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An Overview of Mineral Trioxide Aggregate in Apexification

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Authors' contributions

This work was carried out in collaboration between all authors. Authors FH and ZA designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Authors SAR and MMH managed the analyses of the study. Authors AFMAC and MK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim of this paper was to present an overview of Mineral Trioxide Aggregate adjacent to apexification, which discover the properties and clinical approach of MTA on apexification in dentistry.
Materials and Methods: This study was to search in six electronic data bases where some keyword combinations were utilized to systematically search for those literatures.
Results: In view of the inclusion and exclusion criteria, of these, we identified 40 articles including original articles as well as literature reviews.
Discussion: Conventional management of a premature non-vital permanent tooth is usually apexification with using calcium hydroxide. Traditionally, calcium hydroxide has been the material of choice for the apexification of immature permanent teeth but MTA holds significant promise as

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an alternative to multiple treatments with calcium hydroxide.
Conclusion: Mineral Trioxide Aggregate is an outstanding material with innumerable qualities essential of an ideal material. Apexification with calcium hydroxide is comparatively unpredictable and makes the tooth less resistant to fracture.

Keywords: Mineral trioxide aggregate; apexification; root end closure; immature apex; open apices.

1. INTRODUCTION

In the field of dental science seeking for newer materials are never finishing. To obtain good clinical performance several types of materials have been formed, experienced and standardized [1]. Mahmoud Torabinejad at Loma Linda University, California, USA was introduced One such new material that is Mineral Trioxide Aggregate (MTA) [2]. In 1993, the first literature about MTA appeared.[2] MTA was initially formed to afford the physical properties, [3] setting requirements [4] and characteristics necessary for an ideal repair and medicament material [2,5]. Studies on MTA expose that it not only exhibits good sealing ability, it has excellent long term prognosis. It has also comparative ease of manipulation and nice biocompatibility but favors tissue regeneration as well [2,3,6-10].

On an annual basis, it is approximate that over 24 million endodontic procedures are performed, endodontic apical surgery, perforation repair, and apexification treatment was involving up to 5.5% of those procedures [11]. On non-vitalteeth, a nonsurgical method of inducing a calcific barrier at the open root apex, this method is known as apexification [12]. Toxins and bacteria are prohibited from entering peri radicular tissue because of the calcific barrier and facilitates placement of a filling material and root canal sealant [11].

For doing apexification most important material of choice is Calcium hydroxide pastes. Although its effectiveness, this dressing has numerous disadvantages also, such as inconsistency of treatment period, amount of appointments and radiographs, trouble in patient follow-up, belated treatment and risk of increased tooth fracture after calcium hydroxide use for extensive periods [13].

MTA as an alternative to calcium hydroxide, MTA is used as an apical obstruction for teeth with not fully formed apices, repair of root perforations, root-end closure, pulp capping, and pulpotomy procedures [12]. MTA has numerous good characteristics including biocompatibility, antimicrobial activity and preclusion of bacterial leakage, no cytotoxicity, and can encourage cytokine release from bone cells to prop up hard tissue formation [14,15]. It also has a shorter treatment period in comparison with calcium hydroxide, and a more conventional time to apical closure [14,15]. However, MTA has a few limitations such as non-reinforcement of root canal dentin and an advanced expenditure than calcium hydroxide [12].

2. MATERIALS AND METHODS

The principle methodology of this study was to search in six electronic databases [Table 1] where some keyword combinations [Table 2] were utilized to systematically search for those literatures.

Here, the principle concern was to discover the properties and clinical approach of MTA on apexification in dentistry. Data were completely gathered for a purposive study. The inclusion criteria were identified as the papers utilizing MTA in apexification as a part of the endodontic treatment. Then again, the papers utilizing MTA for other reason, which was not identified with endodontic unquestionably, were rejected from the study. In exclusion criteria, it additionally included that those studies not done in human and the publications not in English.

After this electronic database searching, the aggregate sum of paper was established and from that, we chose various papers in view of inclusion and exclusion criteria.

