Endodontic Materials

Securing the root canal
Endodontic materials

- Master cones
- Sealers
- Root-end filling materials
Root-end filling materials

- Materials that are usually used for other purposes like
  - IRM
  - Super EBA
  - Amalgam

- Mineral Trioxide Aggregate (MTA)
Composition of MTA
Elemental Constitution

- Calcium
- Silica
- Aluminium
- Bismuth

Camilleri J, Montesin FE, Brady K, Sweeney R, Curtis RV, Pitt Ford TR. The constitution of mineral trioxide aggregate
Dental Materials 2005; 21:297-303
Phase constitution

- Tricalcium silicate 53%
- Dicalcium silicate 22%
- Tricalcium aluminate <1%
- Calcium sulphate 2-3%
- Bismuth oxide 22%

Camilleri J.
Characterization of hydration products of mineral trioxide aggregate.
Hydration of MTA
Camilleri J.
Hydration mechanisms of mineral trioxide aggregate.
Hydration products

- Calcium silicate hydrate 49.5%
- Calcium hydroxide 14.4%
- Ettringite 2.1%
- Bismuth oxide 8.4%
- Unhydrated calcium silicate 25.5%

Camilleri J.
Characterization of hydration products of mineral trioxide aggregate.
Camilleri J.
Hydration mechanisms of mineral trioxide aggregate.
Initial stages of reaction

- Formation of calcium silicate hydrate
- Coating of cement particles with silicate hydrate preventing further reaction

- Tricalcium aluminate dissolves and reacts with the calcium and sulphate ions present in the liquid phase producing ettringite that also precipitates on the cement particle surface.
Dormant period

- The hydrate coating on the cement grains prevents further hydration. Dormant period is 1-2 hours of relative inactivity where the cement is plastic and workable.
Acceleration stage

- The progress of hydration accelerates again. The rate of tricalcium silicate hydration increases and more calcium silicate hydrate gel is formed.

- The hydration of dicalcium silicate also increases at this stage.

- Sulphate ions get depleted and monosulphate forms

- Crystalline calcium hydroxide precipitates from the liquid phase.
Camilleri J.
The hydration mechanisms of mineral trioxide aggregate.
Only 8.4% of the bismuth oxide remains unbound. The rest is taken up in the calcium silicate hydrate structure replacing the silica.

Camilleri J.
- Release of calcium hydroxide
- Release of bismuth

<table>
<thead>
<tr>
<th></th>
<th>MTA</th>
<th>Bismuth µg/g</th>
<th>Calcium µg/g</th>
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<tbody>
<tr>
<td>Week 1</td>
<td></td>
<td>3.62</td>
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<td>Week 2</td>
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<td>8534.64</td>
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<td>Week 3</td>
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<td>Week 4</td>
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<td>10.13</td>
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<td>Week 5</td>
<td></td>
<td>16.64</td>
<td>2459.13</td>
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</table>

Camilleri J.
Characterization of hydration products of mineral trioxide aggregate.
Leached minerals

Camilleri J.
Characterization of hydration products of mineral trioxide aggregate.
Properties of MTA
Camilleri J
The use of Portland cement and its modified forms as a dental core build-up material.
PhD thesis 2006
Biocompatibility

## Strength

<table>
<thead>
<tr>
<th>Publication</th>
<th>Age of test</th>
<th>Reported strength</th>
</tr>
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<tbody>
<tr>
<td>Torabinejad et al. 1995</td>
<td>3</td>
<td>40</td>
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<tr>
<td>Islam et al. 2006</td>
<td>4</td>
<td>86.02</td>
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<tr>
<td>Ber et al. 2007</td>
<td>3</td>
<td>30.4</td>
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<tr>
<td>Nekoofar et al. 2007</td>
<td>/</td>
<td>~ 70</td>
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</table>
Marginal adaptation

Camilleri J
The use of Portland cement and its modified forms as a dental core build-up material. PhD thesis 2006
Camilleri J
The use of Portland cement and its modified forms as a dental core build-up material. PhD thesis 2006
Improvement in properties
Setting time

1) Addition of an accellerator
   - Calcium chloride
   - Mixture of methyle cellulose and calcium chloride
   - Calcium nitrate
   - Calcium formate
   - Sodium hypochlorite
   - Lidocaine
   - Chlorhexidine gluconate
   - Sodium phosphate
   - Saline
Mode of action of the accelerator

- **Saline**
  - Sodium chloride usually accelerates the cement hydration but can act as a retarder especially in the initial stages

- **Calcium chloride**
  - Accelerates the reaction between tricalcium aluminate and gypsum
  - Accelerates hydration of tricalcium silicate

- **Calcium formate, calcium nitrate**
  - Accelerates hydration of tricalcium silicate

