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Comprehensive review on recent root canal filling materials and techniques – An update

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Abstract
Obturation is the most important step in the triad of endodontics. Carefully and properly achieved obturation will lead to the formation of “fluid tight seal” which is essential for the success of the endodontic treatment. Over the past decade, the science & practice of root canal therapy has changed dramatically on evidence based protocols to develop highly advanced obturation materials and techniques. Gutta percha with sealer is the most versatile obturating material. But it has very big disadvantage that it does not bond to the root canal dentin. To overcome this drawback, bonded resin materials where developed. Many parelling techniques, materials where developed to improvise the obturation of the root canal. They include heat, injection, vibration, compaction & carrier based system. In this article all the root canal filling materials and techniques available at present are discussed.

Keywords: Gutta-percha, Obturating material, Obturating technique, Obturation.

1. Introduction

The success of root canal treatment depends upon proper diagnosis and treatment planning, knowledge of canal anatomy and morphology, canal debridement, sterilization of canal and obturation. Root canal obturation is defined as “the three- dimensional filling of the entire root canal system as close to the cementodentinal junction as possible. Minimal amounts of root canal sealers are biologically compatible, are used in conjunction with the core filling material to establish an adequate seal”. [1] Clinician should choose a path of treatment that will result in best possible cleaning & shaping of the root canal system, coupled with an obturation technique that will provide a 3-D seal, apically, laterally, and coronally within the confines of the root canal system. We have progressed in endodontic obturation to realize that the sealer is the key to obtaining a true fluid tight seal. The challenge, more specifically, has been to find a sealer that would simultaneously bond to the canal wall as well as to the gutta-percha cone or a similar core material. Endodontic science has realized that if it could satisfy such a challenge, we would then have the possibility of creating a true monobloc. Root canal filling materials and techniques have advanced dramatically in the last two decades. Traditionally, gutta percha point combined with sealer has been the obturation of choice. Gutta percha is versatile, with a long history of use, but the drawback of gutta percha is it does not bond to root canal. Techniques for obturating root canals include the use of heat or chemically-softened gutta percha, injection techniques, ultrasonics, vibration and carriers. Carrier based materials are available that utilize a core carrier around which obturating material is coated. The introduction of bonded obturating materials (methacrylate resins) has enabled the clinician to obtain a bonded seal to the root canal dentin in areas reached by the etch/adhesive materials. In addition, a carrier-based system is now available that combines a carrier technique and adhesive technology for bonded obturation.[2] In this article, root canal filling materials and techniques will be discussed.

1.1 Historical Background

Before 1800 root canal filling, when done, was limited to gold. Subsequent obturations with various metals, oxychloride of zinc, paraffin, and amalgam resulted in varying degrees of success and satisfaction. In 1847, Hill developed the first gutta percha root canal filling material known as “Hill’s stopping”.[3] The preparation, which consisted principally of bleached gutta percha and carbonate of lime and quartz, was patented in 1848 and introduced to dental

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profession. In 1867, Bowman made claim (before the St. Louis Dental Society) of the first use of gutta percha for canal filling in an extracted first molar.[4] In 1883, Perry claimed that he had been using a pointed gold wire, wrapped with some soft gutta percha.[5] In 1887, the SS White company began to manufacture gutta percha points. In 1893, Rollins introduced a new type of gutta percha to which he added vermilion.[6] The softening and dissolution of the gutta percha to serve as the cementing agent, through the use of rosins, was introduced by Callahan in 1914.[7]

