A comparative Clinical Study of MTA Vs Portland cement as Capping Materials in Pulpotomy of Primary Molars.

دراسة اكلينيكية للمقارنة بين مادتي ثالث أكسيد المعادن الكلي و الأسمنت البروتلندبي في تغطية عصب الأضراس اللبنية

Thesis
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Abbreviations used in current thesis:

MTA = Mineral Trioxide Aggregate
GMTA = gray MTA
WMTA = white MTA
PC = Portland Cement
GPC = gray PC
WPC = white PC
APC = Accelerate PC
FC = Formocresol
FS = Ferric Sulfate
CH = Calcium Hydroxide
ERR = External Root Resorption
IRR = Internal Root Resorption
PR = Periapical Radioluency
FR = Furcation Radioluency
SP = Spontaneous Pain
SS = Sinus or Swelling
EM = Excessive Mobility
CI = Confidence Interval
Introduction

Dental decay in primary teeth remains a considerable health problem. Historically when dental decay had reached dental pulp in primary dentition, teeth were commonly extracted, but this could have deleterious effects on developing oral tissues. Where decay extends to involve the dental pulp, pulp treatment techniques are often used to manage both symptomatic and symptom free teeth. Pulpotomy is the most widely accepted clinical procedure for treating primary teeth with inflammation of coronal pulp without the involvement of radicular pulp (Nadin et al., 2003).

Many medicaments were used in pulp treatment techniques. Formocresol was regarded as the ‘gold standard’ (King et al., 2002).

The use of formocresol has been challenged because of its deleterious effects, potential carcinogenic in action, immune sensitization, mutagenicity and cytotoxicity. This has led for investigations of alternative techniques and materials for more than 30 years. World Health Organization (WHO) – International Agency for Research on Cancer in 2006 also stated that "Formaldehyde is carcinogenic to humans" (International Agency for Research on Cancer, 2004).
With the development of materials which are not only biocompatible but also bioinductive, the emphasis had shifted from fixation or preservation to regeneration of the remaining pulp tissue. One such material which has shown potential for regeneration is Mineral Trioxide Aggregate (MTA). Although it was proved to be an excellent capping material, the main disadvantage of MTA is its highly expensive cost (Roberts et al., 2008).

Since the beginning of 21 century, great interest has been focused on the evolution of Portland cement (PC) as an inexpensive alternative to MTA (Estrela et al., 2000). Several studies have compared both materials (De-Deus and Coutinho-Filho, 2007; Sakai et al., 2009; Steffen and van Waes, 2009; Viola et al., 2011).

The current trial was designed following the CONSORT statement (Moher et al., 2010) to guide practice by comparing MTA versus PC in terms of clinical and radiographic success as pulpotomy medicament of pulpally involved primary molars.

This trial was conducted based on recommendations of a Cochrane systematic review about pulp therapy in primary molars in which the authors recommended that high quality randomized controlled trials (RCTs), with appropriate unit of randomization and analysis are needed to determine the optimum treatment or technique for pulpally involved primary molar teeth (Nadin et al., 2003).
A review compared MTA and PC stated that “Studies to compare MTA and PC as endodontic medicament in pediatric dentistry are necessary and a debate should be encouraged to substitute formocresol by PC” (Steffen and van Waes, 2009).

A Randomized Controlled Trial compared both MTA and PC in pulpotomy of primary teeth and recommended that before unlimited clinical use of PC, further studies are needed (Sakai et al., 2009).

American Association of Pediatric dentistry (AAPD) guidelines 2009 encourages additional research for consistently successful and predictable techniques using biologically-compatible medicaments for vital and non-vital primary and immature permanent teeth (Guideline on pulp therapy for primary and young permanent teeth, 2008).
Review of literature

**Pulpotomy:**

Pulpotomy is the most widely accepted clinical procedure for treating primary teeth with inflammation of the coronal pulp caused by caries with no involvement of the radicular pulp. This technique consists of removing the coronal pulp and preserving the radicular pulp with a medicament. The purpose is to remove the bacterial infection leaving the treated tooth asymptomatic until its exfoliation (Fuks, 2002).

