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Rat Subcutaneous Tissue Response to MTA Fillapex® and Portland Cement

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The aim of this study was to evaluate the response of rat subcutaneous tissue to MTA Fillapex® (Angelus), an experimental root canal filling material based on Portland cement and propylene glycol (PCPG), and a zinc oxide, eugenol and iodoform (ZOEI) paste. These materials were placed in polyethylene tubes and implanted into the dorsal connective tissue of Wistar rats for 7 and 15 days. The specimens were stained with hematoxylin and eosin, and evaluated regarding inflammatory reaction parameters by optical microscopy. The intensity of inflammatory response against the sealers was analyzed by two blinded and previously calibrated examiners for all experimental periods (kappa=0.96). The histological evaluation showed that all materials caused a moderate inflammatory reaction at 7 days, which subsided with time. A greater inflammatory reaction was observed at 7 days in the tubes filled with ZOEI paste. Tubes filled with MTA Fillapex presented some giant cells, macrophages and lymphocytes after 7 days. At 15 days, the presence of fibroblasts and collagen fibers was observed indicating normal tissue healing. The tubes filled with PCPG showed similar results to those observed in MTA Fillapex. At 15 days, the inflammatory reaction was almost absent at the tissue, with several collagen fibers indicating normal tissue healing. Data were analyzed by the nonparametric Kruskal-Wallis test (α=0.05). Statistically significant difference (p<0.05) was found only between PCPG at 15 days and ZOEI at 7 days groups. No significant differences were observed among the other groups/periods (p>0.05). MTA Fillapex and Portland cement added with propylene glycol had greater tissue compatibility than the PCPG paste.

Introduction

Successful endodontic therapy depends on correct diagnosis, effective cleaning, elimination of infection and adequate filling of root canals (1). The root filling material will be in contact with the apical tissues and therefore the biocompatibility of dental materials is an important requirement because the toxic components in these materials could produce irritation or even degeneration of the surrounding tissues. Therefore, the biocompatibility of all experimental dental materials that might come in contact with tissues should be examined (2).

Periapical tissue reaction after root canal treatment may be influenced by various factors depending on the chemical nature of the endodontic sealer (1,3). Biocompatibility is one of the most important properties of root filling materials (1,4) because the release of certain substances from sealers may generate different reactions in the periapical tissues and compromise apical repair (1,3). Subcutaneous tissue reaction is one of the in vivo biocompatibility tests that have been used for examining several root filling materials (2,5-8).

Mineral trioxide aggregate (MTA) has been originally developed to seal root-end cavities and root perforations (2,5). However, due to its excellent biological properties and mineralization-inducing ability, this material became being indicated for other clinical endodontic procedures as well. Initially, MTA was not recommended as a root canal sealer because of its poor handling properties (9). However, a new endodontic sealer with a resin sealer based on mineral trioxide aggregate (MTA Fillapex®; Angelus, Londrina, PR, Brazil) was recently developed with this indication (6,8).

On the order hand, great interest has been focused on the evolution of Portland cement (PC) as an alternative to MTA and several experimental studies have compared both materials (10-12). Both materials have comparable antibacterial activity (13,14) and almost identical properties macroscopically, microscopically and by x-ray diffraction analysis (11,13,14). It was also shown that PC and MTA had similar effect on pulp cells when used for direct pulp capping in rat teeth (15).

The aim of this study was to evaluate the response of rat subcutaneous tissue to MTA Fillapex, an experimental root canal filling material based on PC with addition of propylene glycol (PCPG), and a paste containing zinc oxide, eugenol and iodoform (ZOEI).

Material and Methods

After approval of the research protocol by the institutional Ethics Committee (Process #025/2010), 12 male Wistar rats weighing between 200 and 250 g were
randomly assigned to 3 groups: MTA Fillapex, PCPG and ZOEI paste.

Thirty-six polyethylene tubes (1.0 mm inner diameter, 1.6 mm outer diameter and 10.0 mm length) were disinfected with 5% NaOCl for 1 h, washed with saline for 15 min, dried out with sterile gauze and filled with freshly prepared test materials. The materials were prepared in a sterile glass plate by mixing one MTA kit spoon of each powder with two drops of the respective liquids.

The same surgical sequence was used for all animals. They were anesthetized with an intramuscular injection of a mixture of ketamine and xylazine hydrochloride (Dopalen® - 0.4 mL/kg and Anasedan® - 0.02 mL/kg). The dorsal skin was shaved, disinfected with 5% tincture of iodine, and two parallel small incisions (anterior and posterior), approximately 1.5 cm long, were made with a scalpel blade. Two separated pockets were created by blunt dissection, one in the cranial portion and another on the caudal portion, to implant the tube in the subcutaneous tissue in a 5 cm distance of each other. The tubes containing freshly mixed materials were then introduced into the pockets. Care was taken to prevent spilling of the material into the tissue. After implantation, the wounds were sutured.

