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Histological Examination of Furcal Perforation Repair Using Geristore®: A Preliminary Report

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Abstract

Objective: The aim of the present study was to examine the efficacy of a resin-modified glass ionomer (Geristore® syringeable) to repair accidental furcal perforations occurring during root canal treatment in dogs.

Materials and methods: Two beagle dogs (mean age and weight: 15 months and 13.8 kg respectively) with furcal perforations (2 mm x 3 mm) in the mandibular second premolars (P2) were included. Under general anesthesia, supragingival scaling was performed, perforation sites were irrigated with 0.9% sodium hypochlorite and haemorrhage was controlled. Geristore® syringeable was delivered to the perforation site using intra-oral tips. The material was left over the perforation defect for ten seconds and then light-cured according to the manufacturers' instructions. After 4 months, a periodontal examination was performed following which the animals were sacrificed. Jaw segments were prepared and histologically assessed for the presence or absence of hard tissue apposition in the furcal sites where Geristore® was placed.

Results: Upon clinical examination, teeth with furcal perforations repaired with Geristore® presented with bleeding on probing, pus discharge and bone resorption. Histological results displayed severe gingival inflammation with chronic inflammatory infiltrate around the defect and absence of cementum repair.

Conclusion: Within the limits of the present histological experiment, it is concluded that Geristore® is not advantageous for repairing furcal perforations occurring accidentally during endodontic treatment.

Keywords: Furcal perforation; Geristore®, Resin-modified glass ionomer; Root canal treatment; Tissue repair

Introduction

Furcal perforation may occur accidentally during root canal treatment or restorative procedures [1-3]. The type of material selected for repairing furcal perforations plays an important role in the overall success of treatment. Materials used for furcal repair should ideally be nontoxic, non-resorbable, radiopaque, bacteriostatic and capable to provide a seal against leakage from the perforation site [4-6]. Various studies have assessed the efficacy of different materials used for furcal perforations repair; however, with conflicting results [6-11]. Hydroxyapatite and tricalcium phosphate were reported to be biocompatible, nontoxic, and osteoconductive [6,7]. However, new hard tissue formation was not observed with use of these materials for furcal perforation repair. Amalgam has been criticized for its role in repairing furcal perforations due to potential mercury contamination and increased leakage [9]. Mineral trioxide aggregate (MTA) and super ethoxybenzoic acid (EBA) have also been suggested as suitable materials for repairing furcal and root perforations [11,12]. *In vitro* studies [5,13-16] showed MTA to be superior to super EBA, amalgam or resin composite. It has been shown that MTA possesses properties such as biocompatibility, low solubility, ability to create a tight seal between the pulp chamber floor, furcal periodontal tissues and enhanced tissue healing [17-19].

Geristore® syringeable (Den-Mat, Santa Maria, CA) is a dual-cured resin-modified glass ionomer (RMGI). It has been reported to exhibit superior tissue biocompatibility as compared to other materials used for repairing furcal perforations [20]. Histological results suggested that RMGI can adhere to epithelium as well as to connective tissues in subgingival environment [21]. The potential use of RMGI for guided tissue regeneration purposes has been also studied [22]. It was found that RMGI can be placed subgingivally without sutures and may further assist in periodontal wound healing. Scanning electron microscopy analysis showed that human gingival fibroblasts attach to and spread well over Geristore® with relatively normal morphology when compared to other restorative materials [23].

Most studies assessing the efficacy of Geristore® in repairing furcal perforations were either conducted *in vitro* [4,21-24] or published as clinical case reports [25]. The aim of the present case report was to evaluate histologically the efficacy of a dual-cured RMGI (Geristore®) to repair accidental furcal perforations in a dog model.

Materials and Methods

Ethics

The present study was part of a periodontal regeneration study and was approved by the research ethics committee of the King Saud University, Riyadh, Saudi Arabia.

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Animals

In an ongoing endodontic experiment, the furcation area of mandibular second premolar teeth in two beagle dogs (with a mean age and weight of 15-months and 13.8-kilograms respectively) was accidentally perforated by a no. 4 round bur (D&Z, Wiesbaden, Germany) thereby creating a perforation defeat of dimensions, 2 mm x 3 mm. The perforated teeth were excluded from the ongoing project; however, a perforation repair protocol was implemented for the affected teeth in accordance with the "animal care guidance protocol" of the King Saud University, Riyadh, Saudi Arabia.

