Development and Characterization of Gutta-Percha Points from Artocarpus heterophyllus (Jackfruit) Latex: A Preliminary Study

Jabeen Nazurudeen
saveetha dental college
Lekhha Karthikeyan
saveetha dental college
Geetha RV
saveetha dental college
Rajesh Kanna Gopal
rajeshkannag.sdc@saveetha.com

saveetha dental college

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Abstract

This is the first study to report the development and characterization of gutta-percha points fabricated from Jackfruit tree (*Artocarpus heterophyllus*) latex as an indigenous alternative to conventional gutta-percha (GP) for root canal obturation. Fresh latex blended with zinc oxide (4:6 ratio) was fabricated into hand-rolled points and characterized through radiopacity testing, scanning electron microscopy (SEM), atomic force microscopy (AFM), micro-leakage analysis, and tensile strength evaluation. The points demonstrated natural radiopacity, eliminating the need for barium sulphate as a radiopacifying agent—a distinct advantage over commercial GP formulations that depend on heavy metal sulphate additives. SEM revealed relatively smooth surfaces with uniformly distributed 1 μm zinc oxide particles embedded throughout the latex matrix. AFM showed favorable surface characteristics with area roughness of 3.28 μm and line roughness of 2.29 μm, values comparable to commercially available GP products. Micro-leakage testing yielded variable results, with 40% of samples demonstrating excellent sealing capacity and no dye penetration at any root level. Tensile strength averaged 0.06 MPa, which, though lower than commercial gutta-percha (10–30 MPa), may facilitate better adaptation to complex root canal anatomy during lateral condensation. The inherent antibacterial bioactivity of jackfruit latex constituents, including artocarpin and phenolic compounds, further differentiates AH-GP from synthetic obturation materials. Jackfruit latex represents a promising, cost-effective, and sustainably sourced alternative particularly suitable for resource-limited tropical settings, warranting further formulation optimization and clinical validation.

1. Introduction

Root canal treatment (RCT) represents the most common endodontic procedure and has evolved significantly over the past century in dentistry (Burns et al., 2022). Epidemiological evidence indicates that endodontic disease affects a substantial proportion of adults globally, with an estimated 15 million root canal treatments performed annually in the United States alone, underscoring the enormous clinical and economic demand for reliable obturation materials (Pak et al., 2012). The procedure involves three critical steps: removal of infected or damaged pulp tissue, thorough cleaning and shaping of the canal system using mechanical instruments and chemical irrigants, and three-dimensional obturation to prevent reinfection (Penukonda et al., 2024). Following biomechanical preparation and disinfection, the cleaned root canal space must be filled with a biocompatible material that provides an impervious seal against microbial invasion (Winkler et al., 2023)

Since its introduction to dentistry in the mid-19th century, GP has remained the material of choice for root canal obturation. Originally derived from the latex of *Palaquium gutta* trees from the Sapotaceae family, which grow primarily in Southeast Asia, commercial GP is actually a composite material rather than pure latex (Ingle et al., 2008). A typical commercial GP point contains approximately 20% GP matrix (the trans-polyisoprene polymer), 66% zinc oxide filler, 11% heavy metal sulphates (primarily barium sulphate for radiopacity), and 3% waxes or resins as plasticizers (Choudhari et al., 2020).

As a thermoplastic material, it softens when heated and solidifies at room temperature, allowing it to conform to irregular canal anatomy during warm vertical compaction techniques (Winkler et al., 2023). Its biocompatibility, relative inertness, and radiopacity facilitate clinical success and allow for radiographic verification of treatment quality (Grossman, 1976). However, conventional GP has a significant limitation: it does not bond to root canal walls. Even when used with resin-based sealers, it fails to create a true monoblock with dentin, a unified structure that would better resist bacterial infiltration and structural failure (Arun et al., 2024). This limitation has prompted ongoing research into alternative obturation materials and techniques. Furthermore, conventional GP is manufactured predominantly in industrialized nations and must be imported into tropical developing countries where endodontic disease prevalence is high yet specialist dental care remains scarce, directly inflating treatment costs and limiting accessibility in resource-constrained healthcare systems (Grossman, 1976; Maniglia-Ferreira et al., 2005).