2. Gutta Percha

Gutta percha is the preferred choice as a solid, core filling material for canal obturation. It demonstrates minimal toxicity, minimal tissue irritability, and is the least allergenic material available when retained within the canal system.[8] The successful use of the curious material gutta percha seems to have been as insulation for undersea cables. This was in 1848, and patents followed for its use in the manufacture of corks, cement thread, surgical instruments, garments, pipes, and sheathing for ships. Gutta percha golf balls where introduced by the latter part of the 19th century; until 1920, golf balls where called "gutties". [9] In its pure molecular structure, gutta-percha is the trans-isomer of polyisoprene and has an approximately 60% crystalline form. The cis-isomer is natural rubber, which has a largely amorphous form. Gutta-percha has three possible phase changes. In the unheated tree or in the cone at room or body temperature, gutta-percha is considered to be in the beta phase. In this phase, gutta-percha is solid, compactible, and elongatible; may become brittle when aged; and does not stick to anything. When heated to temperatures of 42^0 to 49 ^{0}C, gutta-percha undergoes a phase change to the alpha phase. In this phase it is runny, tacky, sticky, noncompactible, and non elongatible. The third, or gamma phase, occurs when heating is raised to 56^0 to 62 ^{0}C, but the properties at this level are not well known and seem to be similar to that of the alpha phase. The significance of these phases, in addition to the changes in physical properties, is that the materials expand when heated from the beta to the alpha or gamma phases, from less than 1% to almost 3%. When cooled down to the beta phase, a shrinkage takes place, of similar percentiles, but the degree of shrinkage almost always is greater than the degree of expansion and may differ by as much as 2%. That means that if gutta-percha is heated above 42^0 to 49^0 C (108^0 120^0 F) and then inserted into a prepared canal, a condensation procedure should be applied or some method used to lessen the problem of shrinkage.

2.1 Advantages of gutta-percha

- Compressibility
- Inertness
- Dimensional stability
- Tissue tolerance
- Radiopacity
- Becomes plastic when warmed
- Dissolves in solvents – chloroform & xylene
- Elongatible when fresh, brittle when old.

2.2 Disadvantages of gutta-percha

- Lack of rigidity
- Lack of length control.

2.3 Constituents of commercial gutta-percha cones

Material	Percentage	Function
Gutta-percha	18-22	Matrix
Zinc oxide	59-76	Filler
Waxes/resins	1-4	Plasticizer
Metal sulfates	1-18	radiopaque

2.4 Different types of gutta percha availability

- **Gutta percha points:** They have size and shape similar to ISO standardization.
- **Greater taper gutta percha:** They have taper other than 2%. They are available in 4%, 6%, 8% and 10 % sizes.
- **Auxiliary points:** They are non-standardized gutta cones. They perceive the shape of root canal.
- **Precoated gutta percha:** Metallic carriers are coated with gutta percha. Carriers used are stainless steel, titanium, or plastic materials. Eg: Thermafill.
- **Gutta flow:** In these powdered gutta percha is incorporated in resin based sealer.
- **Syringe system:** Here low viscocity gutta percha is used. Eg: Successfil
- **Gutta percha pellets/bars:** Available in small pellets and are used for thermoplasticized gutta percha obturation. Eg: Obtura system.
- **Gutta percha sealers:** Gutta percha is dissolved in chloroform or eucalyptol to be used in the canal.
- **Medicated gutta percha:** calcium hydroxide, iodoform or chlorhexidine containing gutta percha points.

3. Coated Cones: This process has been developed in an attempt to achieve similar results as those claimed by Resilon-A bond between the canal wall, the core and the sealer. Two versions of coating gutta-percha are available. Ultradent Corporation has surface coated their gutta-percha cones with a resin (Ultradent, South Jordan, Utah). A bond is formed when the resin sealer contacts the resin-coated gutta-percha cone. The manufacturer claims this will inhibit leakage between the solid core and sealer. The technique calls for the use of EndoRez™ sealer (Ultradent, South Jordan, Utah) with this new coated solid core material. Another company has coated their gutta-percha cones with glass ionomer (Brasseler USA, Savannah, Ga.) and is designed for use with their glass ionomer sealer. Their system is called Active GP Plus™.

