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Comparative Analysis Of MTA And Portland Cement - A Review

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Abstract
Context (Background):MTA was developed for sealing of communication between the root canal system & the periodontium especially as a retrograde filling material (1, 2). There are also small quantities of other mineral oxides that assign the physical and chemical properties of the aggregate (eg, bismuth oxide, which aims to assign radio opacity) (3)
Great similarity between MTA and Portland cement has been shown in respect to composition of the basic elements, antimicrobial action and biologic properties, but concern has been expressed about the presence of toxic elements in Portland cement.
Aim: The aim of the study is to compare the use of Portland cement with MTA as root end repair material.
Method: The review of literature was performed by using electronic and hand searching methods for the use of Portland cement and MTA as root end repair material.
Conclusion : Portland cement mixed with radiopacifying agents can become a viable alternative to MTA. Further research is needed to evaluate the behaviour of the radiopacifying agent (ZnO) associated with Portland cement regarding other physicochemical and biological properties of this material.

Key Words
MTA, Portland cement, root end repair, cytotoxicity

Introduction

The main challenge in performing root canal treatment in teeth with necrotic pulps and wide open apices is to obtain an optimal apical seal. Several procedures utilizing different materials have been recommended to induce root end formation. Apexification with calcium hydroxide is the most commonly advocated therapy for immature teeth. Despite its widespread use, a number of disadvantages remain chiefly multiple sittings required and decrease in fracture strength.

Mineral trioxide aggregate (MTA) is widely used in endodontic theapy. MTA has been used as a pulp capping material, root end filling material and perforation repair material[1]. MTA is powder consisting of fine hydrophilic particles of tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide and other mineral oxides which set in the presence of moisture.

Mineral trioxide aggregate (MTA) has been suggested for one visit apexification. The in vitro sealing ability of MTA in teeth with open apices was demonstrated in a laboratory study by Hachmeister et al [2].

MTA offers a biologically active substrate for bone cells and permits cementoblast attachment, growth and production of mineralized matix gene and osteocalcin expression. MTA ability to set is not effected by the presence of blood or serum fluids. Because of its excellent biological properties, low solubility, good marginal adaptation and sealing ability, MTA has been well indicated as a root end filling material.

Review of literature

Carlos et al [20] studied the tissue response to MTA and Portland cement. There were no significant difference regarding inflammatory responses at 7 and 30 days. After 60 days from surgical removal, there were significantly more tissue reaction to the MTA and Portland cement compared to the control group. After 60 days, the fibrous capsule around the Portland cement appeared more organized than tissue surrounding MTA implants.

G.De-Deus and T. Coutinho- Filho[21] studied the use of Portland cement as an apical plug in a tooth with necrotic pulp. The apical 3 mm of the root canal was filled with Portland cement while the remainder of canal was filled with gutta percha. Clinical follow up 1 year later revealed adequate clinical function, absence of clinical symptoms and no signs of periapical rarefaction

Funteas et al [6] analysed samples of MTA and PC for 14 different elements using inductively coupled plasma emission spectrometry. It was concluded that there is no significant difference between the 14 different elements in both PC and MTA

De-Deus et al [8] showed that two brands of MTA and Portland cement created an elevated cytotoxic effect initially that decreased gradually allowing the cell culture to repair. Cell reaction patterns were similar for Pro-Root MTA, MTA Angelus and Portland cement at all experimental periods. The authors concluded that the positive results achieved with the PC were encouraging for its use as an endodontic restorative material with lower cost.

Riberio et al [9] found no in vitro genotoxicity for either MTA or Portland cement. Abdullah [10] reported that Portland cement supported the proliferation of Saos 2 osteosarcoma line cells in vitro and actively stimulated a biological response in these cells through

the production of cytikines and a bone specific protein. These auhors confirmed that it also formed a significant step in development of Portland cement as a restorative material

Discussion

Similarity Of Materials

The chemical composition of MTA is similar to Portland cement, except the presence of bismuth oxide, which is present in MTA. Camilleri et al [3] showed that MTA and Portland cement had the same constituent elements as verified by Energy Dispersive Analysis with X Ray (EDAX) under SEM and also had the same phase constituents verified by X ray diffraction analysis except for bismuth oxide present in MTA. Portland cement and MTA also present the same antimicrobial behaviour, inflammatory tissue response and prostaglandin (PGE2) inhibitory effect on monocytes.

The idea that MTA is Portland cement plus bismuth oxide has been generating a significant body of research in order to evaluate Portland cement as a low cost alternative to MTA. Spanberg [4] was wise in summarizing this background 'the fact responsible to exacerbate this issue is the unreasonably high price of ProRoot MTA in relationship to the inexpensive raw material for manufacturing Portland cement.

Whereas the composition and biological properties of Portland cement were proven to be identical to MTA, the low radiopacity of the Portland cement makes it difficult to visualize on dental radiographs. Thus a radiopacifying agent must be added to Portland cement so that it is visible radiographically.