A Cochrane systematic review presented various forms of pulp treatment. Objectives of that systematic review were to assess the relative effectiveness of various pulp treatment techniques in retaining primary molar teeth with decay involving the pulp. The authors searched 8 website databases and key journals were hand searched. Selection criteria were randomized or quasi-randomized controlled trials comparing different pulp treatment techniques (with each other, with extraction or with no treatment) for extensive decay in primary molar teeth. The main outcome measures of importance to the patient and parents are the long term success and freedom from symptoms. Authors concluded that “Based on the available RCTs, no conclusions can be made as to the optimum treatment or techniques for pulpally involved primary molar teeth due to the scarcity of reliable scientific researches” (Nadin et al., 2003).
Medicaments:

Medicaments used in pulpotomy reported in the literature can be classified according to their effect on pulp as follows: materials act by devitalization (formocresol, electro-coagulation), preservation (ferric sulphate, lasers), regeneration (bone morphogenic proteins, collagen, MTA) and materials with arguable action as for example glutaraldehyde (devitalization or preservation) or calcium hydroxide (preservation or regeneration) (Srinivasan et al., 2006). PC also was considered to be a less expensive substitute to MTA as pulpotomy medicament (Sakai et al., 2009; Storm et al., 2008).

(1) Formocresol (FC):

Buckley’s formocresol was first introduced as a pulp medicament in 1904 (Buckley, 1904), and since 1930 (Sweet, 1930) with a 97% success rate, it has been the treatment of choice for primary molar vital pulpotomies. Formocresol produces an area of necrosis in the adjacent pulp tissue with the fixative effect diminishing as it progresses apically. The apical third of the pulp is unaffected, and retains its vitality for an extended time (Heys et al., 1981). It has been the most popular pulp dressing material for pulpotomized primary molars for the past 80 years.

International Agency for Research on Cancer (IARC) classified formaldehydes carcinogenic to humans in June 2004 (International Agency for Research on Cancer, 2004), leaving the profession to look for other viable alternatives to formocresol. An expert working group of
the IARC evaluated the available evidence on the carcinogenicity of formaldehyde, an ingredient in Buckley’s Formocresol solution. Based on the available information, the expert working group has determined that there is now sufficient evidence that formaldehyde causes nasopharyngeal cancer in humans, a rare cancer in developed countries, limited evidence for cancer of the nasal cavity and paranasal sinuses, and ‘strong but not sufficient evidence’ for leukemia (Yamasaki et al., 1994).

Formaldehyde has been shown to be distributed systemically after pulpotomy. Cresol is also locally destructive to vital tissue (Pashley et al., 1980; Ranly and Fulton, 1976)

On the other hand with the development of materials which are not only biocompatible but also bio-inductive, the emphasis has shifted from devitalization or preservation to regeneration of the remaining pulp tissue. One such material which has shown this potential for regeneration is MTA.

(2) Mineral Trioxide Aggregate (MTA):

MTA was developed by Mahmoud Torabinejad at the Loma Linda University, California, USA. It was first described in the dental literature in 1993 (Lee et al., 1993) for repair of lateral root perforations.
Since then, the material has been tested for several applications in dentistry including root end fillings and repair furcal perforations.

In 1995, Ford et al. compared the histological response to MTA and amalgam as repair materials of intentional perforation in the furcations of mandibular premolars in dogs. Authors concluded that MTA was a far more suitable material than amalgam for perforation repair, particularly when used immediately after perforation (Ford et al., 1995).

MTA has been evaluated also in animal models for direct pulp caps. In 1996, Ford et al. examined the dental pulp responses in monkeys to MTA and calcium hydroxide (CH) when used as pulp-capping materials. They concluded that, MTA had the potential to be used as a pulp-capping material during vital pulp therapy (Ford et al., 1996).

Apexification is another use for MTA in dentistry. Shabahang et al. in 1999 compared the efficacy of osteogenic protein-1 and MTA with that of CH in the formation of hard tissue in immature roots of dogs. Results showed that MTA produced apical hard tissue formation. The difference in the amount of hard tissue produced and the degree of inflammation among the three test materials was not statistically significant (Shabahang et al., 1999).
In 1999, an article by Torabinejad and Chivian stated that “MTA had been investigated as a potential alternative restorative material to the presently used materials in endodontics. MTA had shown that it is biocompatible, and promotes regeneration of the original tissues when it is placed in contact with the dental pulp” (Torabinejad and Chivian, 1999).