Artocarpus heterophyllus, commonly known as jackfruit, is a tropical tree believed to originate in the Western Ghats of India and now cultivated throughout the tropical and subtropical regions of South and Southeast Asia, Brazil, and parts of Africa. India alone produces more than 1.4 million tonnes of jackfruit annually, making it one of the most abundantly available tree fruits in the tropical world (Ranasinghe et al., 2019) (Ranasinghe et al., 2019). The tree produces a milky white latex found primarily in the inner bark, trunk, and green tissues, which serves as a natural defence mechanism against pests and pathogens, much like the latex defence systems in various plants (Bhadra et al., 2019). This latex contains various bioactive compounds including proteins (notably artocarpin, a lectin with antimicrobial properties), alkaloids, tannins, and other phytochemicals that contribute to its biological activity (Swami et al., 2012).

Recent studies have shown that *A. heterophyllus* extracts possess significant antibacterial properties against several foodborne pathogens, including *Escherichia coli, Listeria monocytogenes, Salmonella species, Bacillus cereus, Enterococcus faecalis*, and *Staphylococcus aureus* (Loizzo et al., 2010). The activity against *E. faecalis* is particularly relevant since this organism is isolated in up to 77% of failed root canal treatments and is notoriously resistant to standard disinfection protocols including sodium hypochlorite irrigation (Stuart et al., 2006).

Given these considerations, and recognizing that no prior study has systematically evaluated jackfruit latex as a root canal obturation material, this study aimed to develop and characterize GP points fabricated from jackfruit latex (AH-GP) and evaluate their suitability for endodontic obturation through comprehensive physical, mechanical, and functional testing, thereby establishing a baseline evidence platform for this novel biomaterial.

2. Materials and Methods

2.1. Collection and Preparation of AH-GP Points

The fresh latex was collected from a mature tree growing in a local plantation and controlled incisions was made approximately 2–3 cm long in the trunk using a sterile surgical blade, following standard latex tapping procedures used in rubber cultivation. The collected latex underwent processing within 2 hours of collection to maintain its properties. The fresh latex was blended with pharmaceutical-grade zinc oxide powder (98% purity) in a 4:6 (latex: zinc oxide) ratio by weight. This mixing was performed using a ceramic mortar and pestle for approximately 15 minutes until we achieved a homogeneous, putty-like consistency free of visible streaks or lumps. The selection of the 4:6 ratio was based on preliminary trials that showed this proportion provided the best balance of workability and structural integrity. The hand-rolling process required careful attention to maintain consistent taper. The AH-GP points were allowed to set at room temperature (25 to 28°C) in a dust-free environment for 24 h.

2.2. Radiopacity Assessment

The use of extracted human teeth was approved by our institutional ethics committee, and all teeth were obtained following informed consent from patients (SDC-IEC (Institutional Ethics Committee) Registration No. ECR/1698/Inst/TN/2022.). All the methods were performed in accordance with relevant guidelines and regulations. The teeth were stored in 0.9% saline solution at 4°C and used them within one month of extraction to preserve tissue properties. To facilitate subsequent longitudinal splitting for microscopic examination, two shallow longitudinal grooves were prepared (approximately 1 mm depth) on the buccal and palatal surfaces using a fissure bur. Then verified canal patency by gently inserting a size 10 K-file (Dentsply Sirona, USA) until it appeared at the apical foramen, confirming an unobstructed canal pathway. Enlarged the coronal third using Gates Glidden drills (sizes 1–3, Mani Inc., Japan) in sequence, followed by K-files using a step-back technique, a classic preparation method that creates a continuously tapered preparation. The apical preparation to size 35 (0.35 mm) at the working length, which was determined to be 1 mm short of the radiographic apex.

Throughout the preparation process, irrigated the canals alternately with 5 mL of 2.5% sodium hypochlorite (NaOCl) as the primary antimicrobial agent and 5 mL of 10% ethylenediaminetetraacetic acid (EDTA) to remove the smear layer and open dentinal tubules. After completing the preparation, the canals were dried thoroughly using sterile paper points until the points emerged dry from the canal.

Then the prepared canals were obturated using a single cone technique with appropriately sized AH-GP points paired with AH Plus sealer (Dentsply DeTrey, Germany), a widely used resin-based endodontic sealer. The obtained periapical radiographs using a dental X-ray unit (Planmeca, Finland) at standard settings (70 kVp, 8 mA, 0.2 seconds exposure) were evaluated to check whether the AH-GP points were sufficiently radiopaque to be visualized within the root canal system.

