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Perspective

The Evolution of Gutta-Percha – From Golf Balls to Endodontics

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Abstract

Root canal obturation is part of the triad specific to endodontic treatment, in addition to cleaning and shaping, and disinfection. Over a century after its documented introduction in endodontics, gutta-percha remains the most widely used core material for root canal obturation. However, it took gutta-percha a long and fascinating journey before its use in dentistry was discovered. With a wide range of applications, ranging from insulating transatlantic cables to manufacturing decorative items and gramophone records, gutta-percha was used for an impressive number of purposes before it became such an important material in endodontics.

Keywords: Gutta-Percha; Root Canal Obturation; History

The success of endodontic treatment is based on:

- Shaping and thorough cleaning of the root canals using the various instrumentation systems available today.
- Advanced disinfection of the endodontic system, through modern endodontic irrigation, using ultrasonic, laser or sonic activated systems as well as aspiration of the irrigation solutions.
- A three-dimensional sealing of the entire complex canal system with an inert material that prevents the root canal from connecting with the periapical tissues.

The root canal obturation aims to: prevent the apical infection or reinfection, promote apical healing and ensure the long-term functional maintenance of the endodontically treated tooth [1]. Any root canal filling consists of a solid central core and a sealer. The core is, from a historical perspective, represented by gutta-percha [2].

The name of gutta-percha originates from joining two Malay words: "getah" meaning gum and "pertja" meaning the name of the tree of the genus Palaquium in the family Sapotaceae.

Gutta-percha was discovered by the British naturalist, traveler, horticulturalist, collector and gardener John Tradescant the Younger (1608-1662), in Malaysia and brought to England in the year 1656. His collection of rarities including unusual plants was after his death taken by Elias Ashmole and presented to Oxford University, where it constitutes the basis of the Ashmolean Museum [3].

Figure 1: Palaquium gutta - Healing Garden, Singapore Botanic Gardens.

Figure 2: John Tradescant the Younger (Thomas de Critz, Ashmolean Museum, Oxford).

Gutta-percha was not really used until the 1840's. William Montgomerie (1797-1856), a Scottish military doctor with the East India Company, and later head of the medical department in Singapore, sent in 1843 gutta-percha samples to the Royal Asiatic Society in London, aiming to use it for medical apparatus [4].

Figure 3: William Montgomerie (1797-1856).

The Gutta Percha Company was established by Hancock and Bewley in the United Kingdom in 1845, and started what was to become a plethora of different uses for gutta-percha:

- Electrical insulation of underwater telegraph cables, the first successful transatlantic cable being laid in 1866
- All sorts of furniture, including ornate pieces some of which were shown at the 1851 Great Exhibition in London
- Decorative objects, plates, boxes, pipes, chess pieces
- Canes and walking sticks
- Golf balls.

Figure 4: Landing of the Atlantic Cable of 1866, Heart's Content, Newfoundland Robert Charles Dudley (1826-1909). Peter Winkworth Collection [5].

Figure 5: Sample of gutta percha insulated cable, 1863-1867, excavated in Gloucester, 1959. Science Museum Group Collection [6].

Figure 6: XIX century objects made of gutta-percha.

Figure 7: XIX century golf balls made of gutta-percha. The Golf Museum at James River Country Club, Virginia, USA.

Gutta-percha was first introduced in dentistry in the 1850's, for temporary coronal fillings - Edwin Thomas Truman, in 1851 - and denture manufacturing [7].

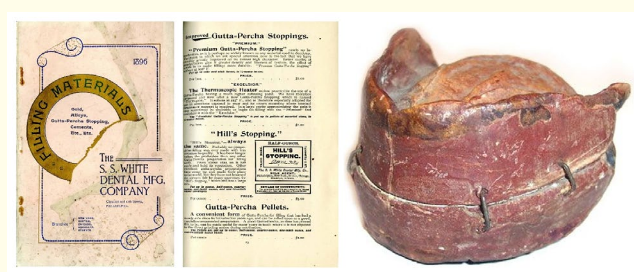

Figure 8: XIX century use of gutta-percha use for temporary coronal fillings and denture bases. Alabama Museum of the Health Sciences.

