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Obturating Materials Present and Past: A Review

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Abstract: *Importance of obturating materials is indispensable in Endodontics. Formation of a hermetic seal during obturation of root canal is pivotal in successful outcome. A number of obturating materials are available presently including basic to highly advanced materials. Gutta percha with sealer is the most versatile obturating material. This article briefly covers the obturating materials along with their present status in today's Endodontic practice.*

Keywords: *Obturating material, Gutta percha, Root canal.*

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I. Introduction

Obturation of root canal system is the most important step in successful root canal treatment. It is defined as 'the three dimensional filling of the entire root canal system as close to the cementodentinal junction as possible. Small quantity of root canal sealers which are biologically compatible are used in conjunction with the core filling material to ensure an appropriate and acceptable seal[1] '. The primary objective is to achieve a fluid tight seal at apical, lateral and coronal sections of root canal system. This starts with proper cleaning and shaping of the root canal system followed by best obturating technique to ensure successful outcome. Also, the role of sealers is very important in formation of fluid tight seal as it would bond simultaneously with canal wall as well as obturating materials. This article reviews the obturating materials briefly alongwith there role in present endodontic practice.

II. History

In the past, various materials have been used to fill root canals like Gold foil, Amalgam, Asbestos, Iron, Lead, Balsam, Bamboo, Cement, Copper, Oxychloride of zinc, Paraffin Pastes, Plaster of Paris, Resin, Rubber, Silver Points, Tin Foil etc. None of these materials proved to be ideal as obturating material. Later, the discovery of Gutta Percha ended the long search for ideal obturating material.

- 200 B.C. : Oldest known root canal filling bronze wire was found in root canal of skull of Nabatean warrior.
- 1656: John Tradescant was the first person to discover guttapercha after his travels from far east.
- 19th century : Koecker used Red hot wire to cauterize pulp and fill the canal with gold.
- 1825: Edward – Hudson used gold foil.
- 1843 : The honour of introduction Gutta Percha goes to Dr. William Montogmerie, medical officer in Indian service, who was first to appreciate potential of this material in medicine. He was awarded Gold medal by the Royal Society of Arts, London in 1843[2].
- 1847: Hill developed the first Gutta Percha root canal filling material known as "Hill's Stopping"[3]. The preparation consisted principally of bleached Gutta Percha and carbonate of lime and quartz which was patented in 1848 and introduced to dental profession.
- 1867: Bowman claimed the first use of Gutta Percha for canal filling in extracted first molar[4].
- 1883: Perry claimed use of pointed gold wire wrapped with some soft gutta percha[5].
- 1893: Rollins introduced a new type of gutta percha to which he added vermilion[6].
- 1898: Gysi introduced formaldehyde paste – Gysi's Triopaste.

- 1914: Callahan introduced the softening and dissolution of gutta percha to serve as cementing agent through the use of rosins[7].
- 1930: Elmer A. Jasper introduced silver points.
- 1977: Yee et al introduced thermoplasticized injectable gutta-percha obturation.
- 1978: W. Ben Johnson described obturation with thermoplasticized alpha phase gutta-percha carried into the canal on endodontic file.
- 1979: McSpadan described new concept of heat softening and compacting gutta-percha.
- 1984: Michanowicz introduced low temperature (70^0C) injectable thermoplasticized gutta-percha technique i.e. ultrafill.
- 1994: James B. Roane described inject R-fill technique.

Principles of Root Canal Filling Material

The standard root canal filling is a combination of sealer cement with a central core material, which until now has been almost exclusively Gutta Percha. The core acts as a piston on the flowable sealer causing it to spread fill voids and to wet and attach to the instrumented dentin wall. By design, it is the sealer that comes into contact with the root canal and pulp stump; only occassionally does the Gutta Percha protrude from the sealer and touch the dentin or periodontal tissues[8]. Therefore, the sealer should possess many of the critical properties of the root filling e.g. biocompatibility and sealing ability.

