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REMINERALISATION OF AFFECTED DENTINE BY DIFFERENT BIOACTIVE MATERIALS IN THE STEPWISE EXCAVATION TECHNIQUE

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Abstract

Introduction. The aim of this study was to assess dentine remineralisation and the possibility to maintain the pulp vitality using several bioactive materials applied in the „stepwise” excavation technique after the carious dentine was removed using the Carisolv™ system (Sävedalen, Sweden).

Methodology. The study was performed on 25 patients with a high caries risk, between 18-34 years old. 30 posterior teeth with acute dental caries were treated using the „stepwise” excavation technique. The patients were divided in three study groups, according to the type of bioactive materials: group 1 (10 acute dental caries) - Ca(OH)₂ liner (Dycal, DeTreyDentsply) and zinc-oxide-eugenol (Caryosan, Spofa Dental); group 2 (10 acute dental caries) - zinc-oxide-eugenol (Caryosan, Spofa Dental); group 3 (10 acute dental caries) - Ca(OH)₂ liner (Dycal, DeTreyDentsply) and glassionomer cement (Ketac Molar Easymix, 3M ESPE). After 6 months the changes of color and consistency of dentine were assessed using both clinical examination and radiographs, and pulp vitality was tested.

Results. In study group 1, the dental vitality was maintained in 100% percent of the cases. In study group 2, a case of chronic pulpitis was recorded. In this study group, the dental vitality was maintained in 90% cases. In study group 3 a case of pulp necrosis associated with a periapical lesion was recorded. This study group also presented therapeutical success in 90% cases.

Conclusion. The „stepwise” technique used after the removal of infected dentine with the Carisolv™ system provided remineralisation of affected dentine in 70-80% percent of the patients and maintained the pulp vitality in 90%-100% cases.

Key words: acute dental caries, „stepwise” excavation technique, Carisolv™, remineralisation, dentine.

Introduction

Acute dental caries, characterized by deep demineralization and high risk of pulp involvement, require a progressive therapeutical approach more adequate in maintaining pulp vitality. The therapy of acute dental caries, using the „stepwise” excavation technique, requires the monitoring of pulp-dentine response to the materials applied for pulp capping. The traditional evaluation uses clinical examination, recording of the changes of dentine color and consistency during therapy. The neodentinogenesis and remineralisation reactions represent an important part of the pulp-dentin protection system, blocking the invasion of bacteria and their co-products. There are two layers of altered dentine with different characteristics: the layer of infected dentine which is heavily contaminated and the layer of affected dentine with a lower degree of bacterial contamination. The infected dentine is soft and yellow and it is characterized by extensive breakdown of the organic matrix. This layer should be removed as its remineralisation potential is lost. The affected layer consists of dentine with medium consistency and some degree of elasticity. In many cases of acute dental caries it is difficult to clearly differentiate the limit between the two layers. Since most of the recent data recommend the maintenance

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Table 1. Results regarding the changes of dentine color in the three groups (in accordance with the different bioactive materials used)

	Group 1/ Ca(OH) ₂ +ZOE	Group 2/ ZOE	Group 3/ Ca(OH) ₂ + glassionomer cement
Dark-brown	50%	30%	30%
Brown-yellow	30%	40%	50%
Unchanged (yellow)	20%	30%	20%

Table 2. Mann Whitney statistical test results when comparing the color changes of the remineralized dentine after 6 months; Group 1-Ca(OH)₂+ZOE; Group 2-ZOE; Group 3-Ca(OH)₂+glassionomer cement

	Group 1	Group 2	Group 3
Group 1	-	0.397	0.516
Group 2	0.397	-	0.776
Group 3	0.516	0.776	-

of the affected dentine, the „stepwise“ excavation technique is focused on its preservation and remineralisation (1-7). For the asymptomatic cases where the pulp exposure seems possible during the treatment, the „stepwise“ excavation technique is the most recommended therapeutical approach. The practical application of this technique presents considerable variations. The acceptable consistency of remaining dentine can vary from soft to hard, while color can vary from yellow to brown. There are also different opinions regarding the optimal moment for the removal of carious dentine.

Acute caries is characterized by periods of intense activity of the pulp tissue alternating with periods of pulp inactivity. Despite the scientific data that highlight the possibility to preserve affected dentine in deep dental caries, most practitioners continue to apply basic surgical principles. Most practitioners are also focused on the complete removal of carious dentine even with the risk of pulp exposure (3). Also, for the treatment of temporary teeth, most dentists perform pulpotomy instead of the stepwise technique. However many researchers are focused on finding efficient therapeutical procedures aimed at stimulating the defensive pulp-dentine complex processes (6,7). There are different recommendations regarding the bioactive materials used in the „stepwise“ excavation technique (calcium hydroxide-based products, zinc-oxycle-eugenol, glassionomer cements). The intervals between treatment stages can also vary, from 4 to 8 weeks or from 2 to 6 months (1-5).