4. Resilon: Resilon™, a new, synthetic resin-based polycaprolactone polymer has been developed as a gutta-percha substitute to be used with Ephiphany®, (Pentron® Clinical Technologies, Wallingford, CT.) a new resin sealer in an attempt to form an adhesive bond at the interface of the synthetic polymer-based core material, the canal wall and the sealer. Advocates of this technique propose that the bond to the canal wall and to the core material creates a "monoblock." It is capable of being supplied in standardized ISO sizes and shapes, conforms to the configuration of the various nickel-titanium rotary instruments, and is available in pellet form for injection devices. The manufacturer states that its handling properties are similar to those of gutta-percha and therefore it can be used with any obturation technique. Resilon contains polymers of polyester, bioactive glass and radiopaque fillers (bismuth oxychloride and barium sulfate) with a filler content of approximately 65%.[10] It can be softened with heat or dissolved with solvents like chloroform. This characteristic allows the use of various current treatment techniques. Being a resin-based system makes it compatible with current restorative techniques in which cores and posts are being placed with resin-bonding agents. [11, 12] Resilon is a nontoxic, non-mutagenic, and biocompatible. Resilon core materials shrink only 0.5% and is physically bonded to the sealer by polymerization. When it sets, no gaps are seen due to no shrinkage. The core material is available in conventional and standardized cones and pellets for use in the Obtura II.

5. Obturation Techniques

5.1. Lateral Compaction*:* A master cone corresponding to the final instrumentation size and length of the canal is coated with sealer, inserted into the canal, laterally compacted with spreaders and filled with additional accessory cones.

Advantages: It can be used almost all clinical situations, it provides length control and thus overfilling is avoided.

Disadvantages: It may not be able to fill the canal irregularities efficiently, it does not produce homogenous mass and thus spaces may be present in between the cones.

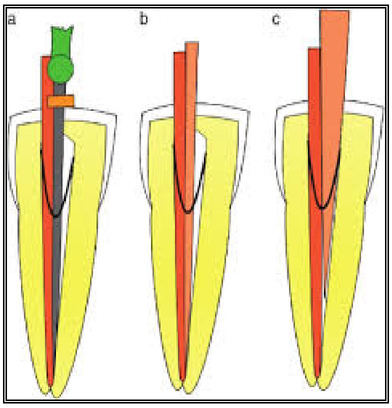

Fig 1: Lateral compaction technique

Variations of Lateral Compaction Technique

Curved canals: NiiTi spreaders are used. For severly curved canal like dilacerated canals, thermoplasticized gutta percha technique is preferred.

Blunderbuss canals: It is characterized by flared out apical foramen, thus apexification is required for apex closure. So for complete obturation of such canals, tailor made gutta percha or warm gutta percha technique is preferred.

Tailor made gutta percha technique: Tailor made gutta percha is prepared by joint multiple gutta percha cones from butt to tip until a roll is formed. Then this roll is softened by using ethyl chloride spray. For use in the canal, the outer surface of tailor made cone is dipped in chloroform, eucalyptol or halothane and then cone is placed in the canal. [13]

5.2 Vertical Compaction*:* A master cone corresponding to the final instrumentation size and length of the canal is fitted, coated with sealer, heated and compacted vertically with pluggers until the apical 3-4mm segment of the canal is filled. Then the remaining root canal is back filled using warm pieces of core material.

Advantages: Excellent sealing of canal apically, laterally and accessary canals.

Disadvantages: Vertical root fracture, overfilling and time consuming.

5.3. System B/Continuous Wave: It was developed by Buchanan. Continuous wave is essentially a vertical compaction (down-packing) of core material and sealer in the apical portion of the root canal using commercially available heating devices such as System B (SybronEndo, Orange, Calif.) and Elements Obturation Unit™ (SybronEndo, Orange, Calif.), and then back filling the remaining portion of the root canal with thermoplasticized core material using injection devices such as the Obtura (Obtura Spartan, Earth City, Mo.), Elements Obturation Unit™ (SybronEndo, Orange, Calif.) and HotShot (Discus Dental, Culver City, Calif.).

