Effect of various mixing techniques of MTA on compressive strength and surface microhardness- A systematic review

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Abstract :

MTA can be mixed manually as well as mechanically. Mixing technique of a material has some effect on its properties. Compressive strength and surface microhardness being one of the major property of a dental material, it is important to evaluate effect of different mixing techniques of MTA on its compressive strength and surface microhardness. This systematic review sought scientific evidence regarding the best available mixing technique for MTA which may be considered gold standard. A systematic search of the PubMed/MEDLINE, Elsevier/Scopus, and Cochrane Library databases was conducted to include articles published from 1st January 2000 up to 30th september 2018. Following the application of inclusion criteria, 4 articles were selected for detailed analysis.In conclusion trituration (mechanical mixing) showed increased compressive strength and surface microhardness compared to manual technique and ultrasonic mixing technique.

Keywords: *Mineral trioxide aggregate, Mixing method, Compressive strength, Surface microhardness*

Rationale :

Mineral trioxide aggregate (MTA) being a particular endodontic cement is composed mainly of tricalcium silicate , tricalcic aluminate, bismuth oxide. Mohmoud Torabinejad introduced MTA at Loma Linda university, California in USA in 1993 and was approved for endodontic use by U.S food and drug administration in 1998.[1] Mineral trioxide aggregate (MTA) which is a unique root-end lling material has diverse advantages such as bioactivity, biocompatibility, superior sealing ability, and marginal adaptation.[2] It can be used in several different treatments, including pulp capping, apexication, perforation repair, and for pulpotomy . MTA is a mechanical mixture of Portland cement (75%), bismuth oxide (20%), and gypsum (5%), which also contains CaO, SiO2, and Al2O3.[3] MTA has a longer working time than Portland cement as it contains approximately half the gypsum content of Portland cement , as well as smaller amount of aluminium species.

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Mineral trioxide aggregate (MTA) consists of fine hydrophilic particles making it a hydraulic cement which progressively hardens in a moist environment. It contains a hydrophilic powder that reacts with water and produces a calcium hydroxide and calcium silicate hydrated gel .[4] Previous studies showed that with dental materials including a liquid part, the homogenicity of the mixture is a challenge for clinicians.[5] Mixing procedure, amount of water, and pH value are three important determinants of amount of voids and bubbles formed in the cement structure.[6]

Optimum properties like compressive strength, consistency are attained by correct proportioning and mixing of the material.[7] The physical and chemical properties of dental materials are influenced by the mixing technique. Thorough wetting of the powder particles and improved unified resultant paste was observed with mechanical mixing as it has the potential to reduce air spaces between adjacent particles.[8] Trituration is one method of mechanical mixing that is used extensively for various dental materials.

Since trituration technique uses conventional mechanical vibration, there might be a potential for ultrasonic energy to be more potent. Ultrasonic vibration has a dispersing effect on the particles of the material, which frequently cluster together.[9] Ultrasonic devices have been used due to their dispersing effect to improve the mechanical properties such as microhardness of the applied materials.[10] many studies have reported that these instruments can increase the surface area of the powder, thereby improving the particle interaction, and decreasing the setting time.[9]

Clinical implications are vast and little information is available on effect of various mixing techniques of MTA on its compressive strength and surface microhardness . However to the best of our knowledge there is no systematic review comparing the effect of mixing techniques of MTA on its compressive strength and surface microhardness.

Focused Question:

what is the effect of different mixing techniques of MTA on its compressive strength and surface microhardness ?

Objectives :

To evaluate effect of different mixing techniques on compressive strength and surface microhardness of MTA.

Study Eligibility Criteria:

Inclusion criteria:

1. Articles in English language or those having summary in English
2. Studies published in 1st jan 2010 to 31st sept 2018
3. Studies done on pro root white MTA.
4. In vitro Studies done using different mixing technique on various mechanical properties of white MTA

Exclusion criteria:

1. Review ,case reports, abstracts, letters to editors, editorials and animal studies
2. In vivo studies.
3. Studies done before 1st jan 2010

The PICOS guidelines that were selected are:

P where Participants were included and this comprised of MTA .I as the Intervention where this was considered as use of manual technique.C as comparison was considered as mechanical mixing technique. O as the outcome where it was assessed effects on compressive strength and surface microhardness. S as the study designs were included in vitro studies. And hence the PICOS are mentioned below:

P-Participants :-MTA

I-Intervention :- manual technique

C-Comparison :- mechanical technique

O-Outcomes :-Changes in compressive strength and surface microhardness of MTA.