Table 1. Electronic databases searched

Google scholar
PubMed
MEDLINE
Science Direct
Web of Science
Cochrane

Table 2. Keywords combination with which systematic literature search was conducted

MTA
MTA + mineral trioxide aggregate
MTA + apexification
MTA + root end closure
MTA + immature apex
MTA + open apices

3. RESULTS

The studies that pursuit in the diverse databases including their selection procedure have been specified in Fig. 1. From aggregate 973 hits, copies were evacuated and 142 studies found in the wake of screening. In view of the inclusion and exclusion criteria, 31 full‑text articles were chosen for this review.

4. DISCUSSION

4.1 Availability of MTA

MTA is an excellent hydrophilic powder available is actually single employ sachets of just one gram [1]. A few companies provide premeasured water sachets with regards to ease of use [5]. The material consists of tricalcium silicate, tricalcium aluminate, tetra calcium aluminoferrite, calcium sulfate dihydrate and silicate oxide [16]. However, other mineral oxides can also be added to enhance physical as well as chemical attributes. The important obstacles to the common use of MTA are its expense and trouble storage [17]. A few commercially available MTA are Pro Root MTA (Dentsply), White Pro Root MTA (Dentsply), MTA- Angelus (Solucoes Odontologicas), MTA- Angelus Blanco (Solucoes Odontologicas), MTA Bio (Solucoes Odontologicas) [1].

4.2 Manipulation and Setting Time

MTA is available either as a box of five 1-gram single-use packets or as premeasured water packs for easy manipulation and application [18]. The powder is mixed with supplied sterile water in a 3:1 powder/liquid ratio. A paper pad or a glass slab and a plastic or a metal spatula is used to mix the material to obtain a putty-like consistency. The mixing time should be less than 4 minutes, as prolonged mixing can cause