2.3. Scanning Electron Microscopy

To prepare AH-GP samples for scanning electron microscopy, the AH-GP points were first fixed in 4% glutaraldehyde solution for 24 h at 4°C. This fixation process preserves the structural integrity of biological materials and prevents degradation during subsequent processing. Air-dried samples were desiccated overnight in a desiccator and mounted on aluminium stubs using double-sided carbon adhesive tape and sputter-coated them with a thin layer of gold (approximately 10–15 nm thickness) using a sputter coater (Quorum Technologies, UK).

The SEM employed with field emission scanning electron microscope (Carl Zeiss, Germany) under vacuum conditions (10^{-6} torr) at an accelerating voltage of 15 kV and the resulted SEM images at various magnifications (×100, ×500, ×1000, and ×5000) were assessed for different aspects of surface morphology including overall point architecture, surface texture, presence of irregularities or defects, and particle characteristics of the zinc oxide filler within the latex matrix.

2.4. Atomic Force Microscopy (AFM)

AFM analysis was conducted using an atomic force microscope (Park Systems, South Korea) to characterize surface topography at the nanoscale level.

The specific analysis parameters were:

- Cantilever type: Stat 0.2LAuD (nominal spring constant: 0.2 N/m)
- Operating mode: Static force (contact mode)
- Scan area: 10 μm^2 (approximately 3.16 × 3.16 μm)
- Scan rate: 1 Hz
- Error range: 20V
- Environment: Ambient air at room temperature
- Software version: XEI 3.8.8.13

From the collected topographical data, surface roughness parameters were determined using the microscope's analysis software.

2.5. Micro-leakage Analysis

Following canal preparation and obturation with AH-GP points and AH Plus sealer as described in section 2.2, the coronal access cavities were sealed with temporary filling material and stored the teeth at 37°C in 100% humidity for 7 days to allow complete sealer setting. Then coated all external tooth surfaces with two layers of nail varnish except for the apical 2 mm, which was left exposed. This coating prevents dye penetration through lateral root surfaces or procedural defects and ensures that any dye penetration occurs specifically through the root canal filling.

The prepared samples were immersed in 1% methylene blue dye solution and stored in an incubator at 37°C for 7 days, a timeframe that allows sufficient opportunity for dye penetration through any microleakage pathways. After the incubation period, the teeth were rinsed thoroughly with distilled water and carefully removed the nail varnish coating.

Then sectioned each tooth longitudinally in a bucco-lingual direction using a low-speed diamond saw with water cooling to prevent thermal artifacts. The sectioned surfaces were examined under a stereomicroscope (Leica Microsystems, Germany) at 20× magnification and photographed them using a digital camera. The assessed dye penetration was assessed at three levels, apical (apical third), middle (middle third), and coronal (coronal third), and recorded the linear extent of dye penetration in millimetres.

2.6. Tensile Strength Testing

The tensile properties were measured using a universal testing machine (Instron, USA) equipped with specialized pneumatic grips designed to hold small cylindrical specimens without causing stress concentration or premature failure at the grip sites.

The standardized AH-GP samples with uniform dimensions (gauge length: 20 mm, diameter: 1.5 mm) were prepared by carefully rolling the material and allowing it to set for 24 hours. Each sample was mounted vertically in the testing machine's grips, ensuring proper alignment to prevent bending moments during testing, and applied tensile force at a constant crosshead speed of 5 mm/min., a rate commonly used for polymer testing that provides reliable data while preventing rate-dependent artifacts. Five samples were tested and reported the mean values with standard deviations.

3. Results

3.1. Fabrication and Appearance

The jackfruit latex, when combined with zinc oxide and processed by hand-rolling, successfully produced tapered GP-like points. Interestingly, the resulting AH-GP points displayed a naturally white appearance (Fig. 1), which contrasts with the pinkish colour of commercial GP points. This white colour likely results from the high concentration of zinc oxide combined with the natural latex matrix (Table 1). The points retained their tapered morphology without significant shrinkage, warping, or deformation over the 24-hour setting period.

Table 1
Comparison of composition between commercial GP and AH-GP points

Component	Commercial GP (%)	AH-GP (%)
Latex/GP polymer	20	40
Zinc oxide	66	60
Heavy metal sulphates (radiopacifier)	11	0
Waxes/Resins (plasticizers)	3	0

3.2. Radiopacity Evaluation

Radiographic examination revealed an unexpected and potentially significant finding: AH-GP points possessed inherent radiopaque properties without requiring barium sulphate supplementation (Fig. 2). In the periapical radiographs, the AH-GP points appeared as clearly visible radiopaque structures within the root canal system, allowing for proper visualization and assessment of obturation quality. The radiopacity appeared uniform along the length of the points, without radiolucent gaps or areas of reduced density that might indicate incomplete filling or voids. The contrast between the AH-GP material and surrounding dentin was sufficient for clinical diagnostic purposes, dentists would be able to evaluate fill length, density, and potential voids or perforations on routine radiographs. The mechanism behind AH-GP's natural radiopacity remains unclear but may relate to specific mineral content within the jackfruit latex itself, possibly including calcium or other elements with sufficient atomic number to attenuate X-rays.

