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Paediatric endodontics. Part. 1: Portland Cements Apical Plug

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Abstract

Treatment of necrotic immature permanent anterior teeth with Portland cements apical plug

The long-term success of endodontic treatment depends on the quality of the apical and coronal seal. In necrotic immature teeth the treatment can be challenging for the clinician as the endodontic anatomy and the presence of bacterial infection need to be addressed with special techniques and materials in order to obtain an effective and biocompatible apical seal. Unfortunately, despite the best treatments, immature permanent teeth have a reduced resistance to fracture due to the arrest of root walls development.

KEYWORDS Apical plug; Apical seal; Coronal seal; Endodontic treatment; Immature teeth; Portland cements.

Introduction

Dental traumatic injuries represent 5% of all traumatic injuries and are the most frequent cause of pulp necrosis in immature permanent incisors in 8–12 year-olds [Andreasen et al., 2003; Levin et al., 2020]. Pulp necrosis in immature permanent teeth causes the arrest of root development and maturation due to death of the odontoblasts producing radicular dentin. The result is a tooth with a wide canal and open apical foramina and thin delicate root canal walls.

The endodontic treatment of a necrotic immature tooth with open apex can be a real challenge since the clinician has to deal with the absence of an anatomical apical stop with higher risks of irrigants extrusion and difficulties in controlling root filling material placement.

In the history of endodontics, many years ago, a special root end filling technique was purposed to deal with wide root canals and foramina using a customised gutta-percha cone molded and adapted with solvents like xylene or chloroform. Unfortunately, this approach was not able to produce an effective apical seal and entailed a significant risk of periapical infection relapse. Moreover, the chemical solvents used to plasticise gutta-percha are known for their toxicity, and their use is questionable [Tomson et al., 2014]. The most common and reliable treatment for these clinical situations was the use of temporary canal medications with calcium hydroxide to chemically disinfect the endodontium and induce the spontaneous closure of the apical foramen with a reactive hard tissue barrier [Campanella et al., 2018]. This procedure, known as apexification, requires, after a delicate mechanical instrumentation and prolonged canal irrigations, the positioning of $Ca(OH)_2$ with a lentulo spiral in the root canal up to the estimated working length. With time, the contact between $Ca(OH)_2$ and the periapical tissues induces the formation of a hard tissue barrier that closes the foramina. The time needed for the desired apical closure is function of the original diameter of the foramina and it is reported in literature to last from 5 to 20 months with an average of 9–12 months. During this waiting time, follow-up visits are required, eventually renewing the $Ca(OH)_2$ every 2–3 months and carefully checking the status of the apical closure with a small K-file [Sheehy et al., 1997].

The traditional apexification (Fig. 1) treatment demonstrated a 95% success rate but has also several drawbacks [Cvek et al., 1992]. Particularly when the root development is in stages 1 to 3, some authors reported a significant reduction in tooth strength [Cvek et al., 1992; Andreasen et al., 2002], also related to the hydrolysis and degeneration of the dentinal organic matrix [Cicek et al., 2017]. Cicek [2017] reported that the prolonged exposure to Ca(OH)2 induces denaturation of carboxylate and phosphate groups, thus decreasing the dentin integrity by proteolytic action on collagenous fibrils. Finally, the need of a temporary coronal seal for a prolonged time may lead to a poor coronal seal and reinfection of the endodontium [Ree et al., 2017].

Portland cements apical plug

In the second half of the 90's a new root-end filling material was introduced, mineral trioxide aggregate (MTA) (Pro Root