Gutta-percha as a material and its many fields of use were abundantly present in scientific European and American literature starting with mid 1850's. Werner von Siemens, Michael Faraday, Lord Kelvin and James Clerk Maxwell were all using in one way or another gutta-percha's properties for their experiments.

Figure 9: Book published under the authorship of Gustaf Torsell in 1849 in Stockholm, P.A. Huldbergs boktryckeri, treating the composition and uses of gutta-percha.

In 1867 G. A. Bowman proposed the use of gutta-percha as the only material for root canal obturation [8].

After SG Perry used pointed gold wire wrapped with soft Gutta-percha, rolled and packed it into the canal (1883) [10], S.S. White Dental Manufacturing Company, founded in 1844 by Samuel Stockton White (1822-1879), was to become the place where the first gutta-percha points for root canal obturation have been manufactured for commercial use in 1887.

The science concerning gutta-percha continued during the 20th century, with an ever-increasing number of research papers dealing with its properties and use in endodontics.

In 1914 Callahan introduced softening and dissolution of Gutta-percha with the use of resins. In 1959 Ingle and Levine were the first to propose standardization of root canal instruments and filling materials and at their behest, standardized Gutta-percha was introduced to the profession in 1959, after the 2nd International Conference of Endodontics has been held at Philadelphia.

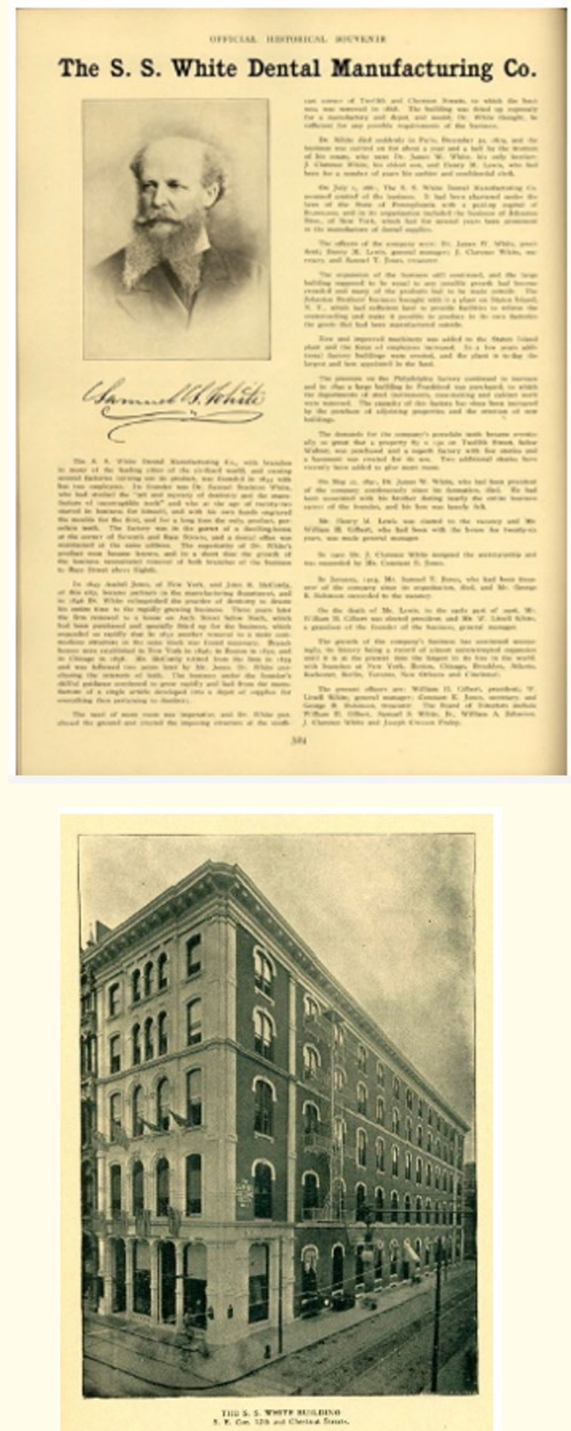

Figure 10: Samuel Stockton White and the S. S. White Dental Manufacturing Co. in 1899 [9].