A review done by Roberts et al. at 2008 showed that MTA has excellent potential as pulpotomy medicament. It had been demonstrated to be biocompatible endodontic repair materials, due to its ability to form hydroxyapatite when exposed to physiologic solutions. The authors of this review illustrated evidence on the success which can accompany the use of MTA in a range of settings including: (i) pulpotomy medicament in primary teeth; (ii) pulp capping agent in young permanent teeth; (iii) apical barrier in immature traumatized permanent teeth; (iv) apical barrier of the coronal root fragment in traumatized permanent teeth with root fractures; (v) repair material for perforation and resorptive defects in permanent teeth (Roberts et al., 2008).

**Properties of MTA**

*I-Chemical composition and structure.*

MTA contains fine hydrophilic particles of tricalcium silicate, tricalcium aluminates, tricalcium oxide, silicate oxide and bismuth oxide. Gypsum is also a constituent of MTA.
There are various commercially available MTA products such as:
(i) Gray ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK, USA);
(ii) White ProRoot MTA (Dentsply Tulsa Dental);
(iii) MTA-Angelus (Solucoes Odontologicas, Londrina, Brazil);
(iv) MTA-Angelus Blanco (Solucoes Odontologicas); and
(v) MTA Bio (Solucoes Odontologicas) (Srinivasan et al., 2009).

Camilleri et al. in 2005 determined the constitution of white and gray MTA before and after mixing with water. White and gray MTA showed to be composed primarily of calcium, silicon, bismuth and oxygen, with the gray MTA also having small peaks for iron and aluminum. They concluded that MTA shown to have broadly similar constitution to ordinary PC except for the addition of bismuth compounds (Camilleri et al., 2005a). Similar conclusion obtained by Roberts et al. in 2008 (Roberts et al., 2008).

When comparing the ProRoot MTA forms to MTA-Angelus, Song et al. reported that MTA-Angelus had a lower content of bismuth oxide than the ProRoot MTAs (Song et al., 2006). However, Srinivasan et al in 2009 stated that “there are no studies to date comparing the relative radiopacity of MTA-Angelus with the ProRoot MTAs” (Srinivasan et al., 2009).
2-Setting/Hardening time.

Hydration of MTA material forms a colloidal silicate hydrate gel that sets in about 3-4 hours. The resulting MTA gel contains CH that is mainly responsible for its biocompatibility. There are few published reports of experimental data related to the comparative setting times of the different forms of MTA (Steffen and van Waes, 2009).

The setting time of grey ProRoot MTA was reported by Torabinjad et al. as 2 h and 45 min (± 5 min) (Torabinejad et al., 1995b).

Islam et al. reported final setting times of 140 min (2 h and 20 min) for white MTA, and 175 min (2 h and 55 min) for grey MTA. Although the manufacturers of MTA-Angelus claim that since 2002, the setting time of MTA Angelus was modified from 2.5 hours to 15 minutes. They stated that the concentration of calcium sulfate, which is the substance responsible for the long setting time, was decreased. But, there appears to be no independent evidence to confirm this. Also, the presence of gypsum in MTA composition is reported to be the reason for the extended setting time (Islam et al., 2006a).

Accelerators such as sodium phosphate dibasic (Na2HPO4) and calcium chloride (CaCl2) were investigated to reduce the setting time, the effect of (Bortoluzzi et al., 2006). MTA Bio is one commercially available product which incorporates an accelerator and is promoted as a rapid-setting material (Srinivasan et al., 2009).
Ber et al. in 2007 added an admix of 1% methylcellulose and 2% calcium chloride in order to chemically modify MTA that, when compared with unmodified MTA, handled similarly to a reinforced zinc oxide-eugenol cement, gave an approximately equal compressive strength, and set one third faster (57 +/- 3 minutes) (Ber et al., 2007).

3-Compressive strength.

