Histological evaluation of electrosurgery and formocresol pulpotomy techniques in primary teeth in dogs

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The purpose of this study was to compare pulpal and periapical tissue reactions to electrosurgery versus formocresol pulpotomy techniques in the primary teeth of dogs. The study was conducted on 33 primary teeth of three mongrel dogs between the ages of one to three months. Each dog had three teeth treated by Formocresol Pulpotomy with Mechanical Coronal Pulp Removal (FC), three teeth treated by Electrosurgery Pulpotomy with Mechanical Coronal Pulp Removal (ES/MCPR), three teeth treated by Electrosurgery Pulpotomy with Electrosurgical Coronal Pulp Removal (ES/ECPR), and two teeth serving as untreated Controls. Dogs one, two and three were sacrificed performing the pulpotomies at two, four and six weeks, respectively. The pulp, periapical tissue and after surrounding bone were submitted to histological examination and the histological reaction was recorded. The results were fourteen out of 18 unfavorable and zero out of three favorable histological reactions occurred in the FC treated teeth. Six out of 18 unfavorable and one out of three favorable histological reactions occurred in the ES/MCPR treated teeth. Nine out of 18 unfavorable and two out of three favorable histological reactions occurred in the ES/ECPR treated teeth. One out of 18 unfavorable and zero out of three favorable histological reactions occurred in the untreated Control teeth. The conclusion of this study is that of the three experimental groups, the teeth treated by Electrosurgery Pulpotomy with either Mechanical or Electrosurgical Coronal Pulp Removal exhibited less histopathological reaction than the teeth treated by Formocresol Pulpotomy.

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INTRODUCTION

Vital pulpotomy is considered a one-stage procedure and is defined as "the surgical amputation of the coronal portion of an exposed vital pulp, usually as a means of preserving the vitality and function of the remaining radicular portion". Many pharmacotherapeutic agents have been used when performing pulpotomies of primary teeth. Formocresol has been a popular material of choice for use in the pulpotomy procedure, mainly because of its ease in use and excellent clinical success. Yet, despite its excellent clinical success rate, the formocresol pulpotomy has come under close observation because of safety consideration.[1-5] Other medicaments; such as glutaraldehyde, calcium hydroxide, collagen and ferric sulfate, have been suggested as possible replacements for formocresol. Success rates have varied with the agent used and the particular study, with several medicaments contributing to favorable results.

A non-pharmacological homeostatic technique, electrosurgery, has been suggested for the pulpotomy procedure. It is a method of cutting and coagulating soft tissues by means of high-frequency radiowaves passing through the tissue cells. The electrosurgical pulpotomy seems to have merit.[1,2] The self-limiting, pulpal penetration is only a few cell layers deep. There is good visualization and homeostasis without chemical coagulation or systemic involvement. It is less time-consuming than the formocresol approach. The purpose of this study was to compare pulpal and periapical tissue reactions to electrosurgery versus formocresol pulpotomy techniques in the primary teeth of dogs.

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MATERIALS AND METHODS

The study was conducted on 33 primary teeth of three mongrel dogs between the ages of one to three months. Each dog was anesthetized with ketamine hydrochloride, using a dose of 50 mg/kg body weight. Injection was done by intramuscular administration. The crowns of the canines were cut horizontally at the middle third with a fissure bur at low speed. The pulps of the molars were exposed through an occlusal preparation made with a round bur at low speed. Normal saline was used as both an irrigant and coolant during the preparations. The teeth were divided into four groups and treated:

1. Electrosurgery pulpotomy with electrosurgical coronal pulp removal (ES/ECPR)

The coronal pulp was removed with the U-shaped electrode. Short strokes were used to remove the pulpal tissue to the level of the floor of the pulp chamber. Fully rectified current was used and its intensity was adjusted at a setting of three, which caused neither sparking nor tearing of tissue. After homeostasis was achieved, the tooth was restored with reinforced zinc oxide eugenol.

