, cariogenic bacteria are isolated from their feeding supply, which does not allow pulp aggression, maintaining it vital [1,11].

There is evidence that there is the stoppage of the carious process after restoring the cavity. In their study, Handelman et al. [20] applied sealant in 60 teeth with caries lesions involving dentin. Twenty-nine unsealed teeth were used as controls. Some teeth were submitted to bacterial culture at time intervals ranging from one week to two years. They found a substantial reduction in the number of cultivable microorganisms in sealed lesions when compared to unsealed control teeth. In addition, the authors observed bacterial reduction rate within two weeks after treatment.

Al-Zayer et al. [11] carried out a retrospective study that evaluated 187 posterior teeth in 132 patients treated with indirect pulp capping. An affected dentin layer was left to prevent pulp exposure. Through clinical and radiographic assessment for a period from two weeks to 73 months after treatment, of the 187 teeth, only nine (4.8%) had pulp complications, making success rate of 95% of cases.

The ultraconservative therapy of deep caries lesions recommends the total removal of the carious tissue only from the cavity sidewalls. Removal is partial in the pulp and axial walls aiming to a perfect sealing of the cavity, which in most cases, is sealed with adhesive materials. Although pulp floor and axial walls represent areas of reduced bond strength, if the affected remaining dentin is properly lined with protective material, these fluids do not penetrate into dentinal tubules, preventing sensitivity and allowing better adhesion of the restorative material [17,21].

Ribeiro et al. [22] reported that there is no consensus about the need of a second clinical session to remove remaining carious dentin. The article reviewed studies that evaluated the effect of the caries-lesions partial removal as temporary or definitive treatment, and the pulp response or the progression of caries lesions in primary teeth. The results showed that partial removal, carried out in a single session, is more effective than in more sessions. Such treatment allows the inactivation of caries lesions, reducing the presence of microorganisms in the dentin and the risk of pulp exposure during reopening and excavation of the remaining carious tissue. Authors also reported that the effectiveness of partial caries removal in one session supports the indication of this technique as the most appropriate treatment for primary teeth.

Ferreira et al. [23], in a systematic review, analyzed which would be the ideal limit for the removal of carious tissue during the treatment of a carious lesion. They searched for randomized clinical trials published between 2000 and 2010 on total or partial decayed tissue removal. As a result, three relevant articles were selected. After the full reading, it was suggested that minimally invasive procedures in dental tissues are a viable option for the treatment of caries lesions. The partial or non-mechanical caries lesions removal favors the stoppage of the cariogenic process.

Thompson et al. [1] reported that the literature supports the premise that the maintenance of a carious dentin layer after excavation does not represent a problem for the treatment of extensive caries lesions, since studies have shown that cariogenic bacteria, as isolated from feeding supply by restoration, die or remain latent and do not represent a risk for dental tissues. Therefore, there is no risk of pulp exposure during the removal of carious tissues.

Ricketts et al. [18] tested the null hypothesis that no difference was observed in the incidence of pulp damage, caries progression and longevity of restorations regardless of whether caries removal had been minimal (ultraconservative) or complete. Randomized clinical trials and controlled clinical trials on the partial or complete removal of caries lesions in restored permanent and deciduous teeth were

compared. After analysis, the hypothesis of the lack of difference in the incidence of pulp damage, regardless of whether caries removal was partial or total, was rejected. These authors suggested that the partial caries removal is preferable, considering the risk of pulp exposure, but further studies should be carried out to determine such treatment protocol.

Dalpian et al. [24] evaluated dentin microhardness of primary teeth submitted to indirect pulp capping therapy after partial caries removal. After caries removal, primary molars were restored with a self-etching primer followed by filling the cavity with composite resin. From this sample, 10 teeth were coated with calcium hydroxide prior to sealing, while 7 were left without coating. After exfoliation, they compared the dentin microhardness in the deepest part of the cavity and concluded that the primary teeth that had partially removed carious lesion showed similar hardness regardless of the coating used.

Gu et al. [25] studied the *in vivo* effect of acid attack on cariogenic bacteria present in dentin after partial caries removal in 28 decayed permanent teeth. These teeth were randomly divided into two groups, one received acid etching and the other group was not etched before restoration. The number of bacteria and their activity were assessed by PCR (polymerase chain reaction) and RT-PCR (real time quantitative PCR). Although no significant differences between groups were found, this study suggests that acid etching in the affected dentin prior to adhesive restoration can, directly or indirectly, have an inhibitory effect on the cariogenic activity caused by residual bacteria.

Orhan et al. [26] compared the results of indirect pulp capping therapy in one or two sessions and also if the operator decides, successfully, when to stop removing caries without exposing the pulp. The study involved a total of 154 teeth (94 second primary molars and 60 first permanent molars) and included 123 patients aged 4-15 years. Teeth were randomly selected and treated in one indirect pulp therapy session, two indirect pulp therapy sessions or direct complete excavation. Clinical and radiographic analysis were performed at intervals from 3 months to 1 year and they concluded that indirect pulp therapy can be performed in one or two sessions in primary and permanent teeth, with no differences between procedures.

