

## The Effect of Full Crown Preparation on Normal and Inflamed Pulp Tissue: An Animal Study

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### Abstract

**Introduction:** Full crown preparation may have adverse effects on pulp tissue. In this study, the effect of full-crown preparation on intact versus inflamed pulp tissue was studied. **Methods:** Fifteen healthy mature cats were randomly selected for this study. The study was performed on four canine teeth of each cat. Cats were anesthetized and then radiographs were taken from the canine teeth. Class V cavities were prepared in cat canine teeth. Soft decayed dentin was placed on the floor of cavities and sealed. After 1 month, all of the samples prepared for crown fabrication. Before crown preparation, an impression was taken in a custom tray. During crown preparation, the remnants of carious dentin were removed and undercuts were sealed by glass-ionomer. After preparation, self-cured acrylic temporary crowns were fabricated in a direct procedure and cemented permanently by glass-ionomer. One week later, teeth of the opposite jaw were prepared in a similar procedure. After 2 months, vital perfusion performed and the pulp tissue was histologically examined. **Results:** There was no significant difference between 4 groups, regarding to histologic status of the pulp. In healthy lower jaw, inflammation was the most frequent but in the other groups, necrosis was most frequent. Also, there was no significant difference between the upper jaw and the lower jaw groups regarding to the frequency of necrosis and inflammation. **Conclusion:** There is no significant difference between intact and inflamed groups regarding the frequency of necrosis and inflammation.

**Key Words:** Animal study, chronic inflammation, crown preparation.

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### Introduction

Tooth preparation procedures for crown fabrication are usually performed on teeth which have extensive caries or restorations. These teeth probably have chronic inflammation and therefore stressed pulp situation may be existed. The process of crown preparation for these teeth may lead to pulp injury and resultantly, pulp vitality would be compromised. The pressure and heat induced during the cutting procedure, cutting depth, wide range amputation of odontoblastic process, drying of dentin, impression, fabrication of temporary crowns, and permanent cementation are some of irritants which occur during crown preparation (1).

Goto and Jordan (2) evaluated the effect of full-crown preparation on the primary pulp. The teeth were cut, the crowns were cemented, and then in various periods of time (immediately after cementation up to 1626 days after cutting), they were extracted and assessed. Inflammatory changes from mild to severe were mostly observed in 2-14 days samples. Reparative

dentin was evident in the cases in which more than 30 days passed compare to cutting time.

Tjan et al. (3) measured and compared thermal changes in the pulp chamber during the fabrication of provisional crowns by direct method using various brands of auto-polymerizing resin systems. The results suggested that the amount of heat transferred in the pulp chamber during the curing of resins may be damaging to the pulp and odontoblasts.

Kim et al. (4) investigated the effects of several restorative procedures on pulp microcirculation in dog canine teeth. Pulpal blood flow decreased steadily as the remaining dentin thickness became smaller with crown preparation without water spray. A careful preparation to a remaining dentin thickness of 1 mm under copious water spray had a negligible effect on pulpal blood flow.

Goldman et al. (5) tested three different types of crown margin preparations to determine whether or not the margin preparation could affect microleakage. Resultantly, all crowns demonstrated significant leakage following the path of dentinal tubules into the pulp which could possibly be one of the causes of pulpal inflammation and even pulpal death under full crowns.

The purpose of this study was to compare the effect of full-crown preparation on intact versus inflamed pulp tissue of cat canine teeth.

## Materials and Methods

Fifteen healthy mature cats saved in the animal saving unit of Mashhad Faculty of Dentistry, were randomly selected for this study. The study was performed on four canine teeth of each cat.

Firstly, cats were anesthetized by using the combination of Ketamine HCl and Xylazine and then radiographs were taken from the canine teeth. All of the experimental teeth had mature apices without any caries, fracture or periodontal problems. For induction of chronic inflammation, method of Mjor and Tronstad (6) was applied but a pilot study was planned to determine the time necessary for stabilization of chronic inflammation.

### *Pilot Study*

For the pilot study, a healthy cat was used which in its upper right canine, a class V cavity prepared by a diamond inverted cone bur (Diadent Group, Burnaby, BC, Canada) using high-speed handpiece along with air-water spray. More than half of the dentin diameter was removed during cavity preparation. Each bur was used for just only one tooth. Soft decayed dentin which had been obtained from newly extracted human teeth was placed on the floor of the cavities and sealed by glass-ionomer filling material (Fuji, G.C. International, USA). Similar procedure were performed on the upper left canine, lower left canine, and lower right canine at the

second, third and fourth weeks, respectively. One week after placing decayed dentin in the latter tooth (lower right canine); vital perfusion was performed on this cat. The pulp tissue was examined by a light microscope with respect to the inflammatory changes. Regarding to the results of pilot study, one month was required for stabilization of the chronic inflammation.

