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Fabrication of Gutta-percha points derived from the Latex of Manilkara zapota for Obturation treatment in root canal therapy

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Research Article

Keywords: Gutta-Percha, Manilkara zapota, Latex, GP points, Obturation treatment, Radiopacity, Tensile strength

Posted Date: March 29th, 2024

DOI: https://doi.org/10.21203/rs.3.rs-4120313/v1

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Additional Declarations: No competing interests reported.

Abstract

The Gutta-percha (GP) points are filling material used in the obturation treatments in endodontic root canal therapy. The GP points are manufactured from the latex of a Malaysian tree called a Percha Tree (*Palaquium gutta*, family: Sapotaceae). However, in this study, an attempt has been made to fabricate an alternative GP points from the latex of a tree *Manilkara zapota* from the same plant family Sapotaceae. The latex was obtained by wounding the tree trunk using a sterile blade and collected in a sterile container. Then the latex was vigorously mixed with a 3.5:6.5 ratio of latex and zinc oxide respectively. The *MZ*-GP points were made by hand-rolling method and characterized for their radiopacity, and tensile strength. Simultaneously, the latex was tested for its antibacterial activity against *Pseudomonas aeruginosa, Enterococcus faecalis, Streptococcus mutans, Staphylococcus aureus*, and Methicillin-resistance *Staphylococcus aureus* (MRSA). The hand-rolled *MZ*-GP points have a similar structure to a commercial GP point, are white and also have good filling capability during obturation with natural radioopaque properties. The average tensile stress at the break for the control was 1.59 MPa, whereas, the same was 0.09 MPa for the *MZ*-GP points. However, the displacement was 3 mm for the control and 0.6 mm for the *MZ*-GP points. The latex of *M. zapota* has limited antibacterial activity showing very little zone of inhibitions (< 8 mm) on all the bacterial strains tested. The latex of *M. zapota* is an alternative to the latex of *P. gutta* for the manufacturing of GP points for Obturation treatments. However, the formulation may be modified to improve the properties of the *MZ*-GP points.

Introduction

Research into novel endodontic obturating materials is frequently undertaken in an attempt to satisfy biological requirements and provide predictable long-term treatment outcomes while also producing superior materials that are currently available. Several substances have been investigated and evaluated for use in root canal restorations[1]. The results have varied, sometimes turning out disastrous and other times excellent. Gutta-percha (GP) has been the most clinically studied material, and it has remained stable over the years in various clinical settings worldwide [2]. Some of the various GP points brands that were commercially available in the 1970s were produced by Dent-O-Lux, Indian Head, Mynol, Premier, and Tempryte, among other companies. Since the development of NiTi rotary endodontic systems, brands like Tanari (Tanariman, Brazil), Meta (GN Injecta, Brazil), Dentsply (York, USA), Roeko (Coltene, Switzerland), Diadent (Korea), and Sybronendo (Orange, California) have become more well-known[3]. In addition to GP, other materials that have been tested include polymers (Resilon), solids or metal cores (Gold, Stainless Steel, Titanium, and Irridio-Platinum), coated cones, silver points, and cement and pastes (Calcium Phosphate, Gutta Flow, Hydron, MTA). Many of these materials, meanwhile, need to fulfill all the requirements needed to obturate root canal systems. The only materials with potential that are based on calcium silicates, such as MTA and similar bioactive cement have shown some results.[4]

A peculiar kind of tropical plant produces GP, which is a dried coagulated sap. The Sapotaceae family of trees, which are found extensively across the Malay Peninsula in Southeast Asia, is where it was initially

discovered. The word "percha sap" (getah) in Malay is "perca." The Malay Archipelago, Singapore, Indonesia, Sumatra, the Philippines, Brazil, South America, and other tropical nations are the primary locations of the trees. These trees have a trunk diameter of up to 1 m and a height of medium to tall (around 30 m). Part of its outrageous price is that it is typically imported from Central South America for use in dentistry. The Palaquium genus includes many different species that produce GP, four of which have been identified in India: Assam's *P. obovatum* and Western ghats of *P. ellipticum*[5]. It is a trans-isomer of polyisoprene. Its chemical structure is 1, 4, trans–polyisoprene. The molecular structure of GP is close to that of natural rubber from *Hevea brasiliensis*, which is a cis-isomer of polyisoprene. Both are high-molecular-weight polymers and structured from the same basic building unit or isoprenemer. [6]

The Sapotaceae family contains 800 species, the majority of which are tropical trees, and 35–75 poorly defined taxa. The plant is known as *M. zapota* (L.) Van Royen, which is also known by the names *M. zapotilla, M. achras, Mimusops manilkara*, and *Acras zapota*[7]. It was studied chemically and flavonoids, tannins (mostly from unripe fruits), triterpenes, and saponins (mostly from the seeds) were isolated as a result of the study.[11, 10] Additionally, the plant has been shown to have analgesic[15], antioxidant, and antibacterial properties [12, 13, 14].