Properties of ideal root canal filling material

"Grossman's Criteria" for ideal root canal filling material[9] (Table 1)

Table 1. Requirements for an ideal root filling cement.
It should be easily introduced into the canal
It should seal the canal laterally as well as apically
It should not shrink after being inserted
It should be impervious to moisture
It should be bacteriostatic or at least not encourage bacterial growth
It should be radiopaque
It should not stain tooth structure
It should not irritate periapical tissue
It should be sterile, or quickly and easily sterilized before insertion
It should be easily removed from the root canal if necessary

Sundqvist and Fidgor[10] assigned three primary functions to the root filling : sealing against ingrowth of bacteria from oral cavity, entombment of remaining microorganisms; and complete obturation at a microscopic level to prevent stagnant fluid from accumulating and serving as nutrients for bacteria from any source.

III. Obturating Materials

Classification

- Plastics : Gutta Percha, Resilon
- Solids or metal cores : Silver points, Coated cones, Gold, Stainless Steel, Titanium and Irridio-Platinum
- Cements and Pastes : Hydron, MTA, Calcium Phosphate, Gutta Flow

Gutter Perch

The name Gutta Percha is derived from two words,
"GETAH" - meaning gum
"PERTJA" - name of the tree in Malay language

Gutta-Percha is a dried coagulated extract of plants of Palaquium, Blanco genus of Sapotaceae family which are natural inhabitants of South East Asia[2]. It is a material with minimal toxicity, minimal tissue irritability and is least allergic when retained within canal system[11]. Therefore, Gutta-percha is the preferred choice as a solid, core filling material for canal obturation. Gutta-percha is the trans-isomer of polyisoprene and has an approximately 60% crystalline form. The cis-isomer is a natural rubber which has a largely amorphous form. Crystalline Gutta-percha may occur in Alpha or Beta phase. At room temperature, Gutta-percha is considered in beta phase. In this phase, it is solid, compactible and can be elongated. It is nonsticky and becomes brittle with age. Gutta-percha changes to Alpha phase when heated to 42^o - 49^o C. In this phase, it is sticky, runny, tachy, noncompactible and cannot be elongated. After cooling to beta phase, shrinkage occurs which is greater than the degree of expansion seen after heating. This should be considered while inserting Gutta-percha into a prepared canal and a condensation procedure should be applied to counter this problem. Commercially available form is beta form.

Advantages of Gutta-percha
- Compressibility
- Inertness
- Dimensional Stability
- Tissue Tolerance
- Radio-opacity
- Becomes plastic when warmed
- Dissolves in solvents - chloroform and xylene
- Can be elongated when fresh, brittle when old

Disadvantages of Gutta-percha
- Lack of rigidity
- Lack of length control
- Easily displaced by pressure
- Lacks adhesive quality

Constituents of commercial Gutta-percha (Friedmann et al) (Table No 2) :

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

Different types Gutta-percha availability
- Gutta-percha points: They have size and shape is similar to ISO standardization (2% taper from sizes No 15 to 140).
- Greater taper Gutta-percha: They have taper other than 2%. They are available in 4%,6%,8% and 10% sizes.
- Variable taper Gutta-percha: They have points suiting the taper of variable taper shaping instruments like protaper F1, F2 and F3.
- 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, e.g. Thermafill.
- Gutta flow: In these powdered gutta percha is incorporated in resin based sealer.
- Syringe system: Low viscosity gutta-percha is used, e.g. Successfil.
- Gutta-percha pellets/bars: Availability in small pellets and are used for thermoplasticized gutta percha obturation, e.g. Obtura syatem.
- 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.

Medicated Gutta-Percha

1. Calcium Hydroxide containing gutta-percha: They are made by combining 58% of calcium hydroxide in matrix of 42% gutta-percha. They are available in ISO size of 15-140. Action of $Ca(OH)_2$ is activated by moisture in canal.

Advantages of $Ca(OH)_2$ points
- Ease of insertion and removal
- Minimal or no residue left
- Firm for easy insertion

Disadvantages
- Short lived action
- Radiolucent
- Lack of sustained release

$Ca(OH)_2$ plus points : They contain tenside which reduces the surface tension. Due to the presence of water soluble components tenside and sodium chloride, they are 3 times more reactive than $Ca(OH)_2$ points. Also, they have superior pH and increases wettability of canal surface with increased antibacterial property. They have sustained alkaline pH for one week.