Canines in 15 cats (60 teeth) divided into 4 groups. Study stages performed at 3 sections in each cat.

### *First Section*

Chronic inflammation induced by a method similar to the pilot study in half of the upper and lower canine teeth in all cats.

### *Second and Third Sections*

After one month, all of the samples prepared for crown fabrication. The first step was general anesthesia. In each section, only the teeth from one jaw were prepared for avoiding the disadvantages of the long-term general anesthesia. It was determined accidentally that which jaw was prepared in the second section. Local anesthesia by injection of 2% lidocaine with 1:100000 epinephrine at the apex of each tooth was achieved to obtain similarity by clinical situations. Before crown preparation, an impression was taken by Spidex in a custom tray. Each of the cutting burs, which were diamond with similar surface roughness, was used only for one tooth. Crown preparation performed with a high-speed handpiece and air-water spray. During crown preparation, the remnants of carious dentin were removed and undercuts were sealed by light-cured glass-ionomer.

After preparation, self-cured acrylic temporary crowns were fabricated in a direct procedure and cemented permanently by glass-ionomer cement (Fuji II, G.C. International, USA). One week later, teeth of another jaw were prepared in a similar procedure.

In the study period, a soft diet was used for cats. Two months after the last preparation, the animals were euthanized. Vital perfusion with 10% formalin through common carotid artery was performed. Canine teeth were extracted and saved in 10% formalin for 14 days. Finally, sectioning and staining of samples followed by light microscope examination.

### *Sample Evaluation*

Reactions were classified to complete necrosis, partial necrosis, and inflammation. Regarding to Mjor and Tronstad criteria (6), the severity of inflammatory reactions were classified to mild, moderate, and severe.

Mild reaction includes slight increase in the cellularity adjacent to the cell free zone corresponding to the respected amputated tubules, small irregularities in the odontoblastic layer often associated with displacement of odontoblasts nuclei into the dentinal tubules, and decrease in the width of predentin.

Moderate reaction includes distinct increased in the cellularity, manifestation of granulocytes, localized hyperemia with occasional hemorrhages in the odontoblastic and subodontoblastic region, disruption of odontoblastic layer, and width reduction or total absence of predentin.

Severe reaction includes marked cellular infiltration (mainly granulocytes) in the pulp tissue adjacent to the amputated tubules, localized abscess, hemorrhage, disruption or destruction of odontoblastic layer, and width reduction or total absence of predentin.

Statistical analysis of the results was firstly performed using the Chi-Square test. Considering the fact that in more than 25% of situations, the expected samples were less than five it was decided to conjugate the partial necrosis group to total necrosis group. In repeated test, in more than 25% of situations, the expected samples were less than five, too. So the Exact Fisher Test was used. Also, considering a 95% confidence interval, the data were analyzed using Kruskal-Wallis test.

## Results

Eight cats died during the period of study. The high rate of mortality was regarded to the long-term preservation of cats in cages and change of their diet.

In the remained of 7 cats, samples evaluated histologically, divided into total necrosis, partial necrosis, chronic inflammation, or repair (Table 1). There was no statistically significant difference between 4 study groups, regarding to histologic status of the pulp ( $P=0.28$ ). In healthy lower jaw, inflammation was the most frequent but in the other groups, necrosis was most frequent (Table 2).

There was no statistically significant difference between the upper jaw and the lower jaw groups regarding to the frequency of necrosis and inflammation ( $P=0.112$ ) (Table 3). Also, there was no statistically significant difference between intact and inflamed groups with regarding to the frequency of necrosis and inflammation ( $P=0.29$ ) (Table 4).

**Table 1.** Histologic responses of the pulp

	<b>Total necrosis</b>	<b>Partial necrosis</b>	<b>Healing</b>	<b>Severe inflammation</b>	<b>Moderate inflammation</b>	<b>Mild inflammation</b>
<b>Intact upper jaw</b>	5	-	1	-	-	1
<b>Inflamed upper jaw</b>	4	2	-	1	-	-
<b>Intact lower jaw</b>	2	1	-	2	1	1
<b>Inflamed lower jaw</b>	4	1	-	1	1	-

**Table 2.** Frequency of necrosis and inflammation in studied groups

	<b>Total necrosis</b>	<b>Partial necrosis</b>	<b>Healing</b>	<b>Severe inflammation</b>
<b>Necrosis</b>	83.3%	85.7%	42.9%	71.4%
<b>Inflammation</b>	16.7%	14.3%	57.1%	38.6%