The phytochemical constituents have antihyperglycemic, hypocholesterolemic, and antioxidant activities —in the leaves of *M. zapota* (L.) Van Royen, a Sapodilla fruit is high in nutrients since it mostly consists of water (73%), which is followed by bioactive substances (antioxidants and polyphenols), vitamins (A, C, folate, niacin, and pantothenic acid), minerals (Cu, K, and Fe), sugars, ascorbic acid, and fat [8] Mature fruit contains a higher proportion of free sugars with a tiny amount of carbohydrates. The fruit generally weighs around 75 and 200 grams and has an oval to spherical form with a 5 to 9 cm diameter. Fruit's outer layer is often dark and rusty in color, with a rough texture. The pulp is paradoxically soft, sandy but sweet, reddish-brown in colour, and easily metabolized[9]. The fruit's sweetness is from a plant grown in Egypt, as no prior research had been done on the plant. Very limited studies were carried out on the latex of this plant, hence, in this study, the latex was collected from the plant, and mixed with zinc oxide[10] to fabricate *MZ*-GP points and its properties were studied and characterized.

Materials and methods

Fabrication of MZ-GP points

The plant latex was obtained from the tree trunk by creating small wounds using a sterile blade and the oozing out latex was collected in a sterile container. The latex was then mixed with zinc oxide at a ratio of 3.5:6.5 and the *MZ*-GP points were made by hand-rolling method. Radiopactity, tensile strength and antibacterial activity were determined.

Radiopacity:

Single-rooted straight tooth extracted for periodontal reasons was chosen. The crowns were removed using a diamond but at the cement-o-enamel junction level by a high-speed water-cooled handpiece. The moisture content in the root canal was blotted and removed using sterile paper points, the hand-rolled MZ-GP point was fixed inside the root canal and an X-ray was taken to check the radio-opacity of the MZ-GP point and photographed.

Tensile strength:

The tensile strength testing of the *MZ*-GP material was carried out using a Universal testing machine INSTRON E300 UTM. The tensile stress at break and displacement were evaluated. The commercial GP point was used as a control.

Antibacterial activity

The latex was diluted in a DMSO (dimethyl sulphoxide) and tested for its antibacterial activity. The test pathogenic bacterial strains were *Pseudomonas aeruginosa, Streptococcus mutans*, Methicillin-resistant *Staphylococcus aureus, Staphylococcus aureus*, and *Enterococcus faecalis*. Fresh MH broth suspensions were prepared and adjusted to 0.5 McFarland standards. Lawn cultures were propagated onto sterile Mueller Hinton Agar plates. Wells were cut using a sterile cutter with a volume of 50 µL per well. Three different concentrations of the extract (100%, 50%, and 25%) were added to the respective wells and the plates were incubated at 37oC for 24 hours and the zone of inhibition (clearance) was measured, recorded and interpreted.

Results

Radiopacity:

After obturation treatment in an extracted tooth, the *MZ*-GP point hampers the X-ray transmission and shows natural radiopaque properties (Fig. 1).

Tensile strength

The control GP has average tensile stress at the break of 1.59 MPa, whereas the *MZ*-GP had shown 0.09 MPa. Simultaneously, the elasticity (displacement) was 3 mm for the control and 0.6 mm for the *MZ*-GP (Fig. 2). Even though the elasticity and the tensile strength were not comparable with that of the control, the *MZ*-GP has good filling capability and thus it can be directly used as a paste to fill the root canal or the property of the *MZ*-GP may be improved further.

Antibacterial activity:

The latex of *M. zapota* showed very little antibacterial activity on all the bacterial pathogenic strains tested (Fig. 3). The maximum antibacterial zone observed was 8.33 mm against SM, SA, and MRSA. Moreover, the latex has lower inhibition against the bacterial pathogens tested in this study (Fig. 4).