Advantages: Excellent apical control, thorough condensation of the main and the lateral canals. It creates single wave of heating and compacting thereby compaction of filling material can be done at the same time when it is heat softned.

Fig 2: System B/Continuous Wave technique

5.4. Warm Lateral: A master cone corresponding to the final instrumentation size of the canal is coated with sealer, inserted into the canal, heated with a warm spreader, laterally compacted with spreaders and filled with additional accessory cones. Some devices use vibration in addition to the warm spreader.[14]

5.5. Lateral / Vertical Compaction of Warm Gutta Percha Technique: Lateral compaction provides length control whereas vertical compaction provides dense obturation. So advantages of both these techniques are provided newer devices Endotech II. It comes with battery which provides energy to heat the attached plugger and spreader.[14]

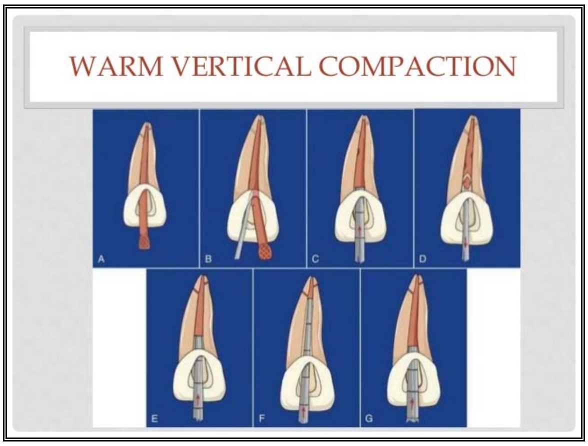

Fig 3: Warm vertical technique

5.6. Sectional Method: It is also called as Chicago technique and promoted by Coolige, Lundquist, Blany.

Advantages: It selas the canals apically and laterally. If post core is planned only apical section of canal is filled

Disadvantage: Time consuming and difficult to remove the sections of gutta percha if there is overfilling.

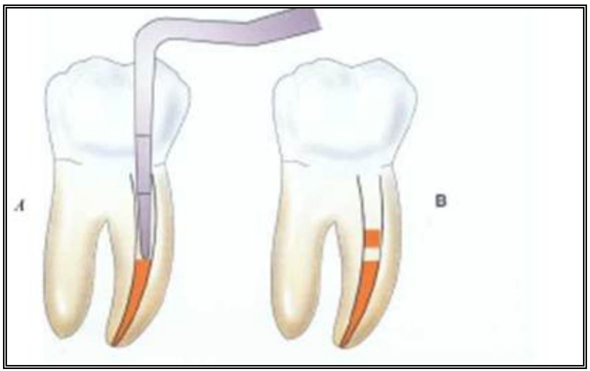

Fig 4: Sectional technique

5.7. Mac-Spadden Compaction*:* It is also called as thermomechanical compaction of gutta percha and it is introduced by Mac-Spadden. In this technique heat was used to decrease the viscosity of gutta percha. It uses Mac-Spadden compactor which resembles reverse hedstrom file.
A cone coated with sealer is placed in the root canal, engaged with a rotary instrument that frictionally warms, plasticizes and compacts it into the root canal. [15]

