Hydraulic cements in endodontics

Josette Camilleri [1]

Endodontic procedures are divided into pulp therapy, non-surgical root canal treatment and surgical treatment. The materials that are most indicated for the following procedures are hydraulic cements. They are:

- Vital pulp therapy
- Regenerative endodontics
- Root canal obturation using the gutta percha point and root canal sealer
- The management of immature apices, either by apical plugs or apical surgery
- Perforation repair.

The aim of this article is to provide an overview of the properties and uses of hydraulic cements in endodontics.

Hydraulic cements

The main features of hydraulic cements are the need of water to set and also environmental moisture to allow the materials to develop their properties.

This has clinical implications because, when performing endodontic procedures, the environment changes with the use other materials and irrigating solutions. There is also the presence of blood and tissue fluids that effect the material properties.

A classification for these materials has been proposed based on the material chemistry (Camilleri, 2020), helping clinicians to understand the differences in the types of material, as this has clinical implications.

Furthermore, the classification also subdivides the materials according to use, which is coronal, intraradicular and extraradicular.

Material composition and presentation

Most of the hydraulic cements are composed of a powder and liquid.

The powder comprises a cement and radiopacifier and may contain additives, depending on the material clinical use.

The liquid is water, which may also contain additives to enhance the material properties. Some materials use non-aqueous vehicles, and these can be delivered in syringes, facilitating delivery. There are three types of presentations, namely:

1. Powder and liquid (Figure 1a)
2. Automix syringes (Figure 1b)
3. Single syringe/container systems, which can be of different consistencies (Figure 1c).

The automix syringes use resins as vehicles and as such cannot be classified as hydraulic cements as the primary reaction is the resin reaction.

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1a

Figure 1A: Powder and liquid systems – such as Proroot MTA and Biodentine.

1d

Figure 1B: Automix syringes – such as MTA Fillapex.

1c

Figure 1C: Single syringe/container systems of different consistencies – such as the Totalfill BC that have a range of sealer, paste and putty.

Hydraulic cements can have different chemistries. The tricalcium and dicalcium silicate chemistry is the one that is most investigated in dentistry. The materials used for endodontic procedures have a tricalcium silicate chemistry. This means, when mixed with water (as in the powder/liquid) or absorbs moisture from the environment in the single syringe system, it will hydrate and form calcium silicate hydrate and calcium hydroxide (Camilleri et al, 2005; Camilleri, 2007; Camilleri, 2008).

Clinicians need to be careful to ensure that the materials they choose for the procedures have the tricalcium silicate chemistry.

Materials containing bismuth oxide should not be used for any endodontic procedure. This is due to the reactivity of bismuth oxide with endodontic irrigation solutions (Camilleri et al, 2020), particularly sodium hypochlorite (Camilleri et al, 2020; Camilleri, 2014) and also in contact with collagen in the tooth structure (Marciano et al, 2014).

Clinical use

Intracoronal use

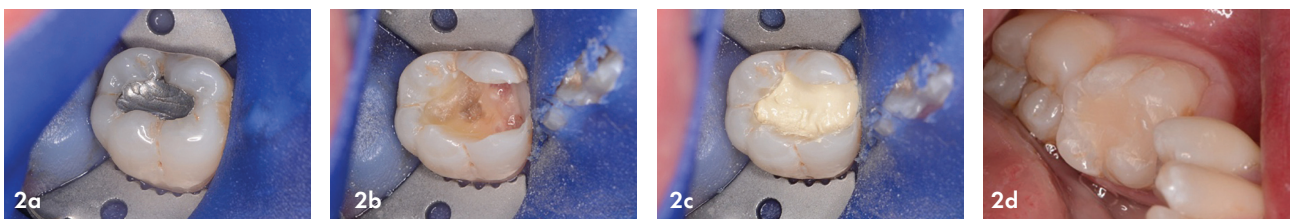
The application of hydraulic calcium silicate cements intracoronally includes their use for vital pulp therapy and regenerative endodontic procedures.

