



## Review Article

## Novel material for root-end applications for bio-allied sciences

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## ABSTRACT

Treating a patient with tooth pain is a multi-factorial process with many factors playing their role to warrant the success of the treatment procedure. One such important factor is to secure the root apex which is important for ensuring good prognosis in endodontics. Also in challenging situations like sealing a fractured root, resorbed apex, or an incompletely formed apex, the need of an intact root apex is much anticipated. Over the years, an array of novel products has been produced for root-end applications to achieve such a favorable condition. The objective of this review is to list and summarize such root-end materials. However, their merits, and claims of superiority over MTA, have to be ascertained via sustained research.

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## 1. Introduction

Over the years, a lot of materials have been discovered, which finds its applications as root-end materials. Though some of them have been used extensively, and have substantial research data, they still are found to be deficient in few aspects, thus providing scope for development of newer materials. With the advent of several materials it is not only the duty of the industry to develop such materials but it is also the duty of the treating physician/clinician to have knowledge of the same. Without the knowledge, no use can be advocated which would mean reduced data to draw some important conclusions on their use. Hence, this review article focuses on the use of such materials with its biochemical properties, advantages, disadvantages as well as its applications.

## 1.1. Mineral Tri-oxide aggregate (MTA)

Since its introduction by Torabinejad in the year 1993, MTA has increasingly become widespread among the clinicians. MTA is essentially Portland cement ( $\text{SiO}_2$ ,  $\text{CaO}$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{MgO}$  and  $\text{Fe}_2\text{O}_3$ ), to which a radio-opacifier ( $\text{Bi}_2\text{O}_3$ ) and anhydrous calcium sulphate have been added. It is biocompatible, osteogenic and capable of interacting with living tissues which allows the deposition of apatite crystals in the MTA-tissue interface. Over the years, MTA has been proven to induce hard tissue formation.<sup>1</sup> Further, it also displays excellent sealing property and also can set in the presence of moisture; hence, the name 'hydraulic silicate cement'.<sup>2</sup> However, there are several disadvantages in case of use of MTA, like

1. Removal of MTA from canals is difficult
2. Extreme pH of the surrounding environment can decrease the surface hardness of set MTA. MTA can expand uncontrollably.<sup>3</sup>

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3. Grey MTA can pose esthetic problems by causing tooth and soft tissue. Impurities could be found in both the variants of MTA. Manipulating MTA could be challenging if not difficult.<sup>4</sup>
4. MTA exhibits greater initial solubility, especially if it lacks an accelerator<sup>5</sup>
5. Since MTA was not devoid of potential drawbacks, ongoing research for ideal material has produced novel products that may be more efficacious.

### 1.2. Bio-aggregate

A water based cement that primarily contains tri-calcium silicate, with radiopacity due to Tantalum oxide; also hydroxyapatite and amorphous silicon oxide have been added to reduce formation of the weak phase- calcium hydroxide.<sup>6</sup> Purity of the compound is ensured via the elimination of aluminum. The material is bioactive.<sup>7</sup> Sayeed et al suggested that bio-aggregate could be considered as a suitable alternative to MTA owing to the former's ability in achieving a hermetic seal. Its sealing capacity could be attributed to:

1. Nano-sized particles
2. Excellent adhesion to the dentinal walls of the root canal, and
3. Hydrophilic nature

The formation of a gel-like calcium silicate hydrate matrix in the set cement, increases strength, hardness, as well as it provides enhanced sealing properties.<sup>8</sup> Bio-aggregate also exhibits excellent biocompatibility and also has the ability to aid periodontal regeneration.<sup>9</sup>

### 1.3. Bio-dentine

Bio-dentine is composed predominantly of tricalcium silicate and dicalcium silicate cement, which is available as a powder and liquid formulation. Calcium carbonate, calcium oxide, and zirconium oxide have been added as the accelerator.<sup>10</sup> Bio-dentine can also be used as a root repair material but it is not indicated for procedures like root amputation and hemi-section. It has a working time of over 1 minute with the setting time in the range between 9 and 12 minutes.<sup>10</sup> Human gingival fibroblasts could readily attach to the surface of set bio-dentine as well as MTA. The former has been found to be as biocompatible as MTA. The liquid portion of the material comprises of calcium extracts.<sup>11</sup>

### 1.4. Endo-sequence root repair material (ERRM)

EndoSequence Root Repair Material is a bio-ceramic material that contains nanoparticles of tricalcium silicate, dicalcium silicate, calcium phosphate monobasic, amorphous silicon dioxide, and tantalum pentoxide.<sup>12</sup> It has been refined to eliminate aluminum and contains

calcium phosphate monobasic and tantalum pentoxide (radiopacifier).<sup>13</sup> It is marketed as a pre-mixed formulation in two different consistencies:

1. Syringeable paste
2. Condensable putty

The former has bendable tips to facilitate intra-canal material placement.<sup>14</sup> According to the manufacturer, the material is easy to handle and dispense. It has a short setting time (~2 hours) and hence, high resistance to washout. The other favorable qualities are radiopacity, hydrophilicity, and high alkalinity (pH 12). Its high alkaline nature contributes to its bactericidal property. The setting reaction is initiated by dentinal moisture.<sup>15</sup> Endo sequence is bioactive.<sup>16</sup> After studying the sealing ability of ERRM when compared to MTA, Hirschberg et al concluded that MTA-restored samples were superior and exhibited lesser leakage.<sup>17</sup> In a study that simulated root resorption defects, a higher pH was observed in specimens where white MTA was placed when compared to EndoSequence Root Repair Material. This was attributed to the greater and sustained release of hydroxyl ions from the MTA specimens. Nevertheless, some MTA samples exhibited discoloration, whereas the EndoSequence Root Repair Material samples did not.<sup>18</sup>