Paillere AM *et al.*, RILEM Report 10; 1995
<table>
<thead>
<tr>
<th>Accellerator</th>
<th>Dosage</th>
<th>Publication</th>
<th>Setting time</th>
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<tbody>
<tr>
<td>Calcium chloride</td>
<td>15%</td>
<td>Abdullah et al. 2002</td>
<td>27 minutes</td>
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<tr>
<td></td>
<td>10%</td>
<td>Bertoluzzi et al. 2006</td>
<td>/</td>
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<td></td>
<td>3%</td>
<td>Kogan et al. 2006</td>
<td>50 minutes</td>
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<td></td>
<td>5%</td>
<td>Kogan et al. 2006</td>
<td>25 minutes</td>
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<tr>
<td></td>
<td>5%</td>
<td>Wiltbank et al. 2007</td>
<td>35 minutes</td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td>Ber et al. 2007</td>
<td>83 minutes</td>
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<tr>
<td></td>
<td>5%</td>
<td>Gandolfi et al. 2008</td>
<td>/</td>
</tr>
<tr>
<td>Methyl cellulose</td>
<td>1%</td>
<td>Ber et al. 2007</td>
<td>215 minutes</td>
</tr>
<tr>
<td>Methyl cellulose and calcium chloride</td>
<td>1/2%</td>
<td>Ber et al. 2007</td>
<td>60 minutes</td>
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<tr>
<td>calcium nitrite/nitrate</td>
<td>1-10/25-50%</td>
<td>Wiltbank et al. 2007</td>
<td>60 minutes</td>
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<tr>
<td>Calcium formate</td>
<td>20%</td>
<td>Wiltbank et al. 2007</td>
<td>10 minutes</td>
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<tr>
<td>Sodium hypochlorite</td>
<td>/</td>
<td>Kogan et al. 2006</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>2%</td>
<td>Kogan et al. 2006</td>
<td>120 minutes</td>
</tr>
<tr>
<td>Chlorhexidine gluconate</td>
<td>/</td>
<td>Kogan et al. 2006</td>
<td>Un-set</td>
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<tr>
<td>Saline</td>
<td>/</td>
<td>Kogan et al. 2006</td>
<td>90 minutes</td>
</tr>
<tr>
<td>Sodium phosphate</td>
<td>15%</td>
<td>Ding et al. 2008</td>
<td>26 minutes</td>
</tr>
<tr>
<td></td>
<td>15%</td>
<td>Huang et al. 2008</td>
<td>26 minutes</td>
</tr>
</tbody>
</table>
Effects of addition of the accelerator

- None of the accelerators reduced the setting time to clinically acceptable levels
- Calcium chloride absorbs moisture from the atmosphere
- Material strength was reduced \( \text{Kogan et al. 2006, Ber et al. 2007} \)
- Workability reduced \( \text{Kogan et al. 2006} \)
- Increase of heat of hydration \( \text{Wiltbank et al. 2007} \)
- Increase in pH and calcium ion release \( \text{Wiltbank et al. 2007, Bertoluzzi et al. 2006} \)
- Same dimensional stability \( \text{Wiltbank et al. 2007} \)
- Same biocompatibility as MTA \( \text{Ding et al. 2008} \)
2) **Omission of gypsum** from the manufacturing process thus producing a clinker

On hydration the tricalcium aluminate reacts producing calcium aluminate hydrate resulting in a flash set.

Camilleri J, Montesin FE, Di Silvio L, Pitt Ford TR.

Camilleri J.
- Setting time: 8 minutes
- Material similar to MTA
  - Composition
  - Biocompatibility
  - Strength
  - pH
  - Water absorption

Camilleri J, Montesin FE, Di Silvio L, Pitt Ford TR.
The constitution and biocompatibility of accelerated Portland cement for endodontic use.

Camilleri J.
The physical properties of accelerated Portland cement for endodontic use.
3) Addition of calcium aluminate cement

- Setting time: 5 minutes
- Increase in compressive strength
- Reduced biocompatibility due to lack of calcium hydroxide in the set cement


Compressive strengths are similar to that of temporary restorative materials. Strength can be improved by:

- **Addition of chemical admixtures**
  Camilleri J.  
The physical and chemical properties of accelerated Portland cement for endodontic use.  

- **Addition of mineral admixtures**
  Camilleri J, Montesin FE, Curtis RV, Pitt Ford TR.  
Characterization of Portland cement for use as a dental restorative material.  

Addition of mineral admixtures reduce material biocompatibility
Effects of dental procedures

- **Reductions in pH**
  - **Reduction in surface micro-hardness**

  - **Reduction in strength**


  - **Increased micro-leakage**
Use of irrigating solutions

- **EDTA**
  
  Reduction in Portland peak suggesting reduced deposition of calcium hydroxide


- **Bio-Pure MTA**
  
  Increase in calcium chelation

Testing procedures

- Dye solutions

A reduction in pH resulted in a variation in the hydration mechanism of MTA

- Absence of needle-like structures normally present within hydrated material