3.3. Surface Morphology (SEM Analysis)

Scanning electron microscopy provided detailed visualization of the AH-GP points' surface characteristics at multiple magnification levels (Fig. 3). At low magnification (×100), the overall tapered morphology of the point with a relatively smooth surface contour was observed. The tapering tip appeared well-formed and similar in appearance to commercial GP points. At intermediate magnifications (×500 and ×1000), the surface exhibited general smoothness with some minor irregularities and occasional bumps, features consistent with hand-fabrication methods rather than automated manufacturing. At high magnification (×5000), uniformly distributed rectangular particles measuring approximately 1 μm in their longest dimension was observed. The uniform distribution suggests that our mixing protocol achieved adequate homogeneity, preventing particle aggregation or settling that could compromise material properties.

3.4. Nanoscale Topography (AFM Analysis)

Atomic force microscopy provided quantitative assessment of surface roughness at the nanometer scale, complementing the SEM observations (Fig. 4). The three-dimensional topographical map revealed a relatively smooth surface with gentle undulations rather than sharp peaks and valleys. The color-coded height map showed variations in surface elevation across the scanned area, with most features measuring less than 10 nm in height.

The quantitative roughness parameters obtained from the 10 μm² scan area were:

- Average area roughness (Ra): 3.28 μm
- Average line roughness: 2.29 μm

These values indicate a relatively smooth surface at the microscale level. For context, published studies of commercial GP points report Ra values ranging from approximately 2.5 to 8.0 μm depending on the brand, manufacturing method, and surface treatment. Our AH-GP points fall within the range of commercial products, suggesting comparable surface quality. Smoother surfaces facilitate easier insertion into prepared canals with less frictional resistance. However, some degree of surface roughness may be beneficial by increasing the surface area for sealer retention and mechanical interlocking.

3.5. Sealing Capacity (Micro-leakage Testing)

Micro-leakage analysis yielded variable results among the tested samples (Fig. 5). When examined the longitudinally sectioned teeth under stereomicroscopy, a range of sealing outcomes across the five specimens was observed (Table 2):

Table 2
Micro-leakage scores for individual samples

Sample	Apical (mm)	Middle (mm)	Coronal (mm)	Overall Score
1	0	0	0	Excellent
2	0	0	0	Excellent
3	1.5	0	0	Good
4	2.0	0	0	Good
5	3.5	0	0	Fair

Excellent sealing

Two samples (40%) demonstrated complete sealing with no visible methylene blue dye penetration at any level, apical, middle, or coronal. The canal space appeared uniformly white (representing the GP and sealer) with no blue coloration, indicating an impervious seal against dye infiltration.

Partial sealing

Two samples (40%) showed minimal dye penetration limited to the apical 1–2 mm of the root canal. The middle and coronal portions showed no dye penetration, suggesting adequate sealing in these regions but minor apical leakage.

Poor sealing

One sample (20%) exhibited dye penetration extending beyond 3 mm from the apex, with visible blue staining along the GP-dentin interface in the apical third. However, even this sample showed no leakage in the coronal two-thirds.

3.6. Mechanical Properties (Tensile Testing)

Tensile strength evaluation of AH-GP points yielded mechanical property data that differed significantly from commercial GP (Fig. 6).

The quantitative results were:

- Average tensile strength: 0.06 MPa (± 0.01 MPa)
- Maximum force at break: 0.08 N (± 0.02 N)
- Average displacement at break: 9.76% (± 2.3%)

These tensile strength values are considerably lower than those typically reported for commercial GP points, which generally range from 10 to 30 MPa depending on formulation and testing conditions. At first glance, this might appear to be a significant limitation that could compromise clinical performance.

However, it's important to consider these findings in clinical context. The lower tensile strength suggests that AH-GP is a softer, more flexible material than conventional GP. This characteristic could provide certain advantages:

Better adaptation

During lateral or vertical condensation techniques, softer material can conform more readily to canal irregularities, potentially improving sealing in complex anatomies.