Discussion

The transformation of *Manilkara zapota* plant extract into gutta-percha unveils a fascinating process central to creating a flexible polymer crucial in dentistry. While gutta-percha, traditionally sourced from the *Palaquium gutta* tree, has long been the go-to for endodontic procedures, the exploration of *Manilkara zapota* latex as a substitute gains momentum due to supply constraints and environmental considerations. Gutta-percha's supremacy in dentistry, particularly for root canal fillings, stems from its biocompatibility, inert characteristics, and adaptability to irregular canal shapes[11]. Shifting to gutta-percha derived from *Manilkara zapota* doesn't compromise these essential attributes. Studies hint at potential variations in properties among gutta-percha from different botanical sources, opening avenues for future advancements in endodontic materials.

The adoption of *Manilkara zapota* as a gutta-percha source aligns with the broader dental trend towards sustainable and eco-friendly practices [12,13]. Dental professionals are increasingly turning to materials obtained from renewable plant resources, showcasing a heightened awareness of the industry's environmental footprint. Opting for *Manilkara zapota* reflects a commitment to sustainability without sacrificing the efficacy of this medicinal material. Nonetheless, standardizing the fabrication process presents challenges in ensuring consistent properties in the final gutta-percha product. Achieving a uniform and reliable gutta-percha from *Manilkara zapota* for general dentistry faces hurdles related to variations in latex composition, weather conditions, and other factors [14]. Researchers are diligently working to optimize the fabrication process, aiming to create a product that not only meets the stringent standards for clinical applications but also guarantees dependability and consistency.

Beyond addressing environmental concerns, utilizing *Manilkara zapota* as a gutta-percha propels the evolution of endodontic materials. This shift underscores the dynamic nature of dental research, constantly seeking materials that strike a delicate balance between clinical effectiveness and environmental responsibility. It serves as evidence of how dental offices can adapt to global sustainability objectives, showcasing a commitment to evolving practices in harmony with both health and the planet.

The cytotoxic study of the *Manilkara zapota* plant is already established by [15] the study also proved its anti-oxidant and anti-tyrosinase activity. The Evaluation of the antimicrobial, anthelmintic and CNS depressant activities of *Manilkara zapota* leaf (Sapotaceae) was tested by (Ganguly et al). Through our study we could interpret the antimicrobial activity of Manilkara zapota plant extract fabricated gutta percha the anti-microbial activity against Methicillin-resistant *Staphylococcus aureus*, *E. faecalis, streptococcus Mutans, Pseudomonas* aeruginosa was noted, The optical density of the *Manilkara zapota* plant extract was tested for the first time in our study. and the results showcased that the *Manilkara zapota* fabricated Gutta percha showcased positive results for same. This study is the first study in which gutta-percha was fabricated using *Manilkara zapota* plant extract, the Tensile strength of the extract was tested in which the difference between the control group and the *Manilkara zapota* fabricated gutta

percha was compared, the tensile strength of the extract was less than the control group, the further path of the study will include strengthening of the gutta-percha extract using natural extracts.

Conclusion

In this study, an attempt was made to fabricate GP points from the latex of *Manilkara zapota, a tree* from the same family of Sapotaceae, in which commercial GP points are manufactured (*Palaquium gutta*). As an alternative raw material to manufacture GP points, the MZ-GP points have good filling capability during the obturation treatment, and natural radiopaque property, but have lower tensile strength than the commercial GP point. The MZ-GP point is an alternative to filling material that could be used directly or the properties may be improved further according to the requirements.

Abbreviations

GP-Gutta-Percha; MZ - Manilkara zapota; MRSA - Methicillin-resistance Staphylococcus aureus; DMSO - Dimethyl sulphoxide; MH - Mueller-Hinton; SM - Streptococcus mutans; SA - Staphylococcus aureus; PA - Pseudomonas aeruginosa; CNS - Central nervous system.

Declarations

Ethical approval

Not applicable

Availability of supporting data

The data are available with the corresponding author and available upon request.

Competing interest

There is no competing interest.

Authors contribution

RKG - Conceptualized the research, RVG - Guided the research, and SM - Carried out and conducted the research.

Funding

This study was carried out without any funding support.

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Figures

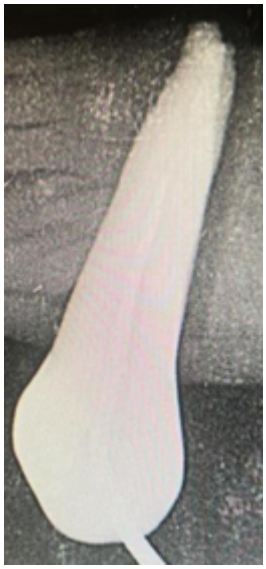


Figure 1

The photograph shows the radiopacity of the MZ-GP point after obturation.