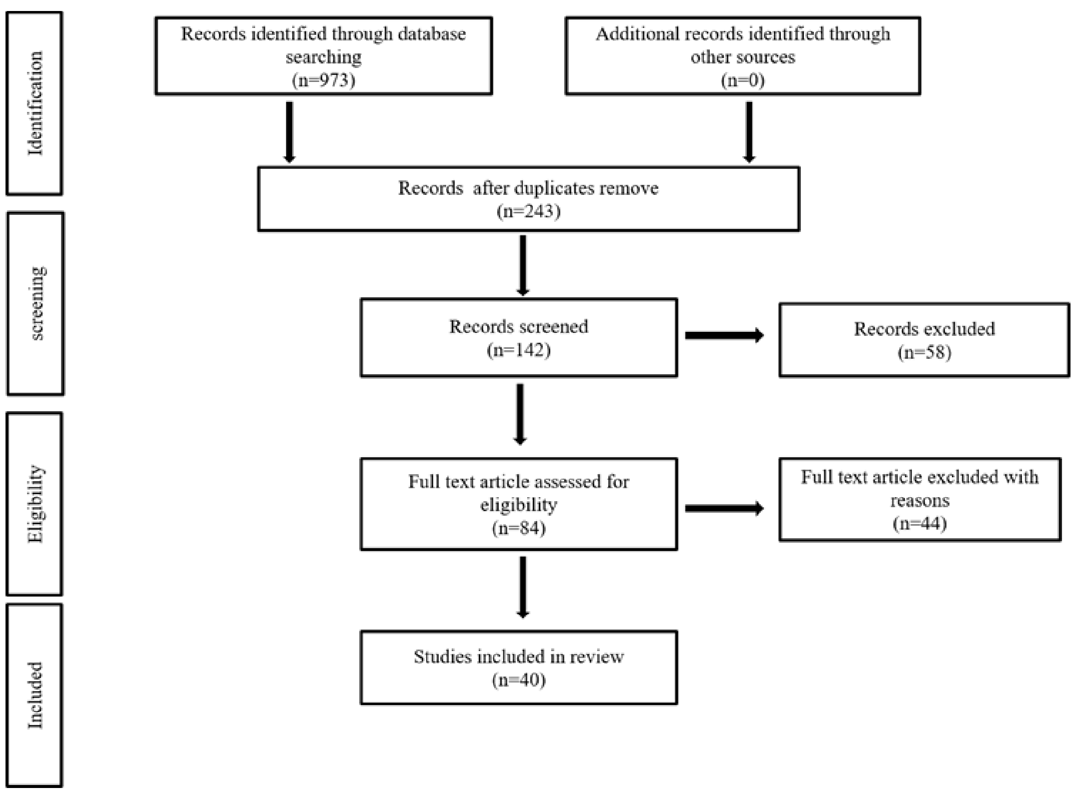

Fig. 1. Literature search criteria

dehydration of the mixture [19,20]. The mixture can be carried with a plastic or metal carrier [18].

MTA is uninhibited by blood or water, as moisture is required for a better setting of the material. The required hydration for setting is provided by a moist cotton pellet placed temporarily (until the next appointment) in direct contact and/or on the surrounding tissues.[18] The hydration reaction during setting occurs between tricalcium silicate (3CaO·SiO2) and dicalcium silicate (2CaO·SiO2) to form a calcium hydroxide and calcium silicate hydrate gel, producing an alkaline pH [21,22]. However, Dammaschke et al reported that calcium hydroxide is a product of tricalcium aluminate hydrogenation [23]. A further reaction forms a high-sulphate calcium sulphoaluminate during the reaction with tricalcium aluminate and calcium phosphate. The released calcium ions diffuse through dentinal tubules, and increase their concentration over time as the material cures [24]. Upon hydration, the poorly crystallized and porous solid gel (hydrated forms of components) that is formed solidifies to a hard structure in approximately 3 to 4 hours (initial set), with mean setting time of 165 ± 5 minutes [25,26]. Although moisture is needed for setting of the material, excess moisture can result in a soupy mix that is difficult to use [1].

The hydrated set material consists of interlocked cubic and needle-like crystals. The needle-like crystals exist as sharply delineated thick bundles filling the inter-grain space between the cubic crystals. MTA retention and push-out strength increase with time, extending from 72 hours to 21 days, indicating a prolonged maturation process of the material [18].

4.3 pH

MTA has a pH similar to that of calcium hydroxide of 12.5 at 3 hours [3]. This specific similarity by using calcium hydroxide is considered to contribute to it is inductive prospective and the resulting hard structure formation. Nonetheless conclusive facts is but to be proven to demonstrate this specific [3]. MTA, similar to amalgam and also super EBA do not present any indications of solubility inside water with 7 days down to ISO along with ADA features [3].

4.4 Compressive Strength

It takes typically three to four several hours for the MTA material to fully solidify It is shown in which once it truly is set, very low compressive toughness equal to IRM and Excellent EBA although less than amalgam [1]. Compressive toughness of MTA within 24hour of mixing seemed to be about 40. 0 MPa and heightens to 67. 3 MPa after 21 days [3]. When compared, grey MTA exhibited better compressive robustness than whitened MTA [27].

4.5 Sealing Ability and Marginal Adaptation

Lack of the best apical closure is largely liable for failure regarding surgical endodontics [16]. The quality of apical seal many different retrograde items have been applied by distinct research categories, based on a higher-level penetration by simply (i) dye (ii) radio-isotope (iii) bacterial (iv) electro-chemical means and (v) fluid filtration techniques [18]. These correctly shown advanced results to get MTA in comparison to other materials. MTA is also linked to less overfills and the exceptional outcome from the material will be observed without or with blood contamination of the main cavities [2,27]. In the study carried out by Fischer et al. [28] working with bacterial leakage model, the period of time in which components began leaky was 10-63 days pertaining to amalgam, 24-91 days just for IRM, and even 42-101 nights for excellent EBA. MTA did not commence to leak until finally day forty-nine. The excellent sealing potential of MTA is perceived as due to the placing expansion the idea undergoes throughout moist natural environment [28].