During the last decades new methods have been developed for removal of carious dentine in an attempt to increase the efficacy, speed and patient comfort. In the absence of a clear macroscopic or

microscopic delimitation between necrotic dentine and affected dentine (that can be remineralized), the use of the chemo-mechanical technique based on the Carisolv™ system was proposed.

The aim of study was to assess the capacity of the mentioned bioactive materials to stimulate dentine remineralisation and to preserve pulp tissue vitality, following the removal of carious dentine with the Carisolv™ system.

Methods

The study included 25 patients with ages between 18-34 years, having 30 posterior teeth affected by acute dental caries and high caries risk. The presence of systemic diseases was an exclusion criteria. The patients were informed about the structure and objectives of study and informed consent was obtained. The ethics Committee of the „Gr.T.Popa“ University of Medicine and Pharmacy gave its approval for this study.

The removal of carious dentine was performed with the Carisolv™ system (Sävedalen, Sweden) by a single practitioner. The Carisolv™ gel was applied on the carious dentine surface. The Carisolv gel was applied to cover the carious dentine from the lesion. After 30 seconds, the gel in the carious lesion was agitated using the excavators. The moist material was removed. A new layer of gel was applied and the procedure continued after waiting 30 seconds. The removal of the carious dentine was considered completed when the surface of the dentine had leather consistency.

The treatment was performed using the „stepwise excavation“ approach. Depending on the bioactive materials, three study groups were formed: group 1 (10 acute dental caries) - calcium-hydroxide liner

Table 3. Results regarding the changes of dentine consistency (in accordance with different bioactive materials)

	Group 1/ Ca(OH) ₂ +ZOE	Group 2/ ZOE	Group 3/ Ca(OH) ₂ + glassionomer cement
Hard	50%	40%	30%
Leather	40%	40%	50%
Soft	10%	20%	20%

Table 4. Mann Whitney statistical test results when comparing the consistency changes of the dentine after 6 months; Group 1-Ca(OH)₂+ZOE; Group 2-ZOE; Group 3-Ca(OH)₂+glassionomer cement

	Group 1	Group 2	Group 3
Group 1	-	0.565	0.344
Group 2	0.565	-	0.744
Group 3	0.344	0.744	-

(Dycal, DeTreyDentsply) and zinc-oxyde-eugenol (Caryosan, Spofa Dental); group 2 (10 acute dental caries) zinc-oxyde-eugenol (Caryosan, Spofa Dental); group 3 (10 acute dental caries) - calcium-hydroxide liner (Dycal, DeTreyDentsply) and glassionomer cement (Ketac Molar Easymix, 3M ESPE). The assessment of the affected dentine was performed using two criteria: the color (yellow, brown-yellow, dark-brown) and the consistency (soft, leather, hard) immediately after completing the excavation procedure and 6 months later. The presence of dentine remineralisation was also assessed on the radiographic images. The vitality tests, assessing the vitality of pulp tissue, were performed using an electric pulp test device (Digitest, Parkell Inc, USA). Statistical analyzes of the results were performed using the Mann Whitney test with a significance level $p < 0.05$, two-tailed.

Results

The results regarding the color changes of the remineralized dentine (Leksell indices) are as follows: in study group 1 (Ca(OH)₂ + zinc-oxide-eugenol) the color of the affected dentine remained yellow in 20% of the cases, while color changed in 30% of the cases in yellow-brown, and in 50% of the cases in dark-brown; for study group 2, the dentine color was yellow in 30% of the cases, yellow-brown in 40% of the cases, and dark-brown in 30% of the cases; for study group 3, the dentine color was yellow in 20% of the cases, yellow-brown in 50% of the cases, and dark-brown in 30% of the cases (Table 1).

No significant statistical differences were obtained when comparing the color changes of the remineralized dentine after 6 month in groups 1, 2 and 3 ($p > 0.05$) (table 2).

Table 3 presents the results regarding the consistency changes (Leksell indices) after 6 months.

Study group 1 (Ca(OH)₂ + zinc-oxyde-eugenol) included 50% cases with hard dentine (total remineralisation), 40% cases with leather consistency (partial remineralisation) and only 10% cases with soft dentine (absent remineralisation). Study group 2 (zinc-oxyde-eugenol) included 40% cases with hard dentine (total remineralisation), 40% cases with leather consistency (partial remineralisation) and 20% cases with soft dentine (absent remineralisation). Study group 3 (Ca(OH)₂ + glassionomer cement) included 30% cases with hard dentine (total remineralisation), 50% cases with leather consistency (partial remineralisation) and 20% cases with soft dentine (absent remineralisation).