The basis for the remarkable properties of natural rubber and gutta-percha, as well as for their differences, was not explained in terms of molecular physics until 1942 [11]. CW Bunn showed that the crystalline phase of gutta percha could exist in two forms: alpha, and beta phases. The alpha phase is the naturally occurring form of gutta percha. If this is heated above 65°C, it melts into an amorphous form. Bunn demonstrated that by very slowly cooling the amorphous material at a rate of 0.5°C per hour it recrystallizes into the alpha phase. If the amorphous material is cooled faster, it recrystallizes as the beta phase [11].

Today gutta-percha is known to contain approximately 19-22 % gutta-percha, 1-4 % plasticizing waxes and resins, 59-75 % zinc oxide, 1-17 % metal sulfates for radiopacity and trace amounts of organic dyes for coloration [12].

Gutta-percha is used in endodontics under two crystalline forms: α-type and β-type gutta-percha.

- α-type is characterized by ordered molecular arrangement, lower viscosity, gets by heating an adhesive character to the substrate and a flowable character and is mainly used in thermoplastic techniques.
- β-type is characterized by higher viscosity - thus allowing condensation - and serves for manufacturing gutta-percha points used in methods applied at room temperature.

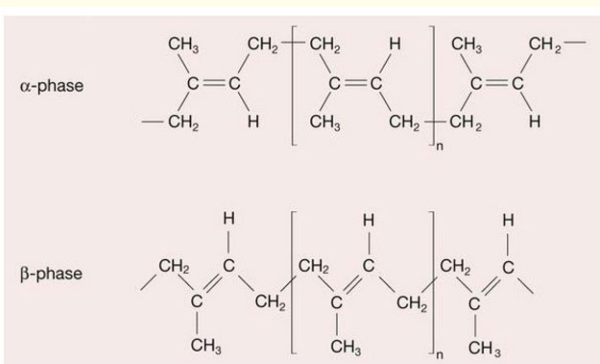

Figure 11: α-phase and β-phase of trans-isoprene of gutta percha.

Currently, the forms of gutta-percha used in endodontics are represented by:

- Standardized and non-standardized points used in single cone, cold lateral condensation and warm vertical condensation ("down pack") techniques.
- Thermoplastic gutta-percha for the backfilling thermoplasticized injection and carrier based obturation techniques.
- Cold fluid gutta-percha capsules, in which gutta-percha is in powder form with a particle size of less than 30 µm and combined with a resin sealer.

Different modified forms of gutta-percha were also tried, to obtain an adhesive character to the sealer and the dentine walls or for antimicrobial purposes. These changes concerned:

- The surface of the gutta-percha cones: the outer surface was coated with various materials, such as glass ionomers, resins, bioceramics.
- Gutta-percha composition: bioceramic-impregnated gutta-percha points and pellets.
- Attempts to make changes by addition of substances with antimicrobial properties, such as chlorhexidine diacetate, calcium hydroxide, tetracycline or amoxicillin were inconclusive, as were the attempts to use enrichment with nanoparticles made of composite biomaterials or silver.

Gutta-percha presents several definite advantages:

- It is a plastic material, malleable, elastic, easy to handle.
- It can be deformed under the action of the spreader in cold lateral compaction techniques.
- It is thermoplastic, being successfully used in warm compaction techniques
- Has thermal insulating properties.
- Presents dimensional stability and is non-resorbable.
- It is an inert material, well tolerated by the periapical tissues.
- It is insoluble in water and alcohol.
- It is easy to disinfect by immersion in 5.25% Sodium hypochlorite for 60 seconds.

The disadvantages of gutta-percha are mainly represented by:

- Chemical adhesion to the sealer or to the walls of the root canal cannot be achieved, which leads to the absence of a complete sealing of the endodontic space, with the risk of micro infiltration.
- Gutta-percha has an increased content of zinc oxide, which can be irritating.

Gutta-percha has a long and interesting history. Being used in endodontics for about 150 years it is obvious that it has stood the test of time, demonstrating its potential as a basic material for root canal obturation. Nevertheless, gutta-percha has been modified over the years to accommodate the changing trends in endodontics, simplify the techniques, and achieve an optimal seal with a better adaptation to the dentinal walls during a less time-consuming process. To remain indispensable in the future certain property modifications are required to achieve increased stability, better flow properties and intra-canal adaptation, with reduced shrinkage and an inherent antibacterial efficacy.

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