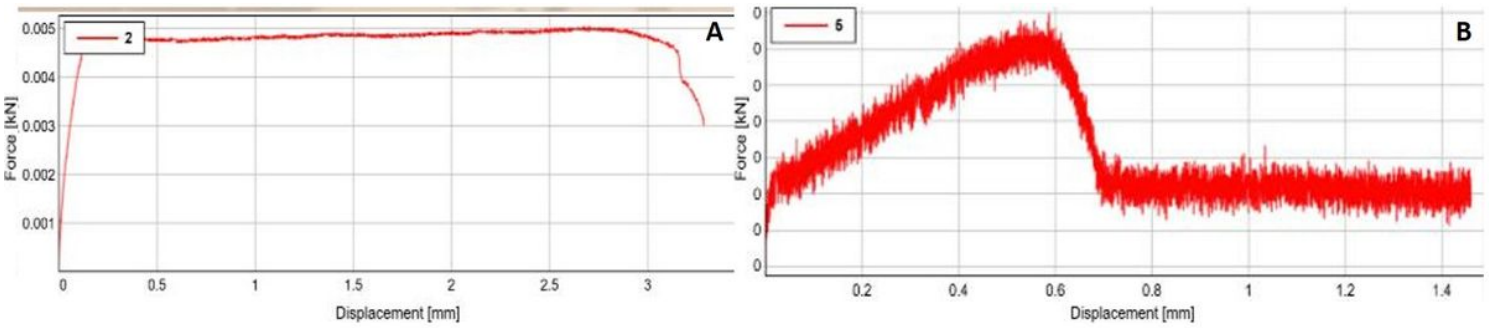


Figure 2

The graph shows the tensile strength and displacement (elasticity) of both the A) commercial GP and B) *MZ*-GP points.

