BioRoot RCS a new biomaterial for root canal filling

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Introduction

Due to progresses in scientific knowledge, endodontic treatments now provide highly predictable results. However, such results are closely tied to the respect of a number of steps that are nowadays clearly identified as key elements for endodontic treatment success. Notably, the filling of root canals is one of them. In clinical applications, it requires both knowledge and thoroughness (Ray and Trope 1995).

Sterilising and obtaining a root canal free of bacteria, following disinfection, is, so far, impossible to obtain (Siqueira et al. 1997). Apart from disinfecting, obturation is responsible for trapping residual bacteria, filling the predisinfected space and ultimately sealing it, in order to avoid any bacterial leakage into the periapical area.

Modern techniques for filling root canals are based on the association of gutta-percha (the core of the filling) and a sealer. The latter acts as a sealing material and, because of its fluidity, it is able to spread into any free space, notably those which were not enlarged during the mechanical root canal preparation.

Depending on the technique used by the practitioner, the gutta-percha is compacted differently: laterally when used with cold lateral condensation or vertically when used with a warm vertical compaction. Both techniques provide good long-term results, as the root canal is filled with a high proportion of gutta-percha with a small volume of sealer. The quantity of the latter needs to be minimal, as being degradable, it may lead to canal bacterial contamination over time.

The single cone technique is still very popular among practitioners, being quick and easy to perform. This technique consists in by employing a single cone with a large amount of sealer, which acts as a filling material. Unfortunately, the currently used sealers are prone to dissolution. As a consequence, with time, the canal is again contaminated with bacteria, leading to treatment failure and the growth of an apical lesion.

Thereby, although being easy to accomplish, the single cone technique is not recommended for root canal filling (Beatty 1987, Pommel et Camps 2001).

However, the single cone technique may be reopened and provided new reliability with new proposed biomaterials based on bioceramics, developed in the last few decades and launched on the market as root canal sealers.

Bioceramics properties

Bioceramics are specifically designed for medical and dental use with the prefix 'bio,' referring to their biocompatibility. In the orthopaedic field, inert bioceramics are used for prosthetic devices, while the active and re-absorbable ones are applied in endodontics.

Bioceramics are composed of alumina, zirconia, bioactive glass, glass ceramics, coatings, composites, hydroxyapatite, resorbable calcium phosphates and radiotherapy glasses (Dubock 2000, Best et al. 2008). Among them, calcium phosphate-based materials are used for filling bone defects. Calcium silicates and bio-aggregates (Mineral Trioxide Aggregate for example) were introduced for apical plug-in apexification procedures, but also for coronal/root repair in case of perforations (Trope and Debelian 2014, Koch and Brave 2009). Three basic types of bio-ceramics must be distinguished: (1) bio-inert high strength ceramics (alumina, zirconia and carbon); (2) bioactive ceramics which form direct chemical bonds with the bones or soft tissues of a living organism (bioglass and glass ceramics); and (3) biodegradable/soluble/re-absorbable ceramics (calcium phosphate based ceramics) that actively participate in the metabolic processes of an organism.

According to the manufacturers, such sealers could be used alone or combined with a gutta-percha point using a single cone technique in the context of an endodontic treatment or retreatment (Koch and Brave 2009). These sealers are mainly composed of tricalcic silicate, calcium phosphate monobasic, cal-
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cium hydroxide, and zirconium oxide that closely resemble the composition of MTA (Tyagi et al., 2013). The premixed form facilitates their use in good conditions, with decreased risk of heterogeneity in the preparation (Yang and Lu 2008).

Bioceramics have shown remarkable properties in terms of biocompatibility and antimicrobial activity with an excellent bioactivity, capable to induce mineralisation of periapical tissues (Zhang et al. 2009, Zhang et al. 2010). Indeed, the bioceramics specific physicochemical properties are what make them so interesting for the endodontic field. Firstly, because of their hydrophilic profile, they can set in a humid environment, such as dentine, which is made of almost 20% water (Koch and Brave 2010). Second, due to their wettability, a decreased viscosity and a higher quality sealing is present in bioceramics when compared with all the current sealers on the market.