2. Electrosurgery pulpotomy with mechanical coronal pulp removal (ES/MCPR)

The coronal pulp was removed with a slow-speed round bur and a sharp excavator. The pulp stumps were touched with the ball-shaped electrode until complete homeostasis was achieved. Partially rectified current was used and its intensity was adjusted at a setting of three, which caused neither sparking nor tearing of tissue. The electrode in a brushing type of stroke touched the pulpal stumps only momentarily. When additional electrocoagulation was necessary; 10 seconds were allowed to elapse before re-administration, to decrease possible lateral heat accumulation. Reinforced zinc oxide eugenol was used to restore the tooth.

3. Formocresol pulpotomy with mechanical coronal pulp removal (EC)

After the coronal pulp was removed with a slow-speed round bur and a sharp excavator, homeostasis was achieved using sterile cotton pellets, and then a five-minute application of full strength formocresol with a moistened cotton pellet was done. The cotton pellet was removed of excess formocresol by blotting it in a gauze square prior to placement over the pulp stumps. Reinforced zinc oxide eugenol was used to restore the tooth.

4. Controls

This group consisted of untreated dog's teeth, which were used as controls.

Electrosurgical pulpotomies were performed using the Ellman Dent-Surg 90 FFP Electrosurgical Unit. Included with this unit were an autoclavable handpiece, autoclavable bendable electrodes, and an insulated, coated ground plate. Postoperatively, the animals were kept in the animal house, in the Physiology Department, Faculty of Medicine, Alexandria University. They were put on a balanced diet, which consisted of meat, milk, and bread with broth until the time of sacrifice. Dogs 1, 2 and 3 were sacrificed after performing the pulpotomies at 2, 4 and 6 weeks, respectively. The chosen teeth were sectioned with a portion of the surrounding periapical tissue and bone, washed in normal saline, and then dried in 10% formalin for about three days. The specimens were decalcified in 5% trichloroacetic acid, which was changed daily until complete decalcification took place. The specimens were then washed under running water for 24 hours. Paraffin blocks were prepared, sectioned at four microns thickness, and stained with hematoxylin and eosin (H & E). The pulp, periapical tissue and surrounding bone were submitted to histological examination and the histological reaction was recorded.

RESULTS

The Table gives a summary of the specific unfavorable and favorable histological reactions observed with each of the four groups. All of the Untreated Control teeth showed well-formed dentin, cementum, periodontal ligament, and pulpal chamber that included an odontoblastic layer rimming a delicate fibrous connective tissue stroma that contained blood vessels. At six weeks, there was physiological root resorption in two cases that revealed osteoclastic activity surrounding the root with Howships' lacunae and irregularly resorbed areas.

The group treated by Formocresol Pulpotomy with Mechanical Coronal Pulp Removal (FC) demonstrated total pulpal necrosis and periapical irritation. Dense acute chronic inflammatory cells with micro-abscess formation were observed. Two teeth showed internal root resorption, and one tooth revealed advanced external resorption with periapical abscess formation. There was no reparative dentin formation in any area (Figures 1, 2).

The group treated by Electrosurgery Pulpotomy with Mechanical Coronal Pulp Removal (ES/MCPR) demonstrated coagulation necrosis with few acute and chronic inflammatory cells. Reparative dentin formation and dentin bridges were observed six weeks post-treatment. Neither internal root resorption nor periapical or furcal involvement was observed (Figures 3, 4).

The group treated by Electrosurgery Pulpotomy with Electrosurgical Coronal Pulp Removal (ES/ECPR) demonstrated coagulation necrosis and fibrosis with acute and chronic inflammatory cells. Reparative dentin was detected four and six weeks post-treatment. Internal root resorption was evident in only one tooth after four weeks. No periapical or furcal involvement was observed (Figures 5, 6).

DISCUSSION

Evaluation of the electrosurgical technique

According to the present results, both electrosurgery techniques (Electrosurgical and Mechanical Coronal Pulp Removal) induced the formation of