The use of hydraulic cement for vital pulp therapy requires a specific clinical protocol (Al Ali and Camilleri, 2022).

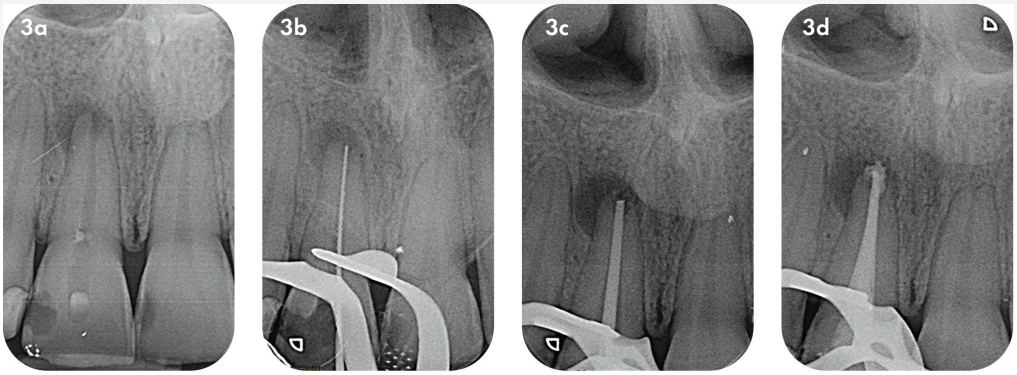
- Dentine cleansing with sodium hypochlorite and ethylene diamine tetracetic acid (Hadis et al, 2020)
- Management of the dental pulp, if necessary. Use of sodium hypochlorite reduces bacterial load
- Placement of a fast setting, bismuth oxide free hydraulic calcium silicate cement. If Biodentine is used, five drops of liquid need to be placed with the powder in the capsule and mixed in Septodont mixer for 30s (Domingos Pires et al, 2021)
- Selective etching with a five-second etch of the hydraulic calcium silicate pulp preservation material and a total etch of the dentine and enamel (Meraji and Camilleri, 2017; Camilleri, 2013). The enamel etch can be undertaken prior to the placement of the hydraulic cement to avoid the washing out of the material
- Application of a dentine bonding agent or use of a resin-modified glass ionomer over hydraulic cement and placement of a composite resin restoration.

If the restoration cannot be undertaken on the first visit the tooth can be restored fully with Biodentine (Hashem et al, 2014). It is not recommended to use a zinc oxide eugenol or a glass ionomer temporary restorative material over the Biodentine, as it interferes with the material setting (Camilleri, 2011).

For regenerative endodontic procedures, the clinical guidance from the European Society of Endodontology is


2a 2b 2c 2d

Figures 2A, 2B, 2C and 2D: Vital pulp therapy in molar showing the total removal of caries and previous restoration, placement of Biodentine and restoration with composite resin on the same visit.



Figures 3A, 3B, 3C and 3D: Management of UR1 with a flared apical terminus. After root canal preparation and working length determination, the master cone is placed to length and radiograph taken to check the fit. The spaces not filled with gutta percha were filled with sealer taking extra care not to extrude the sealer past the root apex.

recommended (Galler et al, 2016).

The hydraulic cements are used as barriers and the same principles as those outlined for vital pulp therapy are recommended.

Intraradicular use

The intraradicular use of the hydraulic cements is for root canal obturation, where they are recommended to be used in single cone obturation technique.

In addition, they are recommended as an apical plug for management of immature apices.

The material features for such procedures are:

- Adequate flow
- Radiopacity
- Antimicrobial characteristics.

