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# Minimally invasive treatment of dental caries – a clinical study

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## Abstract

This study **aims** to compare deep carious lesions of patients treated by the selective removal method of infected dentin to affected dentin(SRAD) and leathery dentin (SRLD).

**Materials and Methods.** Thirty patients aged 20 to 35 were studied. Cases of very deep carious lesions of molars and premolars have been treated. In the first group (RAD), the carious dentin is removed to the affected dentin. In the second group, the carious dentin is removed by the selective removal method of infected dentin to leathery dentin(SRID).

**Results**. In the two groups studied, electric pulp test values decreased statistically significantly in the sixth month of the study.

**Conclusion**. In this study, we found no differences between the two methods for removing infected dentin with the inclusion of ozonation and chemical-mechanical excavation to preserve the vitality of the dental pulp.

***Keywords: selective caries removal; dental caries; chemical mechanical excavation; gaseous ozone***

## Introduction

Dental caries nearly reaching the dental pulp are called deep or very deep caries. In its treatment, accidental opening of the dental pulp is possible [1]. The main question is to what extent to remove the carious mass (infected and affected dentin) to preserve intact and vital dental pulp[2,3].

Modern trends for the treatment of caries processes draw attention to selectively removing infected dentin. It is possible to leave some of the infected dentin only in minimal areas so as not to reveal the dental pulp in cases of very deep caries, reversible pulpitis, and others[4,5].

Several methods are being developed:
1. Removing carious tissue to healthy, normal dentin. Today, this perception is considered obsolete and unnecessary. Studies by Schwendicke and co-authors found that the complete removal of dental caries (infected and affected dentin) to healthy dentin is overtreatment [6,7].
2. Removal of infected dentin to affected (RAD). Only infected dentin is removed. Affected dentin is preserved.
3. Selective removal of infected dentin (SRID) to leathery in one visit and tooth restoration. This approach removes infected dentin in all parts of the carious lesion peripherally of the dental pulp. However, some infected dentin is preserved above the dental pulp at limited points. Therefore, leaving only leathery dentin (the boundary between infected and affected dentin) is desirable. Upon trans-illuminating irradiation, the infected dentin is stained orange. On the same visit, the final restoration is placed [6,7].
To study the removal rate of infected dentin, we conducted a clinical study.

## Aim

This study aims to compare deep carious lesions of patients treated by the removal of infected dentin to affected dentin(RAD) and the selective removal method of infected dentin to leathery dentin (SRID).

## Material And Methods

Thirty patients aged 20 to 35 years were studied. Cases of very deep carious lesions of molars and premolars have been treated. In the study groups, the removal of infected dentin was carried out by chemical-mechanical methods using BRIX 3000@ and hand curettes. The excavation process is controlled by trans-illumination PROFACE, IDENT, Lausanne, Switzerland) and the areas above the pulp with a magnifying technique (operating microscope).
In the first group (RAD), we selectively removed infected dentin to demineralized dentin. The cavity is ozonized for 24 seconds (Ozone Generator Prozone / OZOTOP (TIP TOP TIPS Sarl, Switzerland). Calcium silicate cement Biodentin (Septodont, France), glass-ionomer cement (Fuji LC II, Inter. Corp.Japan), and final composite restoration are placed in one visit (Figure 1).

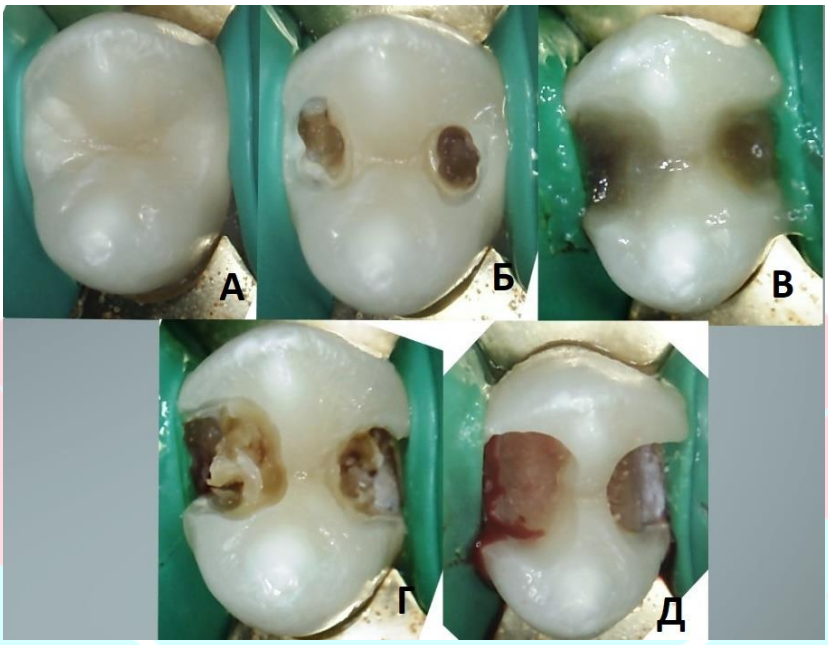


**Figure 1. A case from the first group. Removal of infected dentin to demineralized.**

In the second group (SRID), the infected dentin is removed completely peripherally from the dental pulp. Above the dental pulp, infected dentin (leathery) is left only in some small areas (so as not to reveal the dental pulp). The removal rate of infected dentin was confirmed with trans-illumination. Next, the cavity is ozonized for 24 seconds (Figure 2). Then, Biodentin, glass-ionomer cement, and final composite restoration are placed.