The addition of bismuth oxide as a radiopaque agent to the basic components of the cement seems to be the main formulation of a commercially available MTA (ProRoot, Dentsply). However adding bismuth oxide to Portland cement as a radiopaque agent would be unlikely, since it is not readily available to the regular clinician.

Zn is an essential trace element that can increase the DNA of osteoblasts resulting in increased bone mass. Many attempts have been made to prepare Zn containing bioceramics. Chia tze kao et al [5] studied the properties of Portland cement mixed with different oxides (ZnO and MgO) to enhance cement performance. The x ray diffraction analysis showed them to be similar to MTA. It is speculated that these divalent (Zn) and trivalent (Mg) metals doping into SiO2-CaO-Al2O3 crystal structure might substitute Ca and Al sites or vacancies without changes to crystal type or macrostructure. Also the setting time of these cements was significantly shorter than that of MTA. This fast set reduces the risk of dislodgement and contamination when used as root end filling material.

MTA is a bioactive silicate cement that is non irritating to periapical tissues and also induces the regeneration of cementum and PDL.White Portland cement has also been proposed as a potential material to create an apical plug in teeth with immature apices. Several studies have examined the similarities between MTA and Portland cement.

It has been reported that MTA and Portland cement appear to be almost identical chemically, macroscopically, microscopically as well as according to x ray analysis except for bismuth.

Mechanism Of Action

The antimicrobial activity of MTA has been explained in terms of the release of OH- ions by creating an unfavorable environment for bacteria to survive. The stimulation of hard tissue deposition probably starts with the release of calcium ions. Both Portland cement and MTA produced calcium silicate hydrate and calcium hydroxide on hydration. Both MTA and Portland cement released a high amount of calcium ions which decreased in amount over the 5 week period.

Cytotoxicity

Previous research has demonstrated that MTA and Portland cement provide good biocompatibility. Saidon et al [7] evaluated rat connective tissue reaction to MTA and Portland cement and observed excellent biological response for both materials.

Camilleri et al evaluated the chemical constitution and biocompatibility of accelerated Portland cement for endodontic use. The Chemical constitution of grey and white Portland cement, grey and white mineral trioxide aggregate (MTA) and accelerated Portland cement produced by excluding gypsum from the manufacturing process (Aalborg White) was determined using both energy dispersive analysis with X-ray and X-ray diffraction analysis. Biocompatibility of the materials was assessed using a direct test method where cell proliferation was measured quantitatively using Alamar BlueTM dye and an indirect test method where cells were grown on material elations and cell proliferation was assessed using methyltetrazolium assay. The chemical constitution of all the materials tested was similar. Indirect studies of the eluants shoed and increase in cell activity after 24 h compared with the control in culture medium ($P<0.05$). Direct cell contact with the cement resulted in a fall in cell viability for all time points studied ($P<0.001$).

One important point in the development of a low cost Portland cement for clinical usage is the concern of the amount of arsenic present in the material. High amount of arsenic have been found in cement dust an alkaline byproduct of cement manufacturing. For the human body, the poisoning by inorganic arsenic can be lethal for oral doses above 60 ppm. Gustavo et al [11] concluded that both MTA and Portland cement displayed very low levels of arsenic release. The negligible amount of arsenic present in Portland cements cannot be seen as a real obstacle for clinical usage

ZnO as radiopacifying agent

Whereas the composition and the biologic properties of Portland cement were proven to be similar to MTA, the low radiopacity of the Portland cement makes it difficult to visualize on dental radiographs.

In this study, the choice of ZnO as a radiopaque agent to be added to the Portland cement is due to its adequate radiopacity, prompt availability to the clinician and previous reports as harmless to the pulp and periapical tissues.

Clinical use

From a practical point of view, MTA and Portland cement can both be used in moist environments. This is an interesting property during the treatment of teeth with necrotic pulps and periapical lesions because one of the problems found in these cases is the presence of tissue fluid exudate.

Caroline et al [12] evaluated the influence of the thickness of mineral trioxide aggregate on sealing ability of root end fillings in vitro. The results of this study suggest that the thickness of 4 mm is most adequate for the use of MTA as a root end filling material. Therefore in this study, Portland cement mixed with ZnO was compacted in apical 4 mm whereas the remainder of canal was filled with gutta percha.

Setting Time

The setting time is one of the most clinically relevant factors. A long setting duration can cause clinical problems because of the cements inability to maintain shape and support stresses during this time period. The setting time of ProRoot MTA is 151 minutes. In contrast, Portland cement mixed with ZnO exhibited significantly shortened setting time (5 min). This fast set reduces the risk of dislodgement and contamination. Moreover the remainder of the canal can be filled with gutta percha in the same sitting.

In the present case, Portland cement mixed with ZnO acted as an efficient apical barrier in the wide open apex of an infected root canal system.

Conclusion

Portland cement mixed with radiopacifying agents can become a viable alternative to MTA. Further research is needed to evaluate the behaviour of the radiopacifying agent (ZnO) associated with Portland cement regarding other physicochemical and biological properties of this material.

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