Compressive strength is the capacity of a material to withstand axially directed pressure. Torabinejad et al. reported comparable mean compressive strength after 21 days for ProRoot Grey MTA, IRM and Super EBA. The compressive strength of ProRoot grey MTA increased with time. The authors suggested that this increase over a period of time required the presence of moisture (Torabinejad et al., 1995b).

Islam et al. reported greater compressive strength for the grey form of ProRoot MTA in comparison to the white form at 3 days and 28 days in an in vitro study (Islam et al., 2006a).

4-Radiopacity.

An ideal restorative material should be more radiopaque than its surrounding structures when placed in situ, in order to allow the quality of the restoration or apical seal to be assessed. Several studies have confirmed that MTA is less radiopaque than amalgam and conventional gutta-percha, but is more or in the same range as zinc oxide–eugenol-
based root canal sealers as Super-EBA and IRM (Ding et al., 2008; Shah et al., 1996; Torabinejad et al., 1995b).

5-Setting conditions.

Studies have reported that an initial period of exposure to moisture or humidity is required for the MTA to achieve optimum strength (Danesh et al., 2006; Walker et al., 2006). These authors recommended the placement of a moistened cotton pellet in the root canal for a period of time before placement of the permanent coronal seal when placing an apical barrier in immature teeth.

There is insufficient literature regarding the implications of the setting conditions on the use of MTA as a pulp capping and pulpotomy medication. The role of moisture drawn in from the pulp or peri-radicular tissues is also unclear. Once the MTA has hardened, it becomes extremely difficult to remove, and persistent symptoms can result in the need for surgery or even tooth extraction (Srinivasan et al., 2009).

6-Solubility.

Earlier studies showed no signs of solubility of ProRoot MTA in water when tested under modified International Organization for Standardization (ISO) and American Dental Association (ADA) specifications (Torabinejad et al., 1995b).
Fridland and Rosado demonstrated that both solubility and porosity of the material show a significantly increasing trend that follows the amount of water used when preparing the mix. They tested various water/powder ratios (0.28 g and 0.33g water with 1 g powder) and they concluded that the water/powder ratio recommended by the manufacturer (0.33/1) would be the ideal proportion (Fridland and Rosado, 2003; 2005).

The set or hardened material, on exposure to water, was shown to release calcium as hydroxide. Santos et al. reported that calcium and hydroxyl ions may be released from MTA Angelus during storage in moist conditions for periods up to 360 h (Santos et al., 2005).

7-Marginal adaptation and sealing ability.

These are more important effects in case of using material as root-end filling material but they can also affect coronal seal in case of pulpotomy treatment. An effective root-end filling material should ideally provide a hermetic apical seal, preventing the movement of tissue fluids into the root canal system and the egress of micro-organisms and their by-products from the root canal system (Santos et al., 2005).

Bates et al. reported that MTA was superior to amalgam and comparable with Super EBA in preventing micro leakage when used as a root-end filling in vitro on extracted human teeth (Bates et al., 1996).
Almost a decade later, Shipper et al. compared MTA with amalgam as a root-end filling material on extracted human teeth also. Results were similar. This group of workers suggested that their findings may be linked to the expansion of the material during the hydration setting reaction which is an inherent nature of MTA contributed to the superior adaptation to dentin (Shipper et al., 2004).

An acidic pH (as present in case of inflammation) may inhibit the setting reactions, affect adhesion, and increase solubility of materials placed to affect a root-end seal as in case of other materials as amalgam (Soh et al., 1991) and composite (Ferracane, 1994). This doesn’t happen in case of MTA.

Roy et al. in 2001 compared the sealing ability of MTA and amalgam in vitro on extracted human teeth. Results showed that leakage of MTA was not affected by pH. They concluded that, acid environment did not hinder the sealing ability of MTA (Roy et al., 2001).

Valois and Costa in 2004 studied in vitro the influence of the thickness of MTA on the sealing ability of root-end fillings. They tested different MTA thicknesses (1, 2, 3, or 4 mm). The results of this study suggest that 4-mm-thick MTA was significantly more effective than others (1, 2, 3 mm) in preventing apical leakage (Valois and Costa, 2004).