No significant statistical differences were obtained when comparing consistency changes of the dentine after 6 month in groups 1, 2 and 3 ($p > 0.05$) (table 4)

An analysis of the radiographic images showed that in the study group 1 (Ca(OH)₂ + zinc-oxyde-eugenol) dentine remineralisation was present in 90% of the cases. In this study group, the remineralisation processes were absent in 10% of the cases. This was the lowest percent of failure from all the study groups. In study group 2 (zinc-oxyde-eugenol) dental remineralisation was present in 80% of the cases. In study group 3 (Ca(OH)₂ + glassionomer cement) dental remineralisation was present in 80% of the cases. In Figure 1 is presented the radiographic aspect of demineralised dentine in deep acute carious lesion at 46 tooth. Figure 2 presents the radiographic aspect after 6 months of pulp capping with Ca(OH)₂ and ZOE. It can be seen the area of dental remineralisation associated with neodentinogenesis and retraction of pulp beneath the mesial horn (Figure 2).

Pulp tissue vitality was preserved in 100% of the cases in the study group, 6 months after indirect pulp



Figure 1. Demineralised dentine in contact with mesial pulp horn (arrow). Acute dental caries (tooth 46)

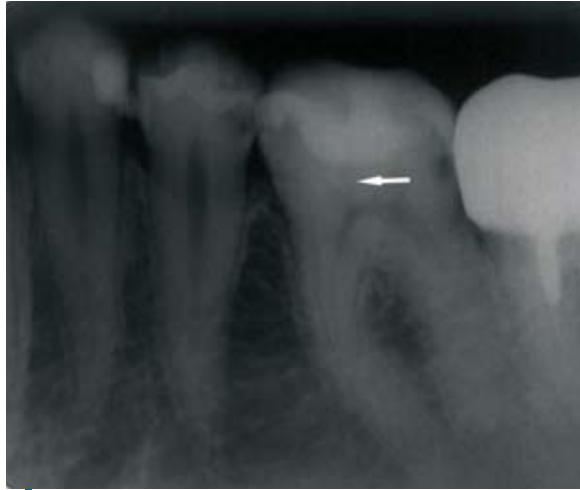


Figure 2. The remineralised dentine, neodentinogenesis and the retraction of mesial pulp horn (arrow), following indirect pulp capping with Ca(OH)_2 and ZOE (tooth 46)

capping with Ca(OH)_2 and zinc-oxide-eugenol. For teeth undergoing pulp capping with zinc-oxide-eugenol, one case of chronic pulpitis was recorded. This study group presented 90% therapeutical success, regarding the preservation of pulp tissue vitality. For teeth undergoing pulp capping with Ca(OH)_2 and glassionomer cement, one case of pulp necrosis associated with chronic apical periodontitis was recorded. For this study group, the failure rate was 10%.

Discussion

Preserving and remineralizing affected dentine minimizes the risk of pulp exposure during the treatment of acute caries. This approach usually requires materials which seal the cavity and medicate the dentine-pulp complex, allowing the preservation of the pulp vitality and apposition of tertiary dentin. These two aspects prove the importance of the temporary restorations in the treatment of acute dental caries.

Remineralisation is not a simple precipitation, but also a result of complex biochemical mechanisms initiated by the pulp tissue. The dentine remineralisation is also performed by odontoblasts through the transfer of mineral salts from the systemic circulation to the mineralization area. In the cases where the remineralisation processes are stimulated by glassionomer cements, the essential elements are represented by fluoride, calcium and strontium. Some glassionomer cements contain a high percent of calcium ions and a low percent of strontium ions, while others contain a high percent of strontium ions. The calcium ions have a major influence in the remineralisation of the affected dentine, while strontium ions have an important antibacterial effect and also stimulate the remineralisation processes. Fluoride ions and strontium ions can penetrate the demineralized dentine and become components of apatite crystals (8). For a short time, glassionomer