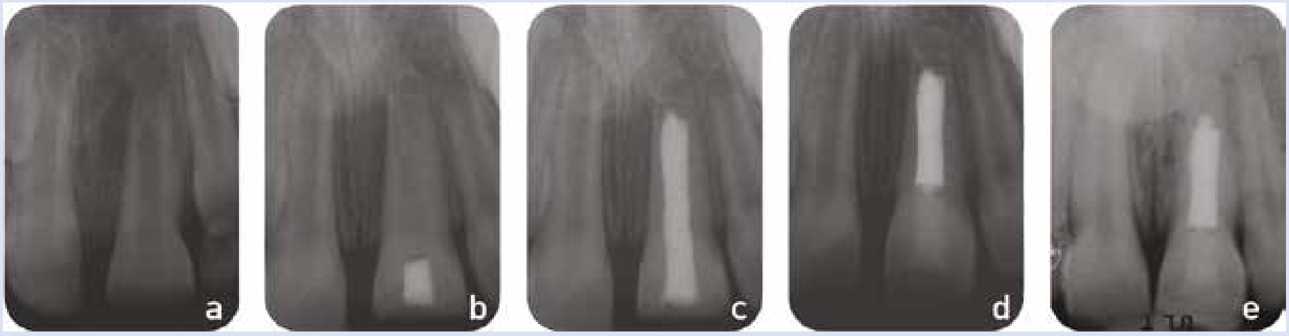

FIG. 1 A: Preoperative X-ray of necrotic immature tooth 2.1 in a 8 y/o patient. A dental trauma was reported 6 months before and the tooth was not restored.
B: $Ca(OH)_2$ apexification of tooth 2.1
C: 1 year after initial placement of $Ca(OH)_2$ medication the apical barrier was confirmed and the root canal obturation was performed with warm gutta-percha technique.
D: 1-year follow-up.
E: 8-year follow-up of the restored tooth. Note progression of the mineralisation of the apical barrier resembling the shape of a shorter root.

MTA Dentsply Tulsa Dental, Tulsa OK, USA), providing the clinicians an apexification treatment method, called apical plug. MTA is a Portland cement, also defined calcium silicate cement, capable to set in wet environment, seal effectively the apical foramina and induce a positive biologic response in the periapical tissues similarly to $Ca(OH)_2$.

Portland cements set in a short time and form an artificial apical barrier, allowing to finalize the treatment after a few days with conventional warm gutta-percha root filling and crown restoration [Torabinejad et al., 1999; Torabinejad et al., 2010]. The apical plug technique stands for the orthograde root-end filling of a wide canal with a 3–5mm thick cement plug placed at the working length. The apical plug with Portland cement is indicated in root canals with apical foramina diameter wider than 0.7 mm [Ree et al., 2017]. The operative protocol calls for local anaesthesia [Campanella et al., 2018], rubber dam isolation and correct endodontic access cavity. After working length determination, mechanical instrumentation of the root canal (if root walls are well represented) and chemical disinfection with prolonged irrigation are performed to eliminate any necrotic pulp and infected residues [Severino et al., 2019; Campanella et al., 2020]. Gauging of the apical foramen is mandatory to select the appropriate carrier to shape and place the Portland cement plug at the root end. The carrier should create a 3 mm long cement plug slightly larger than the diameter of the foramen and reach passively working length minus 3-4 mm. Portland cement must be prepared according to the manufacturer instructions and the recommended powder-to-liquid ratio (i.e. 3:1 for MTA) [Torabinejad et al., 1993] to obtain the correct consistency and expected proper setting reaction. After the carrier delivered 3 mm of Portland cement in the apical region, a plugger 3 mm shorter than the working length is used to adapt the cement to the canal walls. Correct positioning of the apical plug is verified with intra-operatory intraoral X-ray, and the use of a slow setting Portland cement allows for corrections when needed. After a second delivery and adaptation of Portland cement, the desired thickness of 5-6 mm apical plug is obtained and the tooth is restored temporarily, placing a wet cotton pellet inside the root canal