**BioRoot RCS specific properties and composition**

BioRoot RCS is the newest endodontic sealer based on tricalcic silicate materials, benefiting from both Active Biosilicate Technology and Biodentine.

The first provides a medical grade level of purity and, unlike ‘Portland cement’-based materials, it ensures the purity of the calcium silicate content with the absence of any aluminate and calcium sulfate. BioRoot RCS is a mineral-based root canal sealer using a tricalcium silicate setting system. The powder part additionally contains zirconium oxide as a bio-compatible radiopacifier and a hydrophilic bio-compatible polymer for adhesion enhancing. The liquid part contains mainly water, calcium chloride as a setting modifier and a water reducing agent.

BioRoot RCS is bioactive by stimulating bone physiological process and mineralisation of the dental structure (Camps 2015, Dimitrova-Nakov 2015). Therefore, it creates a favourable environment for periapical healing and bioactive properties, including biocompatibility (Reichl 2015), hydroxyapatite formation, mineralisation of dentinal structure, alkaline pH and sealing properties.

BioRoot RCS is indicated for the permanent root canal filling in combination with gutta-percha points and is suitable for use in single cone technique or cold lateral condensation (Camilleri 2015). BioRoot RCS was designed to be used by mixing the powder part with the liquid part by simple spatulation: there is no need for a mixing machine. The working time is around 15 minutes and the setting time is less than 4 hours in the root canal. In addition, BioRoot RCS displayed a tight seal with the dentine and the gutta-percha (Xuereb 2014) and an appropriate radiopacity. The paste is of smooth consistency with good flow and adequate adhesion to instruments in order to enable an optimal placement in the root canal.

Thanks to the use of Active BioSilicate Technology, which is monomer free, there is no shrinkage of BioRoot RCS during setting for reaching a tight seal of the root canal.

Despite the similar composition in terms of viscosity and texture with a sealer, BioRoot RCS must be considered as an adhesive root filling material. A fitted gutta-percha point is used as a plugger-like carrier to facilitate the flow of BioRoot RCS into the canal space. Indeed, BioRoot RCS is also recommended for facilitating the obturation removal in case of retreatment.

**A new concept of obturation**

To achieve root canal filling and prevent any bacterial or fluid leakage, practitioners were always told to associate a core material with a sealer in order to fill the canal space. So far, gutta-percha is the most used material because it is a non-resorbable and well biotolerated. Unfortunately, gutta-percha has no intrinsic adhesive properties to dentine. Thereby, in order to ensure the seal of the final filling, the use of a sealer is required. The latter is also used for filling voids, flowing into anatomical irregularities, notably the ones that were not enlarged by mechanical preparation (i.e. isthmus, lateral/accessory canals).

Nevertheless, sealers are subjected to shrinkage, degradation over time and have no chemical sealing ability to dentine. As a consequence, the use of a large amount of core material with the thinnest layer of sealer is recommended to improve the quality of the filling.

Among the obturation techniques, cold lateral and warm vertical compaction are the best ones. Indeed, they are both capable of pushing the sealer into the non-instrumented spaces, where residual bacteria may persist. However, the first technique leaves excessive cold sealer inside the canal irregularities (instead of leaving gutta-percha) and the second one requires the placement of a plugger within 4 mm of the apex. Furthermore, with the warm lateral compaction, a large volume of coronal dentine needs to be removed, causing concerns among practitioners as it may possibly weaken the tooth structure (Trope and Debelian 2014).