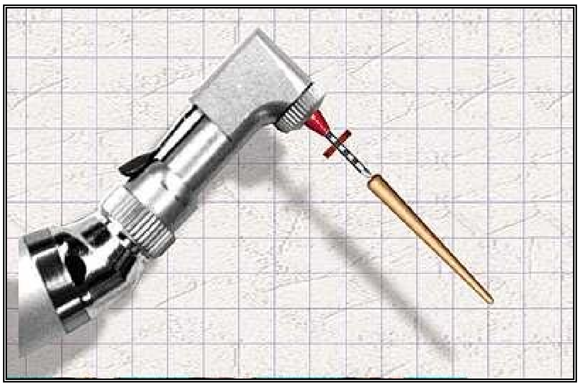

Fig 5: Mac-Spadden Compaction

5.8. Carrier-Based

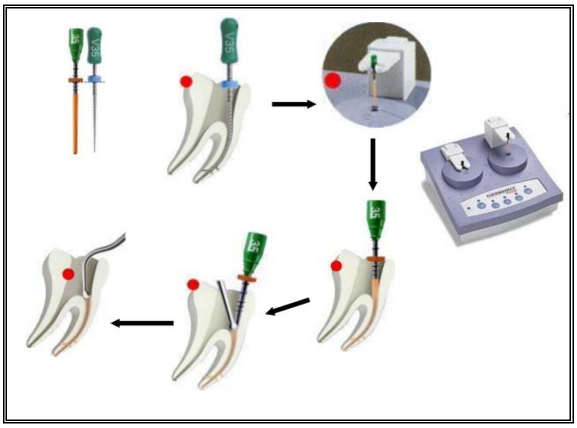

Fig 6: Carrier based obturation technique

5.8a. Obtura II (Obtura Spartan, Earth City, Mo.) Introduced in 1977 at Harvard Institute. It consists of an electric control unit with pistol grip syringe and specially designed gutta-percha pellets which are heated to approximately 365 – 390^{0}F(185-200 ^{0}C) for obturation. Canals should have continuous tapering funnel shape smooth flow of softened gutta-percha. Obtura II is indicated in roots with straight or slightly curved canals and also used in cases of obturation of roots with internal resorption or perforations. [16]

Fig 7: Obtura II

5.8b. Ultrafil (Coltene Whaledent, Cuyahoga Falls, Ohio): It uses low temperature, (i.e.70 ^{0}C) plasticized alpha phase gutta-percha. It is available in three different viscosities for use in different situations – Regular set, firm set and Endoset. Technique: Cannula is placed 6-7mm from apex and confirmed. It is placed in heater (at 900 ^{0}C) for minimum of 15 minutes before use. Sealer applied in canal and needle inserted passively into the canal. As the warm gutta-percha fills the canal, its backpressure pushes the needle out of the canal.

5.8c. Thermafil: Introduced by W.Ben Johnson in 1978. Thermafil endodontic obturators are specially designed flexible steel, titanium or plastic carriers coated with alpha phase gutta-percha.

Advantages: It provides dense three dimensional obturation and fills the canal irregularities like fins, anastomoses and lateral canals. Less strain is required during obturation.

Fig 8: Thermafil

5.8d. Successfil: It's a carrier based technique associated with ultrafil 3-D. Gutta percha is available in syringe is placed in the canal to the prepared length. Compaction of gutta percha is done using various compactors depending upon the canal morphology. At the end, the carrier is severed till opening of root canal orifice.

5.9. Cold Gutta Percha Compaction Technique

5.9a. Gutta Flow (Coltene Whaledent, Cuyahoga Falls, Ohio)**:** Its eugenol free radiopaque form consisting of polydimethyl siloxane matrix filled with powdered gutta-percha, silicon oil, paraffin oil, platinum dioxide and nano silver. It does not require compaction or heating of gutta percha.

5.9b. Chemoplasticized: Chemically softened gutta-percha, using solvents such as chloroform or eucalyptol, is placed on already fitted gutta-percha cones, inserted into the canal, laterally compacted with spreaders and the canal filled with additional accessory cones.

5.9c. Custom Cone/Solvents: Solvents such as chloroform, eucalyptol or halothane are used to soften the outer surface of the cone as if making an impression of the apical portion of the canal. However, since shrinkage occurs, it is then removed and reinserted into the canal with sealer, laterally condensed with spreaders and accessory cones.

5.10. Obturation with silver cone

It is indicated in teeth with fine, tortuous, curved canals and in mature teeth with calcified canals.