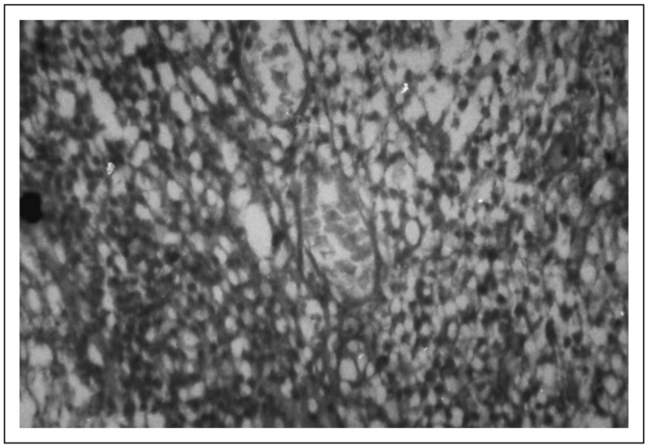

Figure 1. Acellular necrotic zone followed by inflammatory zone in angiomatous stroma with internal resorption [Formocresol Pulpotomy] (H. & E, X450).

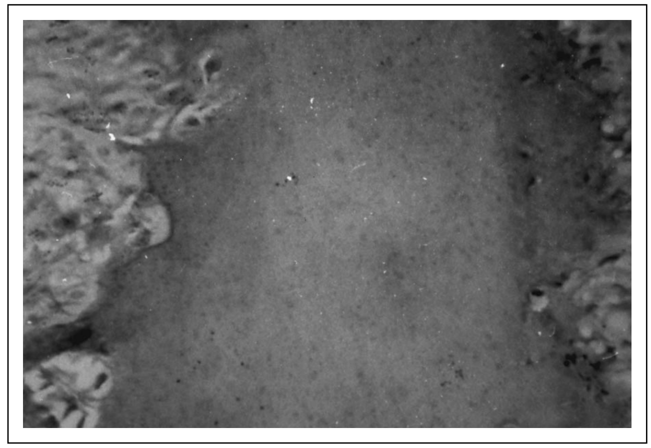

Figure 2. Apical third of the root showing physiological external root resorption and pathological internal root resorption [Formocresol Pulpotomy]. (H & E, X450).

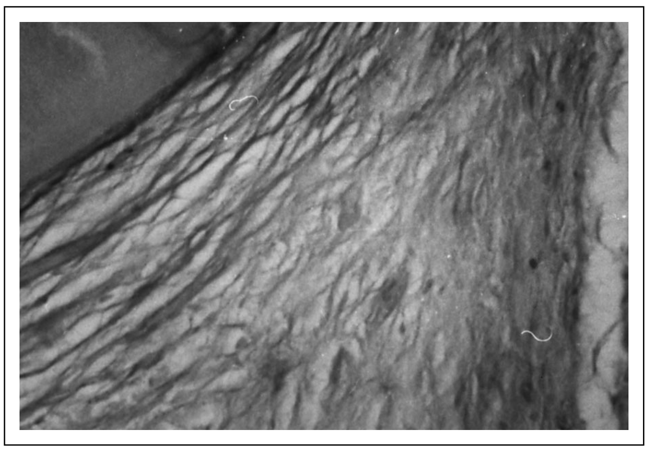

Figure 3. The coronal one-third of the root demonstrating a well-formed dentin bridge followed by a layer of dense fibrous stroma with a delicate angiomatous pulp tissue [Electrosurgical Pulpotomy with Mechanical Coronal Pulp Removal] (H & F, X450).

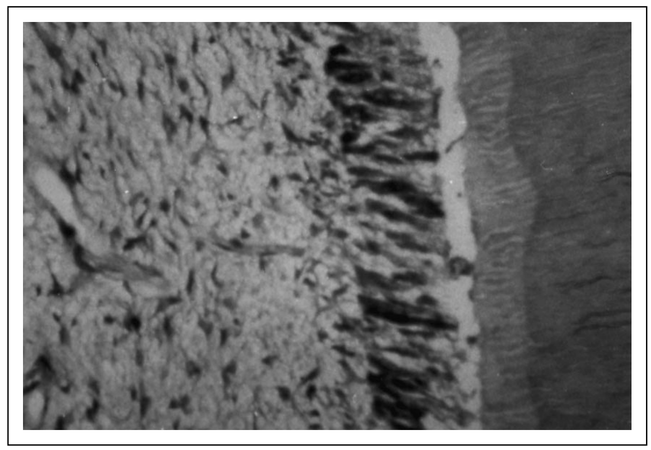

Figure 4. The middle and apical third containing delicate pulp tissue with well-formed vital odontoblasts [Electrosurgical Pulpotomy with Mechanical Coronal Pulp Removal] (H & F, X450).