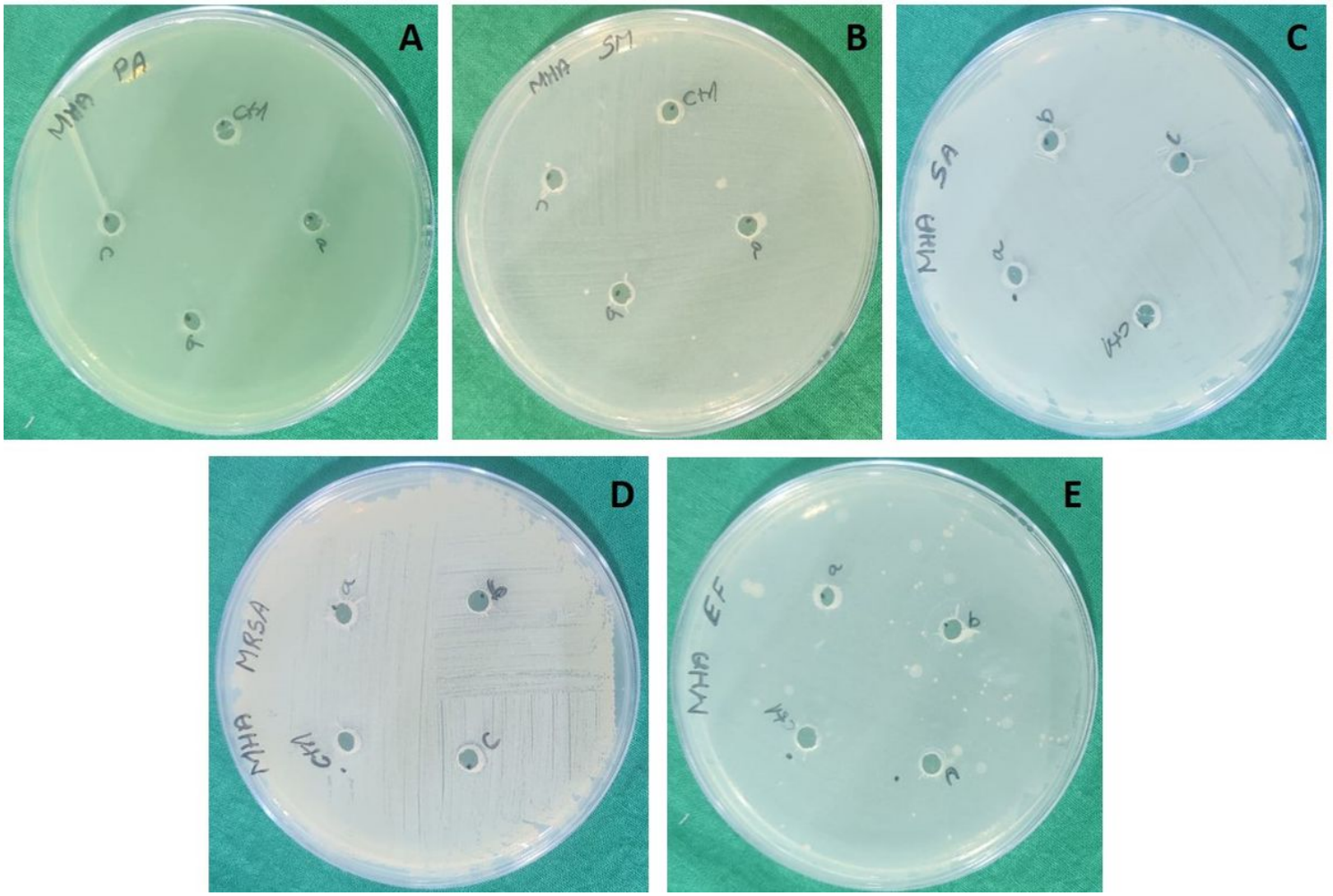


Figure 3

The Petri plates showing the antibacterial activity (Zone of inhibition) of the *M. zapota* latex on different pathogenic bacterial strains, A) *Pseudomonas aeruginosa*; B) *Streptococcus mutans*; C) *Staphylococcus aureus*; D) Methicillin-resistant *Staphylococcus aureus*; and E) *Enterococcus faecalis*.

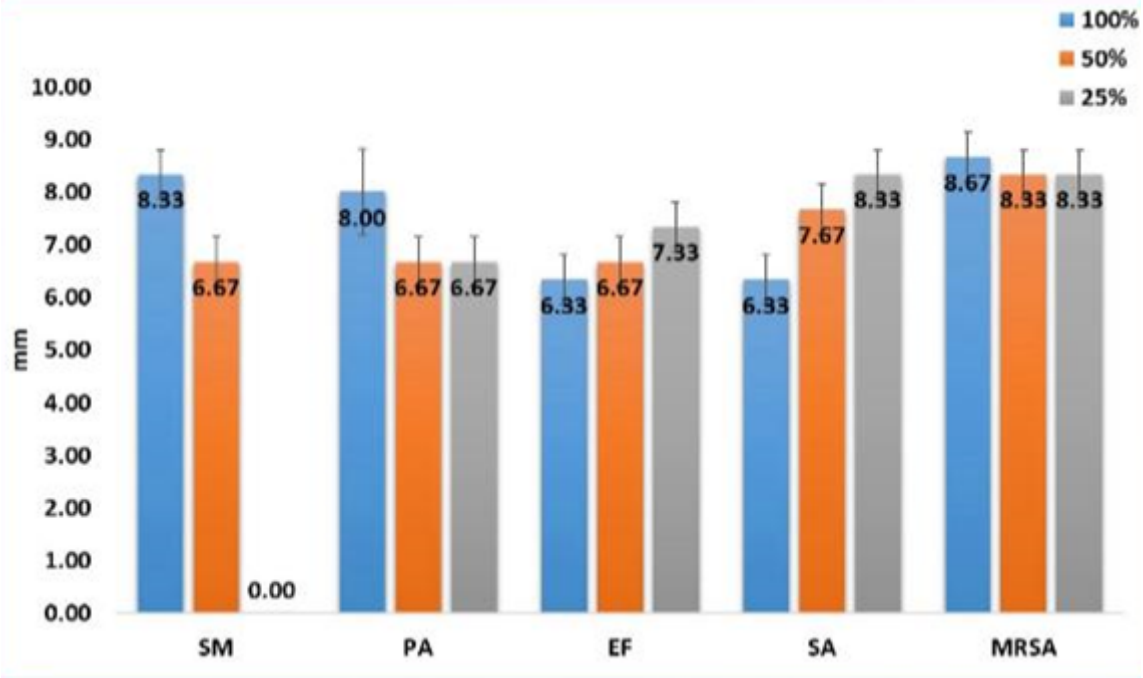


Figure 4

The graph showing the antibacterial activity (Zone of inhibition) of the *M. zapota* latex on different pathogenic bacterial strains, SM: *Streptococcus mutans*; PA: *Pseudomonas aeruginosa*; EF: *Enterococcus faecalis*; SA: *Staphylococcus aureus*; and MRSA: Methicillin-resistant *Staphylococcus aureus*.