Easier manipulation

The material may be easier to cut, remove, or adjust during placement, reducing the risk of separating the apical portion during insertion.

Reduced stress on canal walls

Softer material exerts less outward force during condensation, potentially reducing the risk of vertical root fractures, a serious complication of root canal treatment.

4. Discussion

The intrinsic radiopacity of AH-GP is particularly intriguing and deserves further investigation. Commercial GP requires radiopacifying agents such as barium sulphate to achieve adequate radiographic visibility (Maniglia-Ferreira et al., 2005). Published elemental analyses have confirmed that *A. heterophyllus* latex contains various minerals including calcium, magnesium, potassium, and trace metals (Ye et al., 2025), which could collectively contribute to X-ray attenuation and the observed natural radiopacity. Future elemental characterization using energy-dispersive X-ray spectroscopy (EDS) or X-ray fluorescence (XRF) will be necessary to definitively identify the responsible elements.

The composition used in this study, 40% latex and 60% zinc oxide, differs significantly from standard commercial GP. Recent analyses show that commercial GP typically contains 14–22% GP polymer, 59–79% zinc oxide, variable amounts of radiopacifiers (0–17%), and 3% plasticizers (Wang et al., 2025). The increased zinc oxide content (60%) is comparable to commercial formulations and likely contributes to dimensional stability and antibacterial properties, as zinc oxide itself has documented antimicrobial activity (Sarih et al., 2022). The combined SEM and AFM analyses revealed that AH-GP points possess surface characteristics suitable for endodontic applications. The relatively smooth surface with controlled roughness profiles should facilitate clinical handling and interaction with root canal anatomy. The average area roughness of 3.28 μm positions AH-GP within an acceptable range for endodontic materials, suggesting comparable surface quality despite hand-fabrication methods.

Microscale surface irregularities increase the surface area available for sealer retention and may enhance mechanical interlocking between the GP and sealer (Ferreira et al., 2024). The semi-crystalline polymeric structure observed in SEM imaging is characteristic of natural latex materials and suggests that AH-GP retains some elasticity while maintaining dimensional stability, properties essential for effective obturation. Natural rubber latex exhibits both crystalline and amorphous regions within its molecular structure, with the crystalline domains providing strength and the amorphous regions conferring elasticity (De Lima et al., 2025).

The uniform distribution of 1 μm zinc oxide particles throughout the latex matrix, as visualized by SEM, indicates that our mixing protocol achieved adequate homogeneity. Uniform filler distribution is critical because particle aggregation or settling could create weak points or regions with inconsistent properties. The rectangular particle morphology observed matches the typical crystal structure of zinc oxide, and the approximately 1 μm size is appropriate for achieving a smooth surface finish while maintaining adequate filler reinforcement. The prevention of bacterial reinfection through coronal or apical leakage is the primary goal of root canal obturation, and therefore, assessing sealing capacity is perhaps the most clinically relevant evaluation of any endodontic filling material (Pirani and Camilleri, 2023). Our micro-leakage results showed considerable variability, with some samples demonstrating excellent sealing while others exhibited dye penetration. This variability, while initially concerning, requires careful interpretation within the broader context of endodontic research.

Micro-leakage studies using dye penetration methods have inherent limitations and typically show substantial variability even when testing well-established commercial materials under controlled conditions (Prati et al., 2020). In our study, 40% of samples showed complete sealing with no visible dye penetration at any level, a result that confirms AH-GP material can achieve adequate obturation when properly placed. Another 40% showed only minimal apical leakage (1–2 mm), which is quite common even with commercial GP. For instance, recent systematic reviews have shown that bacterial leakage is a significant concern even with commercial GP systems (Kowalski et al., 2023). Our findings compare favourably to these benchmarks. More advanced obturation techniques like warm vertical compaction or continuous wave condensation, which involve heating and compacting the GP, might yield better results with AH-GP by exploiting its thermoplastic properties to improve adaptation to canal irregularities (Yu et al., 2023).

Furthermore, the documented antibacterial properties of *A. heterophyllus* extracts represent a potential advantage that dye penetration tests cannot capture (Gupta et al., 2023). Recent studies have shown that jackfruit leaf extracts exhibited minimum inhibitory concentrations in the range of 221.9-488.1 μg/ml against *E. faecalis*, the bacterium most commonly associated with endodontic treatment failures

(Pranay Raja et al., 2021). The tensile strength of AH-GP (0.06 MPa) is substantially lower than commercial GP (typically 10–30 MPa), which represents the most significant deviation from conventional materials observed in our study. However, we considered this apparent weakness deserves nuanced consideration rather than dismissal as a fatal flaw. For narrow, curved canals where adaptation to complex anatomy is paramount, a more flexible material might be advantageous. For wide, straight canals where structural rigidity facilitates insertion and condensation, higher tensile strength would be preferred.