cements also release aluminum ions that increase the enamel resistance to acidic attack. Our results regarding the reactions of the pulp-dentine complex, are similar with the results of several studies and support the widespread use of the „stepwise“ excavation technique. Some authors recommend the association between Ca(OH)_2 liners and zinc-oxide-eugenol for at least 3 months, with a 80%-90% success rate, following the environment alcalinisation and odontoblast stimulation by eugenol (1). The calcium ions released by Ca(OH)_2 -based liners influence both passive and active remineralisation by the activation of enzymes associated with the remineralisation processes. Some studies have reported preservation of the pulp vitality in teeth with dentine remineralisation and neodentinogenesis, in 100% of cases, at an interval of 3-6 months (2). In this study, the researchers demonstrated that Ca(OH)_2 -based liners associated with zinc-oxide-eugenol initiate neodentinogenesis and dentine remineralisation in 82,5% of the cases after 8-24 weeks. For the cases treated by indirect pulp capping with zinc-oxide-eugenol, the authors reported a 94% success rate after the removal of temporary restoration (1). Similar success rates were recorded in the „stepwise“ excavation technique using the association of Ca(OH)_2 -based liners with zinc-oxide-eugenol or glassionomer cements (9). Other studies reported a 100% success rate after a 6-12 months interval, following the „stepwise“ technique in acute dental caries (10). Results of some studies proved the association between dentinal remineralisation and a massive decrease of bacterial concentration in carious dentine, after 6 months of „stepwise“ therapy with zinc-oxide-eugenol (11). Similar studies proved the dentine remineralisation following the penetration of dentinal tubules by fluoride and strontium ions (12,13).

Some authors sustain that the use of the “stepwise” excavation technique in deep dental caries plays a

primary role in protecting the pulp-dentine complex (14). When using this technique, the practitioner can arrest the acute progression of the carious lesion, by modifying the cariogenic environment. The soft demineralized dentine is changing in most cases, into a dentine with increased consistency and brown-yellow or dark-brown appearance. The efficiency of the „stepwise“ excavation technique was also assessed after 6-12 months by other authors (15). The clinical changes of demineralized dentine were associated with a high reduction of bacterial contamination. After 6 months, in 90% of the cases the consistency of demineralized dentine increased, while in 20% of the cases there was a complete sterilization of demineralized dentine. Using a standardized scale of consistency and color changes, some authors found the remineralisation of dentine in 94% of the cases after 2-19 months following the „stepwise“ excavation technique (16). The clinical and radiographical changes of the demineralized dentine, following indirect pulp capping with Ca(OH)₂ and zinc-oxide-eugenol, after an interval of 6-7 months, were assessed by different authors (4). The affected dentine became hard dentine in 80% of the treated teeth, while 16,67% of teeth presented demineralized dentine with medium consistency. In the same study, only 3,3% cases were associated with total absence of remineralisation processes.

The „stepwise“ excavation technique is included in the category of new operatory treatment options for dental caries, but some authors claim potential failures in the long-term follow up of the treated teeth (17). Performing a critical review of 23 studies focused on this technique, the authors sustain the use of this technique on a large scale for the treatment of deep acute dental caries. A similar critical review of such studies concluded that the „stepwise“ excavation technique presents positive results in the long-term, regarding the vitality preservation of the pulp-dentine complex (18).

Conclusion

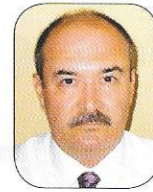
1. The remineralisation of the affected dentine from acute carious lesions performed with zinc-oxide-eugenol or with calcium-hydroxide liner and glassionomer cement in „stepwise“ excavation technique was present in 80% of the cases.
2. After 6 months, 90% of the acute carious lesions treated with calcium-hydroxide liner and zinc-oxide-eugenol in the „stepwise“ excavation technique presented dentine remineralisation.
3. The „stepwise“ excavation technique is an efficient approach in the treatment of acute dental caries maintaining pulp vitality in 90-100% of the cases.

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Questions

Regarding this study:

- a. all the patients had a high cariogenic risk
- b. all patients were old (over 50 years)
- c. there were over 100 patients
- d. There were only two study groups

Regarding the changes of dentine colour accordingly to different bioactive materials:

- a. 50% of the patients in group 1 presented a dark-brown colour
- b. 50% of the patients in group 2 presented a dark-brown colour
- c. 50% of the patients in group 3 presented a dark-brown colour
- d. All the patients had a change in colour

Regarding the changes of dentine consistency accordingly to different bioactive materials

- a. 50% of the patients in group 1 presented a hard consistency
- b. 50% of the patients in group 2 presented a hard consistency
- c. 50% of the patients in group 3 presented a hard consistency
- d. 50% of the patients in group 1 presented a soft consistency

Regarding the pulp tissue:

- a. The pulp tissue vitality was preserved in 75% of the cases
- b. The pulp tissue was assessed 6 months after indirect pulp capping with Ca(OH)₂ and zinc-oxide-eugenol
- c. no cases of chronic pulpitis were recorded
- d. The study group presented 90% therapeutical success