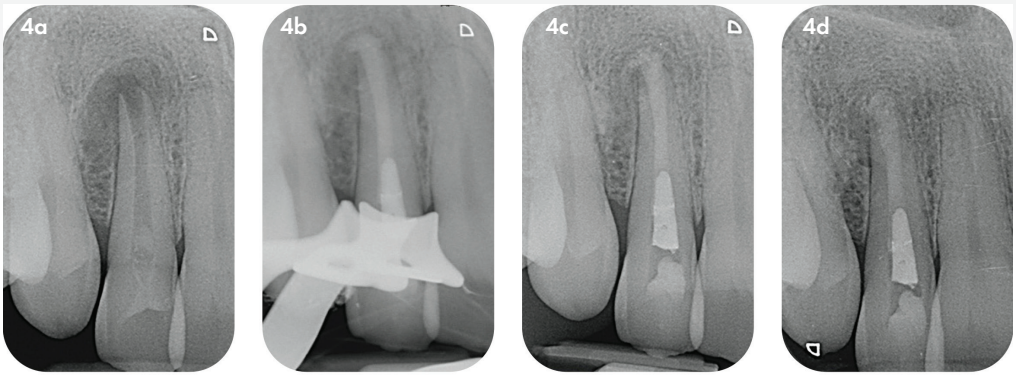
The presentation of root canal sealers varies from powder-liquid to single syringe devices.

Heat carriers used for warm vertical compaction techniques cause desiccation of hydraulic sealers that are in powder to liquid format (Camilleri, 2015) with the single syringe ones being more resistant to heat (Hadis and Camilleri, 2020). The clinical procedure and tooth preparation are similar for both procedures. The following steps are recommended:

- Root canal debridement with copious irrigation with sodium hypochlorite
- Use of ethylene diamine tetracetic acid to remove smear layer. This is specifically important when using single syringe sealers, as the removal of smear layer allows the dentine fluid to re-enter the root canal, enabling the sealer to hydrate. Unless the sealer hydrates, the antimicrobial properties are compromised (Zancan et al, 2021)
- Final irrigation with sterile water. This is done to avoid leaving chemicals that may interfere with the hydration in situ. Since the hydraulic cements are susceptible to environmental changes, the obturation and choice of sealers needs to be matched with the irrigation protocol (Fernandes Zancan et al, 2021)
- For single cone obturation, a cone fit radiograph is taken to check how the cone adapts to the space in the root canal. The sealer is placed at mid-root level. Since the hydraulic cements are water-based, there is a tendency for overfill, which should be avoided. A typical single cone obturation clinical case is shown in Figures 3a to 3d
- For apical plugs in management of immature permanent teeth, the hydraulic cement is packed with a long shank plugger without pressure. Biodentine has adequate handling properties so it can be placed at the canal orifice and the pushed downwards with the pre-measured long shank pluggers. MTA is more difficult to place and necessitates the use of a carrier to place the material. A plug of approximately 4-5mm should be placed. The rest of the root canal can be obturated with syringable thermoplasticised gutta percha. A clinical case is shown in Figures 4a to 4d.

Extraradicular use

Although hydraulic cements were developed for blocking the communication between the root canal and the periodontal ligament space in reparative procedures, such as root-end surgery and perforation repair, there is no research on an



Figures 4A, 4B, 4C and 4D: Dens invaginatus in UR2 leading to immature apex, which was managed by an apical plug of Biodentine. Recall after one and two years is shown after the postoperative radiograph.

optimised clinical protocol.

A collection of a few failed cases indicates that the hydraulic cements used for such procedures tend to be very sensitive to the environment and may not set or be washed out with time, leading to case failure (Camilleri and Aznar Portoles, 2020).

Conclusions

Hydraulic cements are unique materials used in endodontic practice. As they are susceptible to the environmental moisture, an appropriate clinical protocol is necessary to optimise the material properties and avoid case failure.

Not all hydraulic cements have the same chemistry, therefore the interactions may differ (Camilleri et al, 2022).