2. Iodoform containing gutta-percha : Iodoform containing gutta-percha remains inert till it comes in contact with the tissue fluids. On coming in contact with tissue fluids, free iodine is released which is antibacterial in nature.
3. Chlorhexidine diacetate containing gutta-percha : In this gutta-percha matrix embedded in 5% chlorhexidine diacetate. This material is used as an intracanal medicament.

IV. Resilon

Resilon is a high performance polyurethane. It is a new synthetic resin based polycaprolactone polymer which is a biodegradable aliphatic polyster with filler particles consisting of bioactive glass, bismuth oxychloride and barium sulfate[12]. It possesses some antibacterial and antifungal properties. It is recognized as a material that bonds to dentin when Epiphany sealer is used[13]. Resilon polymeric matrix consists of 25-40% polycaprolactone (PCL) and 3-10% dimethacrylates[14]. It can be softened with heat or dissolved with solvents like chloroform. This quality allows its use under various current treatment techniques. Resilon is compatible with current restorative techniques in which cores and posts are being placed with resin-bonding agents[15]. It is nontoxic, nonmutagenic and biocompatible. Resilon core materials shrink only 0.5% and is physically bonded to the sealer by polymerization. After settling, there are no gaps seen due to no shrinkage. Resilon is available in form of ISO sized points and pellets for use with obtura III (Obtura Spartan). System can be placed using lateral compaction, warm vertical compaction and thermoplastic injection. There is a doubt in susceptibility of this material to hydrolytic enzymes. Further clinical trials are required to recommend this material as an alternative to gutta-percha.

V. Silver Points

It was introduced by Jasper in 1941. In the past, root canal instrumentation was aimed at preserving the narrow taper of natural root canal. The widening of curved canals by stainless steel instruments was hazardous with a increased risk of canal transportation and strip perforation of gracile roots. Insertion of small size gutta-percha points in narrow curved canals with small taper often led to buckling and bending of the point. Advantage of silver points is that it would not buckle because of its quality being flexible but quite stiff. Insertion in narrow and curved canals is therefore easier compared to gutta-percha. Silver points was popular because of its ease of handling and placement. However, its use reduced significantly as it does not produce an acceptable three dimensional seal of the root canal system. It produces a plug in the apical constriction, with poor adaptability to root canal walls and do not seal the accessory canals that are frequently present. Also, silver points over a period of time tend to corrode which compromises the apical seal[16]. Therefore, silver points are presently not used as an obturating material in clinical practice.

VI. Coated Cones

Two versions of coating gutta-percha are available. Ultradent have gutta percha surface coated with a resin. In this, a bond is formed when resin sealer comes in contact with resin coated gutta-percha cone. This will inhibit leakage between the solid core and sealer. Use of EndoRez sealer advocated with this new coated solid core material. The other one available is with coating of glass ionomer on gutta-percha and is designed for use with their glass ionomer sealer. It is called Active GP Plus.

VII. Mineral Trioxide Aggregate (MTA)

It was developed by Dr Torabinejad in 1993. It contains tricalcium silicate, dicalcium silicate, tricalcium alumniate, bismuth oxide, calcium sulphate 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. It is available in Grey and White colour. White colour lacks tetracalcium aluminoferrite.

Properties of MTA

- pH is 12.5, so it has biological and histological properties similar to calcium hydroxide.
- Setting time is 2 hours and 45 minutes.
- Compressive strength is 40 MPa immediately after setting and 70 MPa after 21 days.
- Contrast to $Ca(OH)_2$, it produces hard setting nonresorbable surface
- It sets in a moist environment being hydrophilic.
- It has low solubility.
- It shows resistance to marginal leakage.
- It also reduces bacterial migration.
- It exhibits excellent biocompatibility in relation with vital tissues.
- The compressive strength of MTA is equal to IRM and Super EBA but less than that of amalgam.

- MTA is also known as Portland's cement except for addition of bismuth oxide which is added for modifying its setting properties. Its consistency is similar to very hard cement, which can be compared to concrete.

Advantages of MTA
- Water based chemistry, so requires moisture for setting
- Excellent biocompatibility
- Normal healing response without inflammation
- Least toxic of all the filling materials
- Reasonably radiopaque
- Bacteriostatic in nature
- Resistance to marginal leakage

Disadvantages of MTA
- Difficult to manipulate
- Long setting time (3-4 hours)
- Costly

Indications of use of MTA
- As a pulp capping material
- For the repair of root canals as an apical plug during apexification
- For the repair of root perforations during root canal therapy
- For the repair of root resorptions
- As a root end filling material

Gutta Flow

Its eugenol free, radiopaque form consisting of polydimethyl siloxone 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.

