BioRoot™ RCS a new biomaterial for root canal filling

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Introduction

Due to progresses in scientific knowledge, endodontic treatments provide now 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 the root canal is one of them. In clinical application, it requires both knowledge and thoroughness (Ray and Trope, 1995).

Sterilizing and obtaining a root canal free of bacteria, following disinfection, is, so far, impossible to obtain (Siqueira et al 1997). Apart from disinfecting, the obturation act is responsible to trap residual bacteria, fill the pre-disinfected space and ultimately seal it, in order to avoid any bacterial leakage into the periapical area.

Modern techniques for filling the root canal 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 a canal bacterial contamination over time.

The single cone technique, a procedure introduced in the past, is still very popular among practitioners being quick and easy to perform. This technique consists in employing a single cone with a large amount of sealer, which acts as a filling material. Unfortunately, the currently used sealers are poorly resistant 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 re-opened and provide new reliability with new proposed biomaterials based on bioceramics, developed in the last 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 orthopedic field, inert bioceramics are used for prosthetic devices, while the active and re-absorbable ones are applied in the endodontic field.

They 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 bioceramics 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 part 3). These sealers are mainly composed of tricalcic silicate, calcium phosphate monobasic, calcium 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 mineralization of periapical tissues (Zhang et al., 2009; Zhang et al., 2010). Indeed, the bioceramics specific physico-chemical 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 dentin, which is made of nearly 20% of water (Koch and Brave, 2010, part 2). Secondly, due to their wettability, a decreased viscosity and a higher quality sealing is present in bioceramics when compared with all the currently marketed sealers.

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 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 tricalcium silicate setting system. The powder part additionally contains zirconium oxide as biocompatible radiopacifyier and a hydrophilic biocompatible polymer for adhesion enhancing. The liquid part contains mainly water, calcium chloride as a setting modifyier and a water reducing agent.
BioRoot™ RCS is bioactive by stimulating bone physiological process and mineralization of the dentinal structure (Camps 2015, Dimitrova-Nakov 2015,). Therefore it creates a favorable environment for periapical healing and bioactive properties including biocompatibility (Reichl 2015), hydroxyapatite formation, mineralization 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 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 dentin 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 to allow a tight seal of the root canal.
Despite the similar composition in terms 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 bio-tolerated. Unfortunately, gutta-percha has no intrinsic adhesive properties to dentin. 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 which were not enlarged by the mechanical preparation (i.e. isthmus, lateral/accessory canals).

Nevertheless, sealers are subject to shrinkage, overtime degradation and have no chemical sealing ability to dentin. 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 dentin 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 last used file from a given system are now commercialized. 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 3D tight and durable sealing 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 dentin and the reduced need of an 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. Above all, such technique could provide equivalent clinical results, if not even better, when compared to the gold standards. 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 to a true paradigm shift into the field of endodontics.

Description of the technique and case report

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 the material removal in case of retreatement. Indeed, it must not be considered as the core of the filling. The obturation is made by BioRoot™ RCS itself.

Case report :

A pulp necrosis was diagnosed on tooth #36 of a 47 years old male patient. ***(Fig. 1)***

- 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. A final rinse with 17% EDTA and a final flush with sodium hypochlorite were completed before fitting the gutta percha cones.
- Canals were dried with paper points.
- BioRoot™ RCS was mixed, following manufacturer recommandations.
- Each gutta percha point was poured into the mixed material to largely cover the surface of the cone. Afterward, 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 refered to the general practicionner who restored the tooth with a post and core, and a crown.
- Patient was recalled at 6, 12 and 24 months after treatement. *NB: the patient was treated in the framework of a randomized clinical trial (see below), explaing why he was recalled three times* ***(Fig. 3).***

On the 24 months follow up radiograph, there were no signs of bone inflammation. This event is associated with no claims of pain nor discomfort by the patient and that the tooth was functional. Thereby, the treatment maybe considered as successful.

This case report is one of the 22 clinical cases of a randomized clinical trial comparing the succes of an endodontic treatment using warm vertical compaction of Gutta percha versus the above described BioRoot™ RCS. Currently, as the 24 months follow up period is still ongoing, some of the clinical cases are still not complete. The RCT registration number is NCT01728532 and the full protocol is available on https://clinicaltrials.gov

The results are still under analysis and very encouraging, which it allows us to consider this technique as reliable enough to be described here.

Fig. 1: Pre-operative X ray of tooth #36 on a 47 years old man.

Fig. 2: Post-operative X ray after completion of endodontic treatment. Canals were shaped with WaveOne Gold (Dentsply-France), disinfected with 3% sodium hypochlorite solution and the filled with BioRoot™ RCS placement with the help of 6% taper gutta percha cone.

Fig. 3: 24 months post-operative recall.

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 aspects of endodontic research.

The shaping procedures and root canal disinfection have considerably been simplified. Thereby, every practicionner interested in endodontics is now able to complete any easy/middle difficulty root canal treatement with reproducible results without any issue. Obturation, the final step of the procedure, is usually the most difficult and time consuming operation. However, with this new approach of root canal filling, this milestone may be overpassed. 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 randomized 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.

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OBTURATION INNOVATION

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