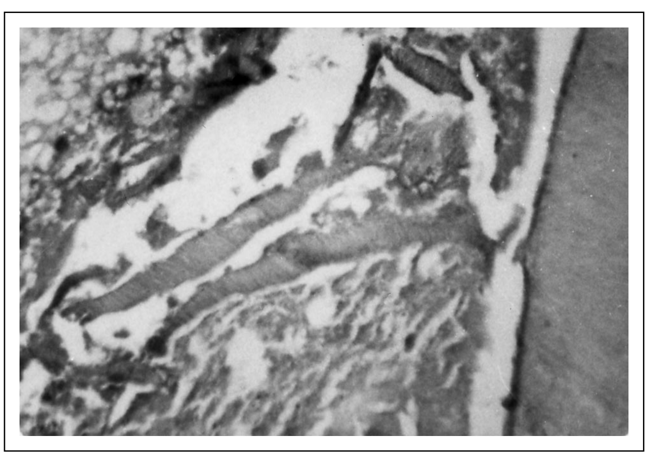

Figure 5. Thin area of necrosis followed by angiomatous fibrous tissue stroma that contains dentinal bridges. Note absence of internal resorption [Electrosurgical Pulpotomy with Electrosurgical Coronal Pulp Removal] (H & E, X450).

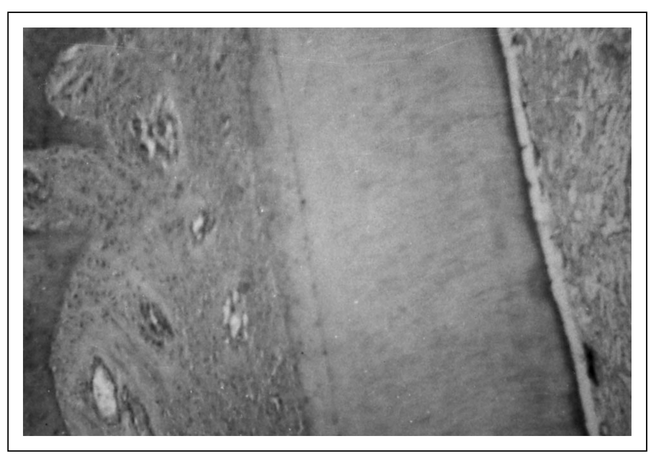

Figure 6. The apical two-thirds revealing fibrotic pulp tissue with an odontoblastic layer rimming regular dentinal wall. The cementum wall is also intact [Electrosurgical Pulpotomy with Electrosurgical Coronal Pulp Removal] (H & E, X450).

reparative dentin in the form of bridging at the pulpal amputation site or along canal walls. This response may represent an attempt by the pulp to heal itself and is in agreement with Reumping *et al.*,[3] Sheller *et al.*[4] and Oztas *et al.*[5] who found evidence of secondary dentin formation. This suggests an effort by a healthy, vital pulp to wall off or heal the area of insult. Increased fibroblastic activity, observed in the middle and apical portions of the roots with early resorption, was a finding reported by many researchers,[3,5,6] and it has been reported that pulpal tissue tries to renew itself with proliferation of fibroblasts. The lack of periapical and furcal involvement suggests electrosurgery to be a viable pulpotomy procedure. This finding is similar to that of Reumping *et al.*,[3] but is in contrast to that of Oztas *et al.*[5] and Shulman *et al.*[2] Perhaps Reumping's use of lower electrosurgical current intensity than Oztas and Shulman explains why his study showed more favorable results.

Regarding the Electrosurgical Coronal Pulp Removal group (ES/ECPR), an acellular periodontal ligament was observed after two weeks and internal resorption was found after four weeks in the specimens. This might have been from an excess amount of lateral heat that can accumulate causing resorption and necrosis. A similar response was noted in the study of Shulman *et al.*[2] Also, heat transfer through the accessory canals on the pulpal chamber floor of the molars may have been responsible for the acellular periodontal ligament. Finally in this group, intense inflammatory cell infiltration was observed in the coronal third of the pulp canals, indicating that complete healing could not be achieved despite dentinal bridges formed. The same finding was found in the study of Oztas.