Treatment

Treatment was performed under general anesthesia, using Ketalar (10 mg/kg body weight; Pfizer Inc, New York, NY) and local anesthesia (2% Xylocaine; Astra, Westborough, MA) with 5 mg/mL epinephrine. The dogs underwent supragingival scaling (twice a week for three weeks) using an ultrasonic scaler (Hu-Friedy, Chicago, IL). The perforated sites were irrigated with 0.9% sodium hypochlorite and hemorrhage was controlled via gentle pressure with sterile cotton pellets on the perforation site. This was followed by lightly drying the cavity with a triple syringe and sterile cotton pellets. Upon completion of non-surgical root canal treatment, a dual-cured resin-modified glass ionomer (Geristore® syringeable, Den-Mat, Santa Maria, CA) was delivered to the perforation site from a syringe using intra-oral tips. The material was left over the perforation defect for ten seconds and then light-cured according to the manufacturers' instructions. The access cavities were sealed with a resin composite restoration.

Postoperatively, the animals were administered with intramuscular injections of Medicycline Vet (5 mg/kg body weight; Norbrook Lab Ltd, County Down, Northern Ireland) once a day for 3 days and placed on a soft diet for 10 days. Plaque control procedures, which included topical application of a 0.2% chlorhexidine digluconate solution (GUM, Chicago, IL) were also performed twice a week for four-months under general anesthesia (as described above).

Euthanasia and jaw sectioning

After four-months, the animals were sacrificed by an overdosage of 3% sodium oentobarbital (WA Butler Company, Dublin, Ohio). The jaw segments containing the root-treated and adjacent teeth were removed en block using an electric saw (Leica SP 1600, Bannockburn, IL) and fixed in 10% formalin for one week.

Histology

After one week, the fixed jaw segments were decalcified in a solution containing equal parts of 50% formic acid and 20% sodium formate for 10 weeks. The decalcified specimens were washed in running water, dehydrated and embedded in paraffin. Seven micrometer thick mesio-distal sections were prepared using a microtome with diamond blade. The sections were stained with Retic and Masson's trichrome stains and submitted to analysis light microscopy analysis.

Results

In both dogs, clinical evaluation prior to sacrifice revealed the presence of moderate to severe gingival inflammation, bleeding on probing, pus discharge and Class-II furcation involvement in the furcal sites where Geristore® was placed.

Light microscopy examination revealed complete absence of hard tissue apposition in the furcal sites where Geristore® was placed (Figure 1a and 2a). The affected areas were devoid of dentin and associated with severe inter-radicular bone resorption in both dogs (Figure 1a and 2a). Higher magnification disclosed extensive chronic inflammatory cell infiltration (Figure 1b-c and 2b-c) and resorptive lacunae (Figure 1c).

Discussion

The present experimental results showed that Geristore® was unable to repair furcal perforations that accidentally occurred during endodontic treatment. The present results are contradictory to previous studies [4,21-25] where excellent results with use of Geristore® to repair furcal perforations were reported. The differences may be due to the fact that previous studies primarily focused on the sealing property of the material without providing histologic evidence of periodontal tissue repair. A possible explanation in this regard may be extracted from the study by Van Dijken and Sjörström [26] that investigated the clinical gingival status and microbial counts in the pellicle in one-year-old subgingival resin-ionomer restorations and compared them with inflammation induced over a 14-day period of experimental gingivitis. The results reported no significant differences in the numbers of bacteria (including *lactobacilli, streptococcus mutans* and

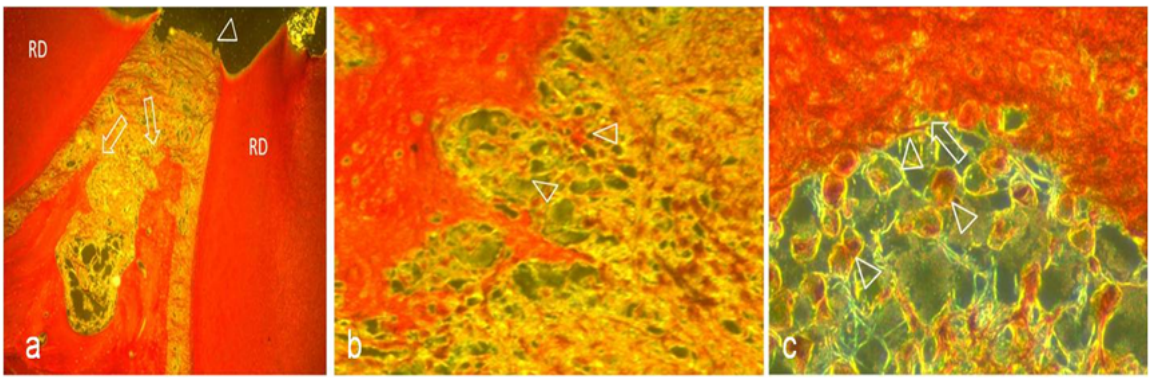

Figure 1: Representative sections obtained from furcal perforation sites repaired with Geristore **(a-c)**. **a**. Masson trichrom-stained section showing no reparative hard tissue apposition (open arrowhead) over the furcation site and severe interradicular bone resorption (open arrow). RD: radicular dentin. (Original magnifications 30X). **b**. Section from another specimen showing multinucleated osteoclast cells (open arrowhead) and inflammatory cells infiltrate separated by a tunnel defect (open arrowhead). (Original magnification 40X). **c**. Modified trichrome-stained section showing multinucleated osteoclast cells (open arrowhead) and resorptive lacunae (open arrow).