**Table 3.** Frequency of necrosis and inflammation in upper and lower jaw

	<b>Upper jaw</b>	<b>Lower jaw</b>
<b>Necrosis</b>	84.6%	57.1%
<b>Inflammation</b>	15.4%	42.9%

**Table 4.** Frequency of necrosis and inflammation in intact and inflamed groups

	<b>Intact pulp</b>	<b>Inflamed pulp</b>
<b>Necrosis</b>	61.5%	78.6%
<b>Inflammation</b>	38.5%	21.4%

## Discussion

In spite of the past studies (2,7,8) in which teeth immediately were extracted after procedure, in this study, follow-up time was considered 2 months. This long period made the possibility of evaluation of marginal microleakage effects. In addition, it was sufficient time for stabilization of inflammatory reactions, healing or necrotic changes.

Dahl (9) observed severe acute pulp reactions subjacent to the dentinal tubules cut in full crown preparation and stated that these reactions may lead to necrotic changes. In the present study, 67.8% of all teeth had necrotic changes (partial or complete) in the period of study.

There are few similar studies performed on animals. Suzuki et al. (10) in 1994 examined pulpal responses of monkey's teeth following crown preparation, sealing of dentin by 4-META (Parkell Co., Farmingdale, N.Y.) and fabrication of provisional crown restoration. After 10 days, pulpal response was similar to those pulps which were under cavities covered by calcium hydroxide. Additionally, there was no sign of permanent interruption in the odontoblastic layer, severe inflammation and necrosis. Difference between the results of Suzuki et al. (10) study and the present study can be related to the destructive effects of marginal microleakage of crown restorations. 4-META resin application not only seals the dentinal tubules, but also prevents from hydraulic conduction in the dentinal tubules. Furthermore, in Suzuki et al. study (10), provisional crown was fabricated by light-cured resins, but self-cured resins used in this study. The heat produced during curing of these resins may severely damage pulp tissue and odontoblasts (3,11).

Langeland and Langeland (12) studied pulp reactions to crown preparation, impression, temporary crown fixation, and permanent cementation. This study indicated that if initial steps were traumatic (insufficient use of coolant during preparation and utilization of self-cured resins for temporary restorations), permanent cementation could induce chronic inflammation and even necrotic changes.

Higher rate of necrosis in the present study may be related to the long-term period of the study. The passing of time can increase the destructive effects of marginal microleakage and also provides sufficient time for stabilization of inflammatory reactions and necrotic changes. Another reason may be the narrowing of the canal and small diameter of apical foramen in cat's tooth which result in less vascularization and less defense and repair ability as compared with human tooth. Another reason may be the smaller size of cat's canine compare to the studied human's teeth (premolars). Also, crown morphology of cat's canine which has a severe curve in middle third of the lingual aspect results in extensive

removal of dentin during cutting procedure. This condition can be attributed to small human's teeth like mandibular incisors, teeth that should be cut extensively because of supra-eruption, misalignment or to parallel the abutment of bridges, and in cases in which, root surface should be prepared because of gingival recession.

In this study, there was no significant difference between intact and decayed teeth in upper and lower jaw with respect to the frequency of inflammatory changes and necrosis possibly because in intact tooth, mild irritation such as amputation of odontoblastic processes in distance more than 1.5 from the pulp at high speed with air-water spray, does not result in replacement of odontoblasts and production of reparative dentin but also odontoblastic process is removed from dentinal tubules and dead tract is produced. Therefore, there is no protective layer for the pulp other than smear layer. However in tooth that is previously traumatized by carries, chronic process of carries can induce production of sclerotic and reparative dentin and resultantly the permeability of dentin is decreased. This can explain why the pulp of most vital teeth is involved following crown preparation (13,14). Therefore it is may be true that mild irritation can increase a defense compatibility of pulp and production of secondary dentin and also decrease the permeability of dentin against irritants.

In this study, the frequency of necrosis in the upper jaw was more than lower jaw (84.6% versus 57.1%) but this difference was not significant. Its reason may be related to equivalent remaining dentin in lower and upper jaw canine teeth after cutting procedure.

## Conclusion

Crown preparation in teeth with thin remainder dentin such as mandibular anterior teeth or teeth which needs more cutting because of misalignment or supra-eruption, may cause pulp necrosis or irreversible pulpitis but there is no statistically significant difference between intact and chronically inflamed groups with regarding to frequency of necrosis and inflammation. Also, there is no significant difference between the upper jaw and the lower jaw groups with regarding to the frequency of necrosis and inflammation.

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