Moreover, these techniques are time consuming, highly operator-dependent and require the use of
visual aids to ensure the best chances of success. As a matter of fact, most of the general practitioners still use the single cone technique, as it is easy and quick to perform. Due to the introduction of nickel-titanium tapered instrumentation, gutta-percha cones fitting in taper and apical diameter with the last file used of a given system are now commercialised. The apical sealing ability of a single cone placed inside the root canal is achieved in such condition in the apical third, because of the concordance of the last file used and the gutta cone design. However, because of the non-circular shape of the canal section on the median and coronal thirds, the cone does not perfectly fit into an ovoid canal. Hence, the remaining space is filled with sealer or voids (Angerame et al. 2012, Schäfer et al. 2013, Somma et al. 2011). On this basis, the single cone technique cannot be considered as reliable, since it provides an imperfect sealing.

Bioceramic sealers may be considered as an interesting solution to make the obturation steps reliable and easier to achieve, potentially replacing the ZnO-eugenol based sealers. In this context, they might provide a tight and durable seal all along the entire length of the root canal without the need of any compaction procedure. Used in combination with an adjusted gutta-percha point and due to its excellent wettability and viscosity, the bioceramic could spread into any root canal irregularity and non-instrumented space. Furthermore, its adhesive properties to dentine and the reduced need of excessive coronal tissue removal would provide an improved resistance to root fracture over time. This new class of materials could finally simplify the obturation stage, making it reproducible in every practitioner’s hands with a reduced learning curve. Notably among them, BioRoot RCS is one of these new bioceramic materials. The purpose of the present article is to describe its properties and introduce a new way of considering this biomaterial, not as a sealer but as a true root canal filling material. If this material can be considered as reliable, we may assist in a true paradigm shift in the field of endodontics.

Description of the technique and case reports

From an operational point of view, the procedure is very similar to the single cone technique. However, few indispensable differences justify the reliability of BioRoot RCS with such technique. Notably, the single cone technique seals a cone alone. Instead, here the cone is employed as a carrier, which is left in place to allow for material removal in case of retreatment. Indeed, it must not be considered as the core of the filling. The obturation is made by BioRoot RCS itself.

Case 1

A pulp necrosis was diagnosed on tooth #16 of a 35-year-old female patient associated with chronic periapical disease (Fig. 1). The patient had experienced chronic sinusitis for over two years and received unsuccessful medical treatments.

After having shaped the root canal and obtained an appropriate tapered preparation, the canal was disinfected with a 3 % sodium hypochlorite solution activated with mechanical agitation (Irrigatys, ITENA). A final rinse with 17 % EDTA and a final flush with sodium hypochlorite were completed before fitting the gutta-percha cones.

The canals were dried with paper points. The BioRoot RCS was mixed, following manufacturer recommendations and injected into the root canals with a spiral used with a low speed of rotation (800rpm). Each gutta-percha point was poured into the mixed material to largely cover the surface of the cone. Afterwards, it was gently inserted into the root canal space until reaching the working length.

The cone was cut at the entrance of the root canal with a heat carrier, and a slight plug was created with a hand plugger. The second and the third canal were filled in the same way (Fig. 2).

The patient was referred to the general practitioner who restored the tooth with a bonded...
overlay. She was recalled at 6 and 12 months after treatment. She no longer experienced a sinusitis and the tooth was asymptomatic. The 12-month recall showed complete healing of the periapical lesion (Fig. 3). Thereby, the treatment may be considered as successful.

Case 2

A 32-year-old female was referred to our endodontic department by her general practitioner for treatment on tooth #47 (Fig. 4). The patient reported a long painful dental history on this tooth. Root canal treatment had been initiated six months before, and several practitioners tried to complete the root canal treatment, unsuccessfully.

The patient complained about severe pain, numbness and loss of sensitivity of the mandible each time the access cavity was closed with a temporary filling.

An intraosseous injection (one cartridge articaine + 1/100,000 epinephrine (Septodont) was completed and root canals were shaped and disinfected with a large volume of sodium hypochlorite activated with Irrigatys (ITENA). The canals were dried, and temporary filled with a calcium hydroxide-based medication. Access cavity was filled with a temporary filling and the crown was drilled for occlusal reduction.