Alves et al. [27] evaluated radiographic results after partial removal of carious dentin held in deep caries lesions over 10 years. Radiographic density changes in the radiolucent area under restoration were quantitatively compared to control areas using digital subtraction radiography. They concluded that sealing of the carious dentin stopped caries process and promoted the deposition of tertiary dentin with induced mineral gain in the radiolucent area.

Lula et al. [8] examined the microflora of primary teeth treated by total or partial removal of carious dentin. Primary molars with acute carious lesions on the inner half of the dentin and vital pulp were randomly divided into two groups of 16 teeth each: in the first group, total caries removal was performed with caries detector dye; in the second group,

partial caries removal technique was used, in which carious dentin was completely removed from the dentin-enamel junction and side walls, while the necrotic carious dentin of the cavity floor was removed only superficially. Teeth were lined with calcium hydroxide cement and restored with composite resin. Dentin samples were collected after 3-6 weeks from treatment, being stored in thioglycolate. Before sealing, a larger number of microorganisms were detected in teeth submitted to partial caries removal in comparison with the complete removal group. However, after sealing, colonization was similar in both groups. Thus, results show that the persistence of bacteria does not seem to be a reason for reopening cavities after partial caries removal.

Discussion

Traditionally, most operators elect the total caries removal as the most common practice, even with the possibility of pulp exposure, disregarding the knowledge of the dental caries pathogenesis, seeking technicality.

Some studies cited in this review demonstrated that bacterial counts in sealed restorations are dramatically reduced [20]. Maltz et al. [16] reported significant reductions in the counts of viable aerobic and anaerobic bacteria and demonstrated radiographic evidence of a mineral gain in affected areas, concluding that “the complete removal of carious lesions is not essential for the control of this injury”.

Studies on excavation in stages have reported that the residual carious dentin recedes and hardens under temporary restorations during the period between initial excavation and reentry. However, some authors, like Kidd et al. [17], do not consider reentry necessary, taking into account that the remaining dentin does not present risks to the nervous structure and such a procedure would offer the possibility of pulp exposure.

Comparing total and partial removal of carious tissue, partial removal technique produces similar results in terms of caries lesion progression and longevity of restorations, and is preferable in terms of tissue pulp preservation [18]. However, some authors have raised doubts about the treatment effectiveness in the long term, considering the possible persistence of viable bacteria in the dentin viewed after the reopening of teeth submitted to partial removal of carious tissue [4], which leads to current controversies over the need or not to reopen the cavity to ensure that all carious dentin is removed prior to final restoration.

One must take into account that microbiological studies of cavities treated by partial caries removal are hampered by the lack of a control group, since there is no way to compare to the traditional treatment and thus there are still doubts about the fact that bacteria remaining after sealing of the cavity treated by ultraconservative caries removal therapy are able to proliferate regardless of the various materials used, as liners and temporary or definitive restorative materials.

Regardless of the technique adopted, some factors must be considered in this approach such as type of treated

tooth, whether primary or permanent; patient age; type of instrument used for removal of decayed tissue – rotary, ultrasonic tips or manual instruments; type of restorative material used for sealing, as well as the size of the cavity to be treated. According to Schwendicke et al. [19], primary teeth have higher risk of failure when compared to permanent teeth when both are submitted to incomplete excavation. Other authors [28-30] have reported that children, younger than four years, especially those who not cooperate during treatment, demonstrated greater risk of failure regarding the longevity of restorations. In addition, Schwendicke et al. [19] observed that teeth with large cavities, with more than one affected face, showed higher failure rate when compared to others in which only one face is involved, regardless of caries removal therapy adopted – total or partial caries removal.

It was also observed that failures vary with the restorative treatment. One has to keep in mind the fact that certain materials should be used only in certain situations; for example, glass ionomer cement is often used in patients at high risk of caries or in cases when the operator wants to postpone the final restorative treatment that is extensive or expensive [31]. In addition, a recent systematic review [32] confirmed that the risk of failure was significantly lower in teeth submitted to partial caries removal when restored with metal crowns, regardless of the extent of preparation.

Regardless of reported biases, a recent meta-analysis [19] showed that ultraconservative treatment or incomplete excavation in one session presents a reduced risk of failure compared to teeth treated with expectant removal therapy in two sessions. Thus, based on studies included in this review, it was observed that there is a current tendency to adopt the partial caries removal therapy in a single session, followed by restoration with definitive materials (also called ultraconservative therapy) in cases of treatment of extensive caries lesions without pulp involvement.

However, the authors of this study do not rule out that further controlled and randomized clinical trials evaluating the partial or complete removal of carious tissue, taking into account the instruments used for caries removal and clinical preservation of cases, are relevant and necessary. There is a lack in the scientific literature of reviews evaluating such therapies (total or partial removal – expectant or ultraconservative), where the type of caries removal is included as a study or confounding factor, which is essential in the decision of the best protocol during ultraconservative therapy indicated in this review, thus determining the limits of its applicability.

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