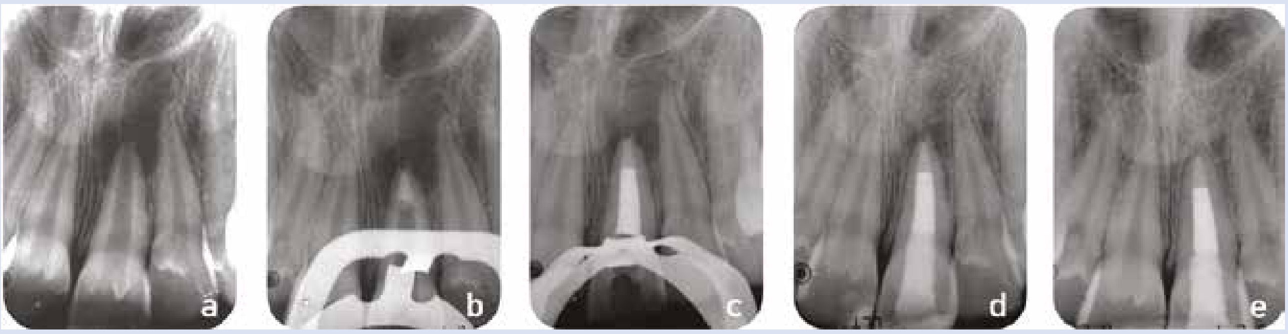

FIG. 2 A: Preoperative X-ray of necrotic immature tooth 2.1 in a 12 y/o patient with large periapical radiolucency. A dental trauma was reported at the age of 9 years. Difference in length and maturation of root are evident by comparison with tooth 1.1.
B: Aureoseal MTA apical plug of tooth 2.1.
C: 1 week after placement of Portland cement the root canal obturation was completed with warm gutta-percha technique, and a direct composite restoration was performed.
D: 1-year follow-up of the restored tooth. Note the complete resolution of the periapical lesion and restored periapical tissues.
E: 6-year follow-up.

to ensure correct humidity for Portland cement setting reaction. After at least 72 hours, the cement is hard enough to complete the endodontic and restorative procedures thus permitting the middle and coronal root canal thirds to be filled with gutta-percha [Libonati et al., 2018; Libonati et al., 2018] and the access cavity closed and sealed permanently with adhesive restorative materials (Fig. 2).

The Apical Plug technique is reported as highly predictable and effective with long-term success up to 15 years [Pace et al., 2014; Ree et al., 2017], but it is more susceptible to operator experience in the use of the carrier and plug placing. There are several MTA carrier on the market like the Dovgan MTA gun (Hartzell and Son, Concord, CA, USA), available in three different sizes (0.80, 0.99 and 1.6 mm), or the MAP System (Dentsply, Maillefer, Switzeland), available in two different sizes (0.90 e 1.1 mm). These devices are expensive and delicate and must be cleaned immediately after use to avoid internal damage due to cement particles. In order to control the positioning of the Portland cement at the desired length more easily, some authors suggest packing the periapical lesion with collagen sponges or platelet-rich fibrine to obtain a matrix onto which the cement can be simply plugged [Sharma et al., 2016; Magro et al., 2017]. Since there is evidence that this invasion of the periapical tissues causes initially an acute inflammatory reaction and there are still few evidences of a faster periapical healing, there is no general agreement on the real utility of an external matrix in apical plug placing [Magro et al., 2017].

Thomson et al. [2003] reported that cementoblasts and likely osteoblasts are able to adhere and proliferate in direct contact with MTA surface. Portland cement, due to its sealing, alkaline pH and biocompatibility properties, stimulates the natural healing of the periapical tissues by means of cell adhesion and mineralisation [Thomson et al., 2003].

A comparison of the resistance to fracture of teeth treated with $Ca(OH)_2$, apexification and MTA apical plug demonstrated that calcium hydroxide tends to weaken the teeth more than MTA. On the other hand, an apical plug thicker than 6 mm filling the whole root canal is associated with higher fracture tendency and is not advised [Cicek et al., 2017].

With time, many new Portland Cements were introduced such as Aureoseal (Ogna, Milano, Italy) with an improved consistency but with same setting time [Cianconi et al. 2016], or Biodentine (Septodont, France) with a fast setting time (12 minutes) and higher adhesion to dentin than MTA [Zhabuawala et al., 2016; Rafaei et al., 2020]. Even more recently the evolution of Portland cements led to a completely new class of endodontic cements and even sealers that are classified as bioceramic cements.

Previously, $Ca(OH)_2$ apexification was considered the gold standard treatment; today Portland cement apical plug represents the best treatment of choice for necrotic immature permanent teeth.

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