4.6 Radio-opacity

MTA is less radio opaque when compared with IRM, Super EBA, amalgam or gutta-percha and has identical radio density occurrence as Zinc Oxide Eugenol [29,30]. The indicate radio opacity of MTA is 7.17 millimeter of similar thickness involving aluminium, and that is sufficient to really make it easy to just imagine radiographically [3].

4.7 Biocompatibilty

In 1997, Koh et al. reported on the biological response triggered by MTA on human osteoblasts *in vivo* [31]. The study evaluated an osteoblast-like standardized cell line to ascertain changes in cytokine release, together with levels of osteocalcin (non-collagenous protein characteristic of osteoblast function) and alkaline phosphatases. This has been set as being an indication with matrix production. Cultured MG-63 cells were definitely trypsinised as well as seeded into dishes that contain standard variety of MTA and polymethylmethacrylate (PMA). In this study, all markers of osteoblast function which are assessed was increased during the presence for MTA.

Material analysis of MTA exhibits the material being divided into calcium oxide and calcium phosphate. The scanning electron microscopic studies says amorphous calcium phosphate confirmed maximum ingress and growth of cells. That they concluded that MTA offers a biological substrate just for osteoblasts along with calcium phosphate phase preferred the difference in cell behaviour that triggered growth above MTA [31].

4.8 Clinical Applications of MTA in Apexification

Conventional management of a premature non-vital permanent tooth is usually apexification with using calcium hydroxide [1]. The purpose of apexification is to attain an apical barrier in order to avoid the extrusion of the obturating material. Though the disadvantage of implementing calcium hydroxide is the lengthy time consumed for the completing the procedure which can range cover anything from 3 to 54 months [32]. Other drawback to calcium hydroxide as said by Andreasen et al. [33] is that the tooth with calcium hydroxide placed for more than 100 days showed a significant reduction in fracture resistance [33]. This problem is definitely solved with the use of MTA. An MTA plug of 4mm thickness installed at the apical region can be adequate to make a screen, sealing the main canal in the periapical area [34,35].

Induction of apical healing, regardless of the material used, takes at least 3–4 months and requires multiple appointments. Patient compliance with this regimen may be poor and many fail to return for scheduled visits. The temporary seal may fail resulting in reinfection and prolongation or failure of treatment. The importance of the coronal seal in preventing endodontic failure is well established [36]. For these reasons one-visit apexification has been suggested. Morse et al. [37] define one-visit apexification as the non-surgical condensation of a biocompatible material into the apical end of the root canal. The rationale is to establish an apical stop that would enable the root canal to be filled immediately. There is no attempt at root end closure. Rather an artificial apical stop is created. A number of materials have been proposed for this purpose including tricalcium phosphate, calcium hydroxide [38,39]. Favorable results have been reported. Recently there have been a number of reports describing the use of MTA in one-visit apexification. Witherspoon and Ham describe a technique using MTA. They assert that MTA provides scaffolding for the formation of hard tissue and the potential of a better biological seal. They conclude that this technique is a viable option for treating immature teeth with necrotic pulps and should be considered as an effective alternative to calcium hydroxide apexification [40].

Regeneration is the ideal desirable outcome for any restorative procedure. The last decade has seen a quest for a material that can regenerate odontogenic tissue successfully, both from a periodontal and endodontic aspect. MTA offers the option of a two-visit apexification procedure, which must have the benefit of better compliance and reduced number of radiographs over the multiple visit calcium hydroxide apexification, particularly in younger patients. With the limitations of materials which have been routinely used as retrograde filling materials, MTA has been used over the last 10 years as a suitable alternative to achieve a peri-radicular seal. There have been no randomised controlled trial comparing MTA and the other commonly used materials, however there are short-term studies indicating favourable success rates with MTA [16].

5. CONCLUSION

MTA is an outstanding material with innumerable qualities essential of an ideal material. Generally, most important applications of MTA in Pediatric Dentistry are in the management of non-vital immature teeth. Apexification with calcium hydroxide is comparatively unpredictable and makes the tooth less resistant to fracture.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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