After 7 and 15 days of the surgery, 6 animals were sacrificed at each experimental period by anesthetic overdose. The tubes were explanted together with skin and connective tissue around them. The samples were immersed in buffered 10% formalin in 0.1 M/L solution for 48 h. Five-micrometer-thick paraffin-embedded tissue sections were made and stained with hematoxylin and eosin.

The histological sections were examined under an optical microscopic, as regards to tissue reaction on the connective tissue around the sealers used in this study (kappa=0.96). The connective tissue response alongside the lateral wall outside of the tube was also evaluated, as a negative control for the technique showing no inflammatory reaction in all experimentation periods. The histological evaluation showed that all the materials caused an intense to moderate inflammatory reaction at 7 days that decreased with time.

After 7 days, 75% of ZOEI group’s specimens received grade 3 inflammation, which consisted of a dense infiltration of inflammatory and giant cells. A bulk of remaining material was also observed in some cases. At 15 days, 58.3% of the specimens demonstrated grade 2 inflammation, in accordance with the tissue repair occurring in these period (Fig. 1).

As much as 66.7% of PCPG group’s specimens were classified as grade 2 after 7 days presenting sporadic inflammatory infiltration cells in some cases without tissue edema. At 15 days, 83.4% of the specimens were graded as 1, with almost absence of inflammation at the tissue, and presence of collagen fibers, indicating normal tissue healing (Fig. 2).

In the MTA Fillapex group, 66.7% of the specimens demonstrated grade 3 inflammation at 7 days, with the tissue presenting infiltration predominantly by macrophages and lymphocytes. At 15 days, 83.4% of the specimens demonstrated grade 2 inflammation, and the presence of fibroblast and collagen fibers were indicating normal tissue healing (Fig. 3).

There was statistically significant difference (p<0.05) between the PCPG group at 15 days and the ZOEI group at 7 days. No statistically significant difference (p>0.05) was observed among the other groups.

These findings are in accordance with the morphological analysis of the specimens in which the MTA Fillapex group showed less inflammation than the ZOEI group. In view of this, both MTA Fillapex and the experimental PC may be considered to present better biocompatibility properties, although tissue repair of the specimens from the PCPG was the most satisfactory in all periods.

Discussion

Implantation of new endodontic materials into the subcutaneous tissues of rats is one of the most suitable methods to determine the local effects and biocompatibility of those (2,7,16-18). The materials used in root-end filling, furcal perforation, and as apical barrier besides the level was defined as p<0.05.
necessary preliminary test, must have their biocompatibility characteristics investigated because the toxic components present in these materials could produce irritation or even degeneration of the surrounding tissues, especially when accidentally extruded into the periradicular tissues (1,5). Several endodontic materials routinely used as root-end fillings materials do not provide complete periodontal regeneration (16).

Several studies have reported excellent results when using MTA in contact with pulp tissue (19-22). MTA has been used in pulp capping, pulpotomy, perforation repairs, and as root-end filling materials with good biocompatibility.

Figure 1. ZOEI group. Intense inflammatory infiltration at 7 days (A) and presence of giant cells close to the residual material at 15 days (B).

Figure 2. PCPG group. Several collagen fibers and almost no tissue inflammation could be observed at 15 days.

Figure 3. MTA Fillapex group. Moderate inflammatory infiltration with the presence of inflammatory cells at 7 days (A) and fibroblasts and newly formed collagen fibers at 15 days (B).
were more biocompatible than the ZOEI paste. This group presented an inflammatory infiltration at 7 days, with the tissue as well as slight formation of collagen fibers. These findings are in accordance with those observed by Gomes-Filho et al. (7) for MTA Fillapex. PC added with propylene glycol demonstrated promising results material in terms of subcutaneous implantation.

The ZOEI group showed a less favorable biological behavior compared with MTA Fillapex and PCPG groups. This group presented an inflammatory infiltration at 7 days, which persisted throughout the study period. At 15 days, bulk of the remaining material from the ZOEI paste was in the tissue as well as slight formation of collagen fibers. These findings are in accordance with those of previous studies (18,25), which tested other cements with zinc oxide and eugenol and found severe inflammatory infiltration up to the latest periods.

For PC, the results of the present study could be used as a preliminary source of information on the biocompatibility of this material for root canal filling. Other experimental and clinical studies are still needed in order to determine the safe clinical indication of these new endodontic cements. In conclusion, MTA Fillapex and the experimental PCPG were more biocompatible than the ZOEI paste.

References
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