Histological evaluation of formocresol

In this study, necrosis of the coronal portion of pulpal tissue next to a thin, superficial fixation layer indicated poor and inadequate fixation. This appearance indicates a coagulation necrosis of the tissue at the amputation site and is supported by the fact that true coagulation necrosis is produced by poisons such as phenol, formaldehyde, or mercuric chloride, which denatures the protein of the cells.[7] Ranly[8] stated that it seems that the rationale of fixation is that "we may create a tolerable irritation which replaces an intolerable infection caused by bacteria".

Two formocresol treated teeth in this study demonstrated histologically different, layered zones in the radicular pulp. The coronal zone was completely fixed, while the deeper pulp tissue in the middle zone changed from incomplete fixation with necrosis to normal viable tissue in the apical region. This is in agreement with Doyle,[9] and Rolling *et al.*[10] In contrast; Berger[11] reported complete loss of vitality with fibrous granulation tissue in the apical third of the root canal.

The inflammatory reaction to the formocresol observed in the present study is in agreement with the findings of many investigators.[12,13] Although Beaver[14] did not consider the inflammatory reaction as a histological failure, Ogilvie and Ingle[15] stated that the conversion of an inflamed pulp into a necrotic mass may occur in a matter of hours or years. In this study, during the second and fourth week postoperatively, the apical portion of the pulp was still vital with signs of chronic inflammation. This is in agreement with Spedding,[16] who suggested that the least amount of breakdown of pulpal tissue occurred in the apical area. According to Beaver,[14] the penetration of formaldehyde into the pulp is one of slow diffusion. Initially, it fixes the tissue to which it has been topically applied. As it diffuses apically, areas of coagulation necrosis, dilated blood vessels and inflammation appear.

Internal resorption, small in size, was observed in two teeth. The fact that internal resorption remains small in teeth treated with formocresol might be due to the severe damage to the residual tissue, also destroying its capacity to resorb. This may be attributed to inflammation of the residual pulp. Periapical abscess with resorption of root surface was evident in two teeth. This result coincides with that of Block,[17] who noted that coagulation necrosis were followed by liquefaction necrosis of the pulp. This liquefaction is caused by the release of powerful hydrolytic enzymes from the dying neutrophilic leukocytes.[18]

In the present study, there was absence of reparative dentin formation after formocresol application. This is in agreement with EI-Kateb[19] and Oztas *et al.*[5] On the other hand, treatment of monkey pulps with formocresol has been associated with the formation of reparative dentin.[2,3,20] Human studies have not reported the finding of reparative dentin in association with the formocresol pulpotomy.[2,21] Shulman *et a1.*[2] suggested that possibly the pulpal tissue of monkeys is stimulated easily to produce reparative dentin by any type of trauma including formocresol.

SUMMARY

Based on the histopathological results of the present study, the Electrosurgical Pulpotomy using Mechanical Coronal Pulp Removal (ES/MCPR) produced more favorable results than when using the Electrosurgical Coronal Pulp Removal (ES/ECPR). Therefore, it appears that it is important to reduce the heat generated in removing the coronal pulp tissue by utilizing an electrosurgical pulpotomy technique similar to that advocated by Mack and Dean,[1] i.e. using a mechanical, low-heat producing procedure such as a large round bur in a slow speed handpiece. Also, these results indicate that the Electrosurgical Pulpotomy Technique produced fewer unfavorable and more favorable histological reactions than the Formocresol Pulpotomy Technique. From this histological study, it appears that the Electrosurgical Pulpotomy is a viable alternative to the Formocresol Pulpotomy.

Further areas of investigation should include procedures that require less application of the electrosurgical current and studies of longer post-operative duration. Additional well-documented studies in human populations should be the next step in evaluating the Electrosurgical Pulpotomy as an alternative to the Formocresol Pulpotomy.

CONCLUSION

The conclusion of this study is that, of the three experimental groups, the teeth treated by Electrosurgery Pulpotomy with either Mechanical or Electrosurgical Coronal Pulp Removal exhibited less histopathological reaction than the teeth treated by Formocresol Pulpotomy.

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