### 1.5. iRoot BP Plus

These are bio-ceramic materials that contain calcium silicate as the primary ingredient and set in the presence of moisture. The other ingredients are zirconium oxide, tantalum pentoxide, calcium phosphate as well as fillers. They are available in both putty as well as injectable forms, which are intended to be used for root canal filling and as a repair, sealing, and restorative material.<sup>19</sup> These materials are claimed to be insoluble and radiopaque. Manufacturers state that it is free from the common contaminant-aluminum, and possess excellent physical properties, and is dimensionally stable after setting.<sup>20</sup> A study found iRoot BP Plus to be biocompatible; nevertheless was found to be inferior to MTA when tested for a longer time period.<sup>21</sup> Under simulated clinical conditions, iRoot FS exhibited a setting time of less than an hour, whereas iRoot BP Plus took significantly greater time to set (seven days).<sup>22</sup>

### 1.6. Ceramicrete

Ceramicrete belongs to the group of chemically bonded phosphate ceramic materials or CBPC, which are commonly used as cements and as shields for radioactive isotopes. Owing to its superior strength, and bio compatibility, this material was deemed to be useful as a dental material too. Radiopacity is due to the incorporation of radiopacifiers like bismuth oxide and cerium oxide. Ceramicrete exhibits good strength, lower porosity that can be attributed to the formation of potassium-magnesium

phosphate hexahydrate ceramic matrix. It also has superior sealing capability.<sup>23</sup> Though the initial pH was found to be acidic at 2.2, it later increased to 11 after 72 hours. The authors opined that the initial acidic pH could compromise an already inflamed tissue.<sup>24</sup> The low pH was cited as the cause for initial osteoblasts death and lack of further cell growth. Low pH is shown to inhibit osteoblast activity.<sup>25</sup> According to one study that observed the setting characteristics of Ceremicrote-D, the material exhibited a chalky consistency even after seven days of setting, which could potentially impact its strength.<sup>26</sup>

### 1.7. Capasio

Capasio is calcium-phospho-alumino-silicate based cement, mixed with a water based gel and contains bismuth oxide as the radiopacifier.<sup>27</sup> When mixed, Capasio develops dough like consistency enabling better handling. According to a study, Capasio exhibited favorable properties such as decreased setting time (9 minutes), improved compressive strength, and washout resistance.<sup>26</sup> Its pH was found to be 10.9.<sup>28</sup> Though its radiopacity was significantly lesser when compared to MTA, it performed marginally better than Ceremicrote-D.<sup>26</sup> Capasio was found to be bioactive. Its mean particle size was significantly lesser ( $5.3\mu\text{m}$ ) when compared to MTA ( $10\mu\text{m}$ ). Smaller particles of Capasio can penetrate dentinal tubules better than MTA (up to a depth of  $18\text{--}26\mu\text{m}$ ).<sup>29</sup> This results in better material adaptation along the margins and retention.<sup>30</sup>

### 1.8. Quick-set

It is an improved version of Capasio. The change includes improved biocompatibility affected by excluding a cationic surfactant from the liquid gel. In a study conducted by Wei et al. murine dental papilla-derived odontoblast-like cells were used to compare cytotoxicity of Quick-Set. It was observed that biocompatibility of Quick-Set was similar to that of WMTA.<sup>31</sup> Ashraf et al. observed that Quick-Set favorably induced osteogenic/ dentinogenic differentiation.<sup>32</sup>

### 1.9. Generex A and B

They are calcium-silicate-based materials with novel setting reactions. Generex A is comprised of tri-calcium silicate, di-calcium silicate, and tri-calcium aluminate. Its powder is finer when compared to that of MTA and uses unique gels for mixing.<sup>25</sup> This enhances the handling characteristics and decreased the setting time.<sup>26</sup> A study that evaluated Generex A, Capasio, Ceremicrote, and MTA for their osteogenic potential, observed that only MTA and Generex A induced osteoblast growth.<sup>25</sup> Generex A set the fastest (1.25 hrs) when compared to Capasio and Ceremicrote (2.5 hours). Generex A also emerged as the strongest among the other materials tested.<sup>26</sup>

### 1.10. Endobinder

Endobinder differs from MTA in that, MgO and CaO, which cause undesirable expansion of the material, and  $\text{Fe}_2\text{O}_3$ , responsible for tooth darkening, are eliminated from its composition.  $\text{Al}_2\text{O}_3$  and  $\text{CaCO}_3$  are calcined at temperatures between  $1315^\circ\text{C}$  and  $1425^\circ\text{C}$  and are ground. Bismuth oxide is added to obtain radiopacity. Purity is ensured by eliminating traces of MgO, CaO, and  $\text{Fe}_2\text{O}_3$ .<sup>32,33</sup> Endobinder produced higher osteoblastic differential than MTA, which was attributed to the lower calcium hydroxide release from Endobinder.<sup>34</sup> It would be interesting to note that release of slightly higher concentration calcium stimulates overall functions of osteoblasts; whereas, an overload can cause cytotoxicity.<sup>35</sup>

## 2. Conclusion

Bioaggregate and Biodentine are tricalciumsilicate-based materials, Endobinder, Endosequence, Generex A and B, and iRoot BP Plus are calcium silicate based materials, Ceremicrote is a phosphate cement; whereas, Capasio and Quickset contain calcium-alumino-silicate. While these novel materials may claim improved properties over MTA, sustained research is essential to establish the same. The future may witness further novel materials, whose composition and characteristics may be entirely different from the materials that are in current use.

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None.

## 4. Conflict of Interest

None.

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