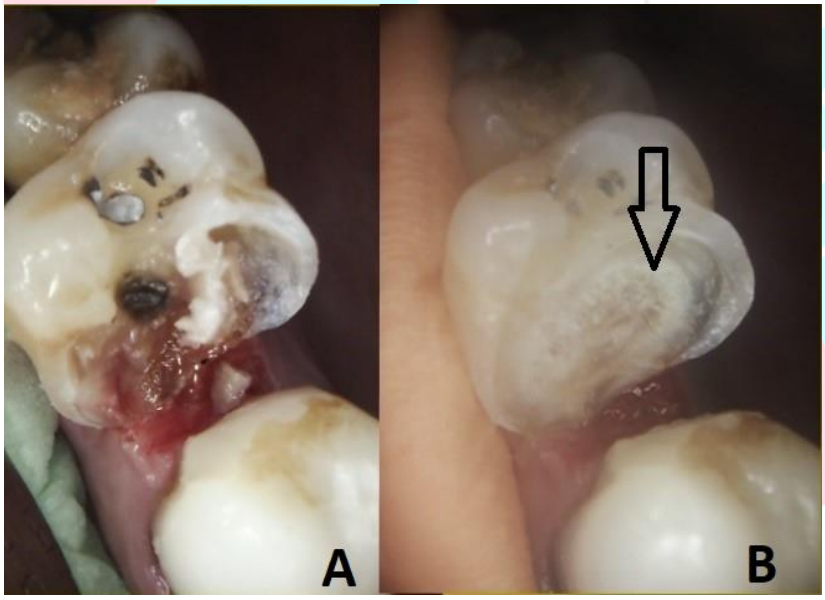


**Figure 2. Case of group two with selective removal of infected dentin to leathery dentin. An arrow indicates the area where there is leathery dentin.**

The results were followed clinically by an electric pulp test after six months and compared with the data obtained during the initial examination after the cavity restoration.

The results obtained were processed statistically by Student's independent t-test.

## Results

Figure 3 compares the results of comparing the electric pulp test immediately after treatment and six months after treatment.

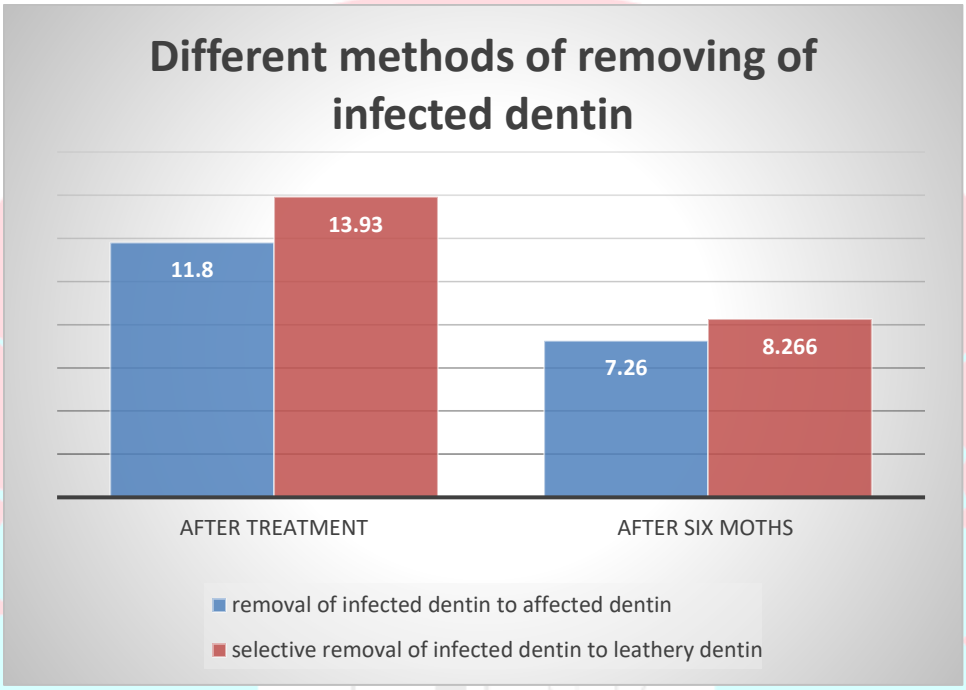


**Figure 3. Comparing the results obtained in both groups immediately after treatment and after six months.**

Table 1 shows the values by which the comparison was carried out. There was no significant difference between the 1st and 2nd group after the treatment, as well as between the two groups six months post-treatment.