Advantages: It negotiates extremely curved canals and easy to handle.

Disadvantages: Prone to corrosion and difficult to retrieve.

5.11. Apical Third Filling

Classification

Carrier based: Simplifill obturator, Fiberfill obturator.

Paste based system: Dentin chip filling, Calcium hydroxide filling, MTA filling.

5.11a. Simplifill obturator: Developed by light speed technology 80. In this technique of obturation the apical gutta-percha size is same ISO size as the light speed master apical rotary. Here a stainless steel carrier is used to place gutta-percha in apical portion of the canal.

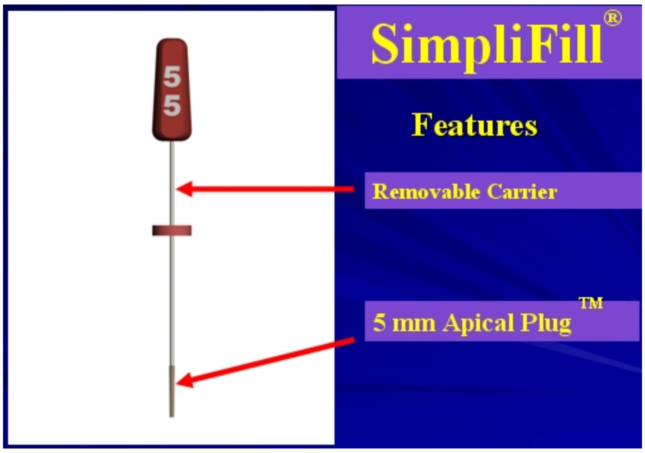

Fig 9: Simplifill obturator

5.11b. Fiberfill Obturator: This obturation technique combines a resin post and obturator forming a single until and apical 5-7 mm of gutta-percha. This apical gutta-percha is attached with a thin flexible filament to be used in moderately curved canals. Its advantage includes less coronal microleakage.

Fig 10: Fiberfill Obturator

5.11c. Dentin chip filling: It is also known as BIOLOGICAL SEAL. In this technique after thorough cleaning and shaping of canal, H-file is used to produce dentin powder in central portion of the canal, which is then packed apically with butt end of paper point.

Advantages: It is biocompatible and promotes healing with no extrusion of filling material from the canal space.

Disadvantage: Infected pulp tissue may get packed at the apex in the dentinal mass.

5.11d. Calcium Hydroxide: Also known as *apical barrier*. Moist calcium hydroxide is placed in the canal with the help of plugger and amalgam carrier, injectable syringes or by lentulospirals. Dry form of Ca $(OH)_2$ is carried into canal by amalgam carrier which is then packed with pluggers. Calcium hydroxide stimulates cementogenesis and is biocompatible and thus used in apexification procedure to induce apical barrier.

5.11e. Mineral Trioxide Aggregate

Developed by Dr. Torabinejad in 1993. It contains tricalcium silicate, dicalcium silicate, tricalcium alumiate, bismuth oxide, calcium sulfate and tetracalcium aluminoferrite. MTA is hydrophilic and sets in moist atmosphere. Advantages of MTA includes excellent biocompatibility reduced toxicity, radiopacity, bacteriostatic nature and resistance to marginal leakage.

5.12. Coronal seal

Coronal leakage can occur in even well obturated teeth leading to infection and failure of endodontic treatment. So coronal seal should be enhanced by using restorative materials like cavit, super EBA, or MTA over the orifices of root canals.

6. Conclusion

To achieve the successful endodontic therapy, it is crucial that all canals are located, cleaned & shaped, disinfected & sealed properly, not only in the apical portion but as well as coronal part of the root canal. Clinician should choose the obturating material & technique depending on the skills, experience and the situation of the root canal morphology. The one who selects the appropriate root canal filling material and uses the appropriate root canal filling technique, so as to completely seal the root canal will be remembered throughout the patients life through his competent work done on the patient tooth.

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