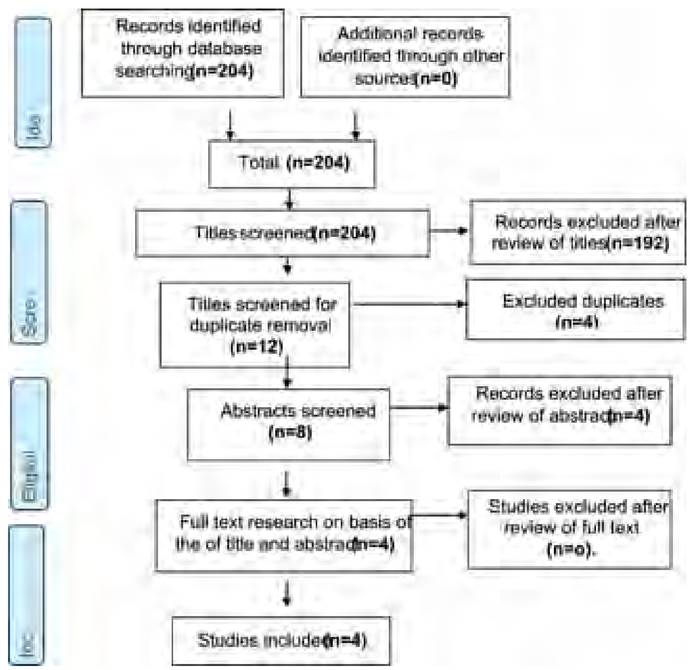
S-Study design : In vitro studies

Information Sources:

English language articles were retrieved from electronic biomedical journal databases. PubMed, Google scholar and ResearchGate were used to complete the search for all full text articles available. The search was done till 30th September 2018. The last data search was conducted on 1st October 2018.

Search

The following databases were searched on : PubMed (The limits used were all full text articles in English dated from 1st January 2000 to 30th September 2018) and Google Scholar. For the electronic search strategy, the following terms were used as keywords in several combinations:



Summary of Evidence

Leakage of irritants into the periapical tissues leads to endodontic failures.[11] Therefore, it is necessary that an an ideal orthograde and/or retrograde filling material seals the pathways of communication between the root canal system and its surrounding tissues; thus, this material should be biocompatible and also dimensionally stable.[12] This led to the development of mineral trioxide aggregate (MTA) material which possess these ideal characteristics. Mineral trioxide aggregate (MTA) has several exciting clinical applications making it a unique material. MTA is one of the most versatile materials of this century in the field of dentistry.[3]

The clinical outcomes of the majority of dental restorative procedures are inuenced by the chemical and physical properties of dental materials. These properties can be affected by mixing technique[8], delivery system [12] exposure to various clinical environments, storage conditions[13] and the ratio of the constituent components. MTA manipulation can be done manually as well as mechanically.

Compressive strength (CS) and an increase in the strength of a given biomaterial over time is an indicator of setting reaction and stability of the material.[14] Mineral trioxide aggregate (MTA) being a root-end filling material must bear mastication forces and CS is one of the properties that enables them to do so.

In the clinical settings, especially when MTA is applied to the coronal part of the tooth, the physical properties of the material such as surface microhardness also play an important role in achieving an ideal seal.[15] Displacement of the restorative material and disruption of the physical seal can occur due to the occlusal loads during mastication.[16]

Hence it is very important to know the effects of different mixing techniques of MTA on its compressive strength and surface microhardness.

Nekoofar et al.(2010) [17] conducted an invitro study to evaluate the inuence of various mixing procedures including ultrasonic vibration, trituration of customized encapsulated mineral trioxide aggregate (MTA) and condensation on the Vickers surface microhardness of MTA. In this study ProRoot MTA (grey), ProRoot MTA (white), and MTA White Angelus(white), MTA Angelus (grey) were prepared using several manipulation techniques including ultrasonic vibration, trituration of customized encapsulated MTA and conventional condensation. Twelve experimental groups (four materials: three techniques) were studied, each containing 35 samples. After preparation all samples were incubated, they were further subjected to Vickers surface microhardness testing after 4 and 28 days. Data was subjected to a two-way Anova. Results showed that application of ultrasonic energy to MTA produced signicantly higher surface microhardness values compared to the other manipulation techniques at both 4 and 28 days. However, there was no signicant difference between condensation and trituration techniques at both time intervals. They concluded that application of ultrasonic energy to MTA produced a signicantly higher surface microhardness value compared to other experimental groups at both 4 and 28 days after mixing.