References

AAE (2021) Position Statement on Vital Pulp Therapy. J Endod 47(9): 1340-4

Al-Ali M, Camilleri J (2022) The scientific management of deep carious lesions in vital teeth using contemporary materials. A narrative review. Front Dent Med Sec Dental Materials 3: 1048137

Camilleri J (2007) Hydration mechanisms of mineral trioxide aggregate. Int Endod J 40(6): 462-70

Camilleri J (2008) Characterization of hydration products of mineral trioxide aggregate. Int Endod J 41(5): 408-17

Camilleri J (2011) Scanning electron microscopic evaluation of the material interface of adjacent layers of dental materials. Dent Mater 27(9): 870-8

Camilleri J (2013) Investigation of Biodentine as dentine replacement material. J Dent 41(7): 600-10

Camilleri J (2014) Color stability of white mineral trioxide aggregate in contact with hypochlorite solution. J Endod 40(3): 436-40

Camilleri J (2015) Sealers and warm gutta-percha obturation techniques. J Endod (1): 72-8

Camilleri J (2020) Classification of hydraulic cements used in dentistry. Front Dent Med Sec Dental Materials 1: 9

Camilleri J, Atmeh A, Li X, Meschi N (2022) Present status and future directions: Hydraulic materials for endodontic use. Int Endod J 55 Suppl 3: 710-77

Camilleri J, Aznar Portoles C (2020) Clinical perspective of hydraulic materials developed for root-end surgery. Special edition: endodontics in the era of hydraulic cements. ENDO 14(3): 205-216

Camilleri J, Borg J, Damidot D, Salvadori E, Pilecki P, Zaslansky P, Darvell BW (2020) Colour and chemical stability of bismuth oxide in dental materials with solutions used in routine clinical practice. PLoS One 15(11): 0240634

Camilleri J, Montesin FE, Brady K, Sweeney R, Curtis RV, Ford TR (2005) The constitution of mineral trioxide aggregate. Dent Mater 21(4): 297-303

Domingos Pires M, Cordeiro J, Vasconcelos I, Alves M, Quaresma SA, Ginjeira A, Camilleri J (2021) Effect of different manipulations on the physical, chemical and microstructural characteristics of Biodentine. Dent Mater 37(7): e399-e406

Fernandes Zancan R, Hadis M, Burgess D, Zhang ZJ, Di Maio A, Tomson P, Hungaro Duarte MA, Camilleri J (2021) A matched irrigation and obturation strategy for root canal therapy. Sci Rep 11(1): 4666

Galler KM, Krastl G, Simon S, Van Gorp G, Meschi N, Vahedi B, Lambrechts P (2016) European Society of Endodontology position statement: Revitalization procedures. Int Endod J 49(8): 717-23

Hadis M, Camilleri J (2020) Characterization of heat resistant hydraulic sealer for warm vertical obturation. Dent Mater 36(9): 1183-1189

Hadis M, Wang J, Zhang ZJ, Di MA, Camilleri J (2020) Interaction of hydraulic calcium silicate and glass ionomer cements with dentine. Materialia 9: 100515

Hashem DF, Foxton R, Manoharan A, Watson TF, Banerjee A (2014) The physical characteristics of resin composite-calcium silicate interface as part of a layered/laminate adhesive restoration. Dent Mater 30(3): 343-9

Marciano MA, Costa RM, Camilleri J, Mondelli RF, Guimarães BM, Duarte MA (2014) Assessment of color stability of white mineral trioxide aggregate angelus and bismuth oxide in contact with tooth structure. J Endod 40(8): 1235-40

Meraji N, Camilleri J (2017) Bonding over Dentin Replacement Materials. J Endod 43(8): 1343-9

Ricucci D, Siqueira JF Jr, Li Y, Tay FR (2019) Vital pulp therapy: histopathology and histobacteriology-based guidelines to treat teeth with deep caries and pulp exposure. J Dent 86: 41-52

Zancan RF, Di Maio A, Tomson PL, Duarte MAH, Camilleri J (2021) The presence of smear layer affects the antimicrobial action of root canal sealers. Int Endod J 54(8): 1369-1382

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