Sealers

The sealers act as fillers for canal irregularities and minor discrepancies between the root canal wall and core filling material. They act as lubricant, enhance the possible attainment of an impervious seal and can assist in microbial control of root canal walls.

Classification of currently employed root canal sealers (Grossman)
- Zinc oxide eugenol based sealers
- Calcium hydroxide based sealers
- Glass ionomer based sealers
- Resin based sealers
- Materials with calcium hydroxide
- Silicone-based sealers

Recent Advances in Obturating Materials

In recent years, there has been an increased concern over the poor sealing properties of the conventional root-filling materials, gutta-percha and the different sealers. Studies have demonstrated microleakage in canals filled with these materials leading to ingress and propagation of bacteria resulting in infection. The introduction of newer root canal filling materials ensures better adhesion to root canal dentine.

VIII. Resilon

It has been developed to replace gutta-percha and traditional sealers for root canal obturation. It offers solutions to the problems associated with gutta-percha:
- Shrinkage of gutta-percha after application of heat.
- Gutta-percha does not bind physically to the sealer resulting in gap formation between the sealer and the gutta-percha. The resilon core material bonds to the sealer by polymerization. After setting, no gaps are seen due to shrinkage.

EndoREZ

It is a hydrophilic, two component (base and catalyst), dual-curing self priming sealer based on the urethane dimethacyrlate(UDMA) molecule. Due to hydrophilic nature, it penetrates into dentinal tubules. The radiopacity is equivalent to gutta-percha, providing simplified radiographic interpretation. It does not compromise the function of dentin bonding agents or luting resin polymerization. It is designed to be used with EndoREZ Points and/or gutta-percha for the filling of cleaned and shaped root canals. EndoREZ along with master cone and accessory cone, provides optimum sealing.

Activ GP

This system is composed of a core material containing gutta-percha which is impregnated and coated on its external surface with glass ionomer. The accompanying sealer is a traditional glass ionomer sealer which can adhere chemically and micromechanically to the Activ GP cones and bond to the dentin. Coating Activ GP with glass ionomer particles is done to overcome the drawback of inadequate bonding between gutta-percha and glass ionomer sealer. Chemically and micromechanically adhesion between the canal walls, the Activ GP sealer and the Activ GP gutta-percha points results in a monoblock within the canal, completely sealing the canal from orifice to apex.

Smartseal

It is a recently introduced root canal obturating system based on polymer technology. Its principle is based on the hydrophilic nature of the obturating points which can absorb surrounding moisture and expand resulting in filling of voids and spaces. Smartseal is a single point and sealer obturation system and constructed in two parts :-

- Central Core : This provides the point with the flexibility to allow it to easily pass around any curves in the prepared canal, while being rigid enough to pass easily to length in narrower canals.
- Outer Polymer Layer : This hydrophillic, hydrogel layer allows the point to swell in order to adapt to the ramifications of the root canal.

Advantages of using hydrogels over existing obturating materials

- Geometry of point can be accurately made
- Controlled expansion
- Biocompatibility

Realseal

RealSeal is a synthetic polyester endodontic obturation material that contains bioactive and radiopaque fillers. It is applied in the same way as gutta-percha. It demonstrates all the advantages of gutta-percha plus the added advantages of reduced microleakage and increased strength. The sealer is a dual cured resin based composite with fillers of calcium hydroxide, barium sulfate, barium glass and silica. The obturation material forms a ‘mono-block’ or continuous bond between the canal wall, sealer and cones, providing a reported improvement in sealing and root strengthening.

IX. Conclusion

The selction of appropriate obturating material is crucial in successful endodontic therapy. Proper root canal filling technique alongwith obturating material and sealer will ensure a complete seal of the root canal. Currently, Gutta-percha with a unique property of inertness, better sealing ability and the ability to do retreatment in case of failure, makes is an indispensible obturating material. Recent advances in alternative root filling materials also promises better adhesion to root canal and avert the short comings of gutta-percha.

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