Saghiri et al. (2013)[18] conducted an in vitro study to evaluate the effects of three different mixing techniques on surface microhardness, initial setting time, and phase formation of white mineral trioxide aggregate. In this study Twenty-one cylindrical glass tubes were selected and divided into three groups of seven in each (n = 7). White mineral trioxide aggregate (WMTA) in groups A, B, and C were mixed by conventional, trituration, and ultrasonic techniques, respectively. Cements were mixed and packed into the glass tubes and incubated at 37°C for 3 days. After incubation, samples were subjected to microhardness evaluation, and four specimens from each group were prepared and observed under a scanning electron microscopy and X-ray diffraction. Data were analyzed by one-way ANOVA and post hoc Tukey's test. Results showed that samples mixed by trituration technique signicantly showed the highest microhardness ($P < 0.001$). However, ultrasonic mixing technique showed the lowest value, even lower than the conventional mixing method. These ndings are inconsistent with previously published studies demonstrating that the ultrasonic technique showed better surface microhardness value than trituration or conventional mixing techniques. They concluded that trituration and conventional techniques were more suitable mixing methods for mineral trioxide aggregate in comparison with ultrasonic technique.

Basturk et al (2013)[19] conducted an in vitro study to evaluate the effect of various mixing techniques including mechanical and manual mixing as well as the effect of ultrasonic agitation during placement on the compressive strength of mineral trioxide aggregate (MTA). In this study one gram of each powder was mixed with a 0.34-g aliquot of distilled water. Specimens were mixed either by mechanical mixing of capsules for 30 seconds at 4,500 rpm or by a saturation technique and the application of a condensation pressure of 3.22 MPa for 1 minute. Half of the specimens were placed in stainless steel molds and agitated using indirect ultrasonic activation. All specimens were subjected to compressive strength testing after 4 days. Results showed that, the compressive strength values of ProRoot MTA (mean = 93.38 26.27 MPa) were significantly greater than those of MTA Angelus (mean = 65.06 25.54 MPa, $P < .05$). The specimens mixed mechanically had higher compressive strength values than those mixed manually ($P < .05$). They concluded that the compressive strength values of ProRoot MTA were significantly greater than those of MTA Angelus. Mechanical mixing enhanced the compressive strength of the material.

Shahi et al. (2015)[20] conducted an in vitro study to evaluate the effect of different mixing methods on these properties of mineral trioxide aggregate (MTA) and calcium-enriched mixture (CEM) cement. In this study Hand, amalgamator and ultrasonic techniques were used to mix both biomaterials. A glass slab (100 g) was placed on the samples and 180 sec after the initiation of mixing a 100-g force was applied on it for 10 min. After 10 min, the load was removed, and the minimum and maximum diameters of the sample disks were measured. To measure the CS, 6 sample of each group were placed in steel molds and were then stored in distilled water for 21 h and 21 days. Afterwards, the CS test was performed. Data were analyzed with multivariant ANOVA and post hoc Tukey tests. Results showed that, in the MTA group, none of the mixing techniques exhibited a significant effect on CS ($P>0.05$). They concluded that in MTA samples, the effect of different mixing techniques on compressive strength was not significant at any time ($P=0.09$ and $P=0.1$ for 21-h and 21-day intervals, respectively).

Limitations

Research and publications related to the concerned topic is limited leading to restrictions in our systematic review.

There were limited full text articles to analyse and because of less access to search forums this study did not give concrete conclusions due to inadequate search of literature.

Future Implications

Introduction of MTA has been a boon in the field of dentistry. MTA is used for creating apical plugs during apexification, repairing root perforations during root canal therapy, treating internal root resorption. This can be used for root-end filling material and as pulp capping material as well. As MTA has vast clinical usage it is essential to know proper mixing technique for better physical and mechanical property of the material thereby providing better clinical outcome and longevity of the treatment

Hence, there is tremendous scope for further comparative studies regarding this topic, Studies with larger sample size and with elaborate search strategies required for better result .

Conclusion

Keeping in mind the limitations of this study it can be concluded that trituration (mechanical mixing) showed increased compressive strength and surface microhardness compared to manual technique and ultrasonic mixing technique in White MTA.

However one of the review stated that ultrasonic technique significantly increased the surface microhardness of White MTA.

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