**Table 1. The results of statistical processing.**

| Groups | First study | Six months post treatment | Comparison between first and second study |
|---|---|---|---|
| First group RAD | 11.8±3.121 | 7.266±0.298 | p=0.000016 |
| Second group SRID | 13.93±3.343 | 8.26±1.948 | p=0.00001 |
| | *p* >0.05 | *p* >0.05 | |

***A statistically significant difference is indicated in red.***

There was a significant difference between the 1st group after treatment and 6 months post-treatment - p=0.000016. There was a significant difference between the 2nd group after treatment and six months post treatment - p=0.00001.
Electric pulp test values decreased statistically significantly after six months in the two groups studied.

## Discussion

Disputes about where and how much it is necessary to remove from the carious dentin dates back to the last century. The idea of differentiating layers in carious dentin and selectively removing part of it dates back to 1960-1970. Today, there are several options for removing infected dentin, depending on at which layer we stop the excavation: soft, leathery and firm dentin(clinical classification). Progress marks the means of distinguishing the layers of infected dentin during its excavation, as well as the means of treating the dental wound [6,8].
In the methods thus applied, it is important to affect the residual infection in the dentin before restoration so as not to reveal the dental pulp and stop the development of caries. Various methods and means are referred to as means of managing the caries process. In Bulgaria, Lazarova and Dogandzhiyska proved the complete removal of microorganisms from partially left-infected dentin by chemical-mechanical means in the areas closest to the dental pulp in combination with photodynamic therapy [10,11]. In the present study, we applied chemical-mechanical excavation of infected dentin above the dental pulp and ozonation of dentin. Studies by Hamama, Juntavee, and Silva Junior prove that papain enzyme in the chemical-mechanical excavation has antibacterial action [12,13,14]. Therefore, in the present study, we precisely and selectively differentiate the layers of infected dentin by chemical-mechanical excavation. The antibacterial action of the papain enzyme helps preserve the vitality of the dental pulp.
Treating the dental wounds is an important step in the minimally invasive therapy of dental caries [15]. Interesting are the conclusions of Nakrathok and co-authors about the reduction of microorganisms in dentine tubules after the application of 35% phosphoric acid and 0.12% chlorhexidine or dentin conditioner (10% polyacrylic acid). After using these agents, there is a significant reduction of bacteria in dentin tubules, but not their complete removal[9]. The results are compared with a control group. Our study is based on the treatment of dentine wounds with ozone. Our previous studies found that gaseous ozone in 24 seconds destroys all microorganisms in the prepared cavity in deep approximal lesions [16,17]. Other authors found that remineralization improves the hardness of enamel and dentin after gaseous ozone application [18,19]. Ozone administration also improves metabolism in inflamed tissues, enhances tissue oxygenation, and reduces inflammation.
Ozone supports the regenerative processes in the dental pulp.This study concludes that ozone treatment of teeth helps to preserve the vitality of the dental pulp in deep carious lesions almost reaching the pulp). This way, less postoperative pain is detected, and the need for endodontic treatment of the treated teeth is eliminated compared to the traditional methods [21]. In this study, we found no differences between the two methods for removing infected dentin when applying gaseous ozone and chemical-mechanical preparation. Studies by Krunić and co-authors found that ozonation of the carious lesion decreses the number of lactobacilli in infected dentin. Furthermore, by examining the electric pulp test in the present study, we found the preservation of the pulp vitality after sixth month.
It has also been shown that ozone, in addition to antibacterial action, affects the formation of tertiary dentin and the influence of growth factors in predentine. The same are located between the mineralized dentin and the odontoblast layer. In addition, it contains type one and type two collagen fibers and non-collagenous elements such as proteoglycans, glycoproteins, glucosamine glycans, and phosphophorine (specific to the

odontoblast layer) [21]. Phosphophorin, secreted by odontoblasts, is specific to the odontoblast layer, and is related to mineralization [21].
Studies by Jardim and co-authors found that after a 5-year follow-up period, a minimum quantity of infected dentin under the restorations in deep caries lesions did not affect the durability of the restoration [22]. In addition, Amalgam and composite restorations have approximately the same durability, regardless of the technique used to remove carious dentin - selective caries removal or stepwise removal [22].
Treatment of deep and very deep dental caries by indirect pulp capping is a way to preserve the vitality of the dental pulp. However, the chemical-mechanical removal of infected dentin allows precise differentiation of the layers of the carious dentin. The results of our clinical studies prove that it is possible to leave leathery dentin in small areas above the dental pulp to avoid communication (selective removal of infected dentin). Therefore, it is necessary to assess where exactly and how much to leave from the leathery dentin over the dental pulp. It is desirable to use caries indicators and magnifying technique for this purpose. In addition, the application of gaseous ozone for 24 seconds affects the removal of microorganisms and the preservation of the vitality of the dental pulp.

## Conclusion

In this study, we found no differences between the two methods for removing infected dentin with the participation of ozonation and chemical-mechanical excavation to preserve the vitality of the dental pulp.

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