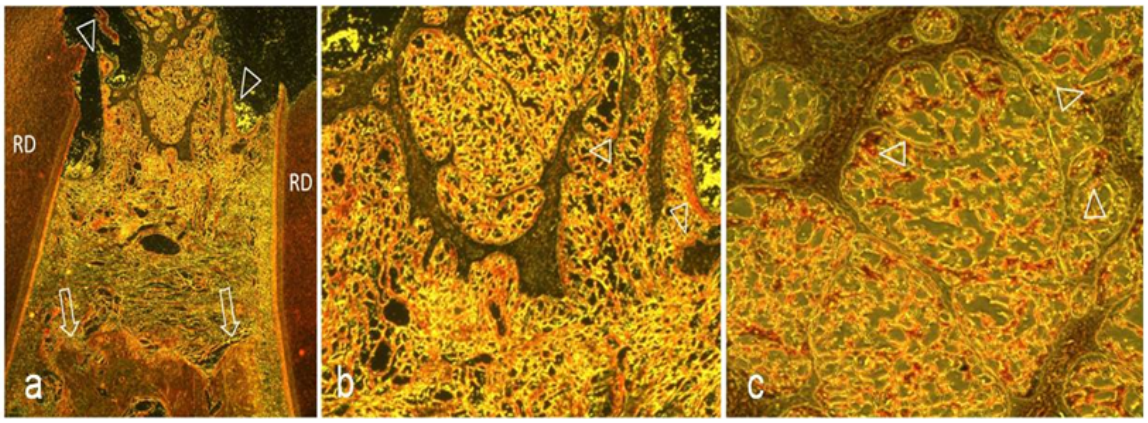

Figure 2: Representative sections obtained from furcal perforation sites repaired with Geristore **(a-c)**. **a**. Retic-stained section showing absence of furcal reparative hard tissue apposition, extensive chronic inflammatory cells infiltrate (open arrowhead) and severe bone resorption (open arrow). RD: radicular dentin. (Original magnifications 30X). **b-c**. Retic-stained section from the same specimen showing large amount of multinucleated osteoclast cells (open arrowhead) and inflammatory cells infiltrate. (Original magnification 40X and 80X respectively).

total *streptococci*) around resin-ionomer restorations placed recently approximately 12-months ago [26]. Although fluoride release from resin ionomer cements is considered advantageous in terms of tissue remineralization; yet the material seems to be inefficient in reducing the bacterial loads around restoration. The present histological study also supports the clinical observations of Fowler and Breault [27] where a patient developed suppuration and periodontal bone loss three months following placement of Geristore® in the furcation area which led to the extraction of the perforated tooth after six-months. It can be hypothesized that an important factor associated with failure of Geristore® to repair furcal perforations is the continued periodontal breakdown due to excessive microbial counts around the restoration; however further studies are warranted in this regard. In an *in vitro* study, Huang et al. [28] investigated the characteristics of perforation-repair materials that are capable of supporting periodontal repair. In their study, cytotoxicity assays were preformed on various perforation repair materials including RMGI. Results demonstrated that growth of cultured human gingival fibroblasts was suppressed by perforation-repair materials during the three-day incubation period. Our results support those of Huang et al. [28] and related studies [29-31] that showed cytotoxic effects of resin ionomers on the periodontium.

Although most *in vitro* studies [4,22-25] reported Geristore® to be effective in sealing furcal perforations; the issue remains controversial. Zakizadeh et al. [32] assessed the efficacy of amalgam, Geristore® and MTA used as intraorifice barriers in a simulated saliva leakage model. It was found that Geristore® barriers leaked significantly more as compared to other materials tested. It is evident that cell growth, proliferation, attachment and matrix synthesis play a critical role in periodontal wound healing and tissues regeneration. It is possible that the sealing efficacy of Geristore® for furcal perforations is temporary and leakage may occur at a later stage due to breakdown by microbes present in the subgingival plaque.

In conclusion, within the limits of this study, it appears that Geristore® should not be the material of choice for repairing furcal perforations accidentally occurring during endodontic treatment.

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