At the second visit, the root canal treatment was completed. Because the proximity of the inferior dental nerve, everything was done to avoid any extrusion of dental material. Because of its excellent biotolerance and non-toxicity, BioRoot RCS was considered as the material of choice for filling the root canals.

The root canals were rinsed again with sodium hypochlorite and 17% EDTA, and then dried. BioRoot was placed inside each canal with a spiral (800 rpm) and gutta-percha points were poured into the material and gently placed inside the canals up to the working length (Fig. 5).

The coronal restoration was completed on a third visit with a CAD/CAM bonded overlay (Figs. 6–8).

The patient never complained of any pain, neither discomfort. The six-month recall radiograph confirms the complete healing of the apical lesions (Fig. 9).

Case 3

A 31-year-old female patient was referred for a root canal retreatment on tooth #46 (Fig. 10). This tooth had already been retreated twice recently, but the patient still complained about pain and abscesses since the tooth had been restored with a post placed into the distal root.

Because the post was not visible on the preoperative radiograph, it was assumed that it might be a fibre post. The shape of the interradicular lesion let us suspect a zipping perforation into the interradicular area.

Root canal retreatment was completed in one visit. The fibre post of distal root and root canal filling material were removed with rotary and manual instruments. The four root canals were then reshaped and disinfected with 3% sodium hypochlorite with mechanical activation and 17% EDTA. During the retreatment process, an interradicular perforation (mesial side of the distolingual root canal) was highlighted (Fig. 11).
In the past, this type of disease would have been completed into two steps. The first step involves filling the root canal up to the level of the perforation, taking care to avoid any extrusion of materials through the perforation, and the second step involves filling the last third of the canal with a silicate-based material such as Biodentine (Septodont).

Because BioRoot is a tricalcium silicate-based filling material, it was decided to combine the two steps in one by filling the canals and the perforation in the same time.

Just as the two previous cases, the root canals were dried with paper points, BioRoot RCS was injected into the canals with a spiral used at low speed (800 rpm) and gutta fitted gutta-percha points were inserted into each canal up to the working length (Fig. 12). A small extrusion of material is visible on the postoperative radiograph, as a confirmation of perforation closure (Fig. 13).

The tooth was restored with a bonded overlay (Figs. 14 & 15) and the patient was recalled at six months after the treatment (Fig. 16).

The tooth is asymptomatic and functional; the periodontal probing is normal, and the six-month recall radiograph confirm the bone healing of the interradicular lesion.

These cases are used to illustrate some specific situation in which we used BioRoot RCS because its valuable properties. These are three of a large number of cases we have completed in the last 18 months. Before the launch of this product, 22 clinical cases were completed in the frame of a randomised clinical trial comparing the succes of an endodontic treatment using warm vertical compaction of gutta-percha versus the above described BioRoot RCS. The RCT registration number is NCT01728532 and the full protocol is available online (https://clinicaltrials.gov).

The results are, at the time of writing, under analysis and very encouraging, which allows us to consider this technique as reliable enough to be described here.

Conclusion

Endodontics is continuously under evolution. In the last 20 years, instrumentation research and development have been very active. Currently, disinfection and irrigation procedures are the two most focused on aspects of endodontic research.

The shaping procedures and root canal disinfection have been considerably simplified. Thereby, every practitioner interested in endodontics is now able to complete any easy/middle difficulty root canal treatment with reproducible results without any issue. Obturation, the final step of the procedure, is usually the most difficult and time-consuming aspect. However, with this new approach of root canal filling, this milestone may be overcome. Considering the fluidity of BioRoot RCS as a filler and not only as a sealer, this represents a true paradigm shift. The preliminary results of the randomised clinical trial are very encouraging. More clinical investigations will be necessary in the future to confirm this new vision of a simpler root canal obturation._

Editorial note: A list of references is available from the publisher.

BioRoot RCS is a registered trademark of Septodont.

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