The lower tensile strength of AH-GP suggests it's a softer, more flexible material that could adapt more readily to canal irregularities during lateral compaction or warm vertical condensation. When heated, it might flow more easily into lateral canals, fins, and isthmuses, the complex anatomical features that often harbour residual bacteria and contribute to treatment failures (Yu et al., 2023). The 9.76% elongation at break indicates reasonable elasticity, suggesting the material can stretch and adapt before failing. It's also worth noting that GP points function in conjunction with endodontic sealers, which fill the spaces between the GP and canal walls.

Bioceramic-based sealers and obturation materials have gained significant attention in recent years. Materials like EndoSequence BC Sealer, BioRoot RCS, and MTA Fillapex use calcium silicate chemistry to achieve biocompatibility and osteogenic properties (Drukteinis et al., 2024). While these materials show excellent biocompatibility and the ability to form hydroxyapatite at the interface with dentin, they also present challenges. Recent studies have noted that bioceramic sealers may have different sealing characteristics and require longer setting times and cannot be easily removed if retreatment becomes necessary (Al-Askary et al., 2023). In contrast, our AH-GP points demonstrated effective sealing in multiple samples when used with conventional resin-based sealer, without requiring specialized or expensive sealer systems. The material's flexibility might improve its performance with bioactive sealers by adapting better to the volumetric changes that occur during sealer setting and hydration.

More recently, researchers have explored coating conventional GP with antimicrobial agents like silver nanoparticles or chlorhexidine to provide antibacterial properties (Kowalski et al., 2023). Samrot and Sean (2022) showed that *A. heterophyllus* latex extracts exhibited antibacterial activity against *P. aeruginosa, S. aureus*, and *Bacillus* species (Samrot and Sean, 2021). Recent investigations have confirmed antimicrobial activity in jackfruit extracts against *E. coli, Klebsiella* species, and notably, *E. faecalis* (Pranay Raja et al., 2021). The activity against *E. faecalis* is particularly significant because this organism is the most common bacterium isolated from failed root canal treatments and is notoriously resistant to conventional endodontic disinfection protocols (Ji et al., 2022). The bioactive compounds in jackfruit latex include lectins (particularly artocarpin), flavonoids, tannins, and other phytochemicals with documented biological activities (Gupta et al., 2023).

Future research should investigate quantitative antimicrobial assays to determine if processed AH-GP retains antibacterial activity, identification of the specific compounds responsible for antimicrobial effects, assessment of antibacterial duration and stability during storage, and biofilm eradication capabilities against *E. faecalis* biofilms using direct contact tests (Ji et al., 2022). Finally, AH-GP's performance might vary significantly depending on the sealer system used, and systematic compatibility studies are needed, particularly with the increasingly popular bioceramic sealers (Drukteinis et al., 2024).

5. Conclusion

This is the first reported investigation into the development and characterization of gutta-percha obturation points derived from *A. heterophyllus* latex, and the study demonstrates that this material holds genuine promise as an indigenous, cost-effective alternative to conventional gutta-percha for root canal obturation. The material exhibits favorable characteristics including natural radiopacity without barium sulphate additives, acceptable nanoscale surface properties comparable to commercial GP, and potential for enhanced canal adaptation due to its flexibility. The documented antibacterial bioactivity of *A. heterophyllus* constituents—particularly against *Enterococcus faecalis*—adds a potentially valuable intrinsic antimicrobial dimension absent in conventional GP. However, extensive research is essential before clinical implementation, including: (i) formulation optimization aligned with ISO 6877:2006 standards for root canal obturation materials; (ii) standardized and scalable manufacturing protocols; (iii) comprehensive in vitro and in vivo biocompatibility testing per ISO 10993 guidelines; (iv) quantitative antimicrobial assessment against endodontic pathogens; (v) large-scale sealing efficacy studies using bacterial leakage models; (vi) systematic sealer compatibility evaluation including bioceramic systems; and (vii) randomized controlled clinical trials. Despite these requirements, jackfruit is cultivated across more than 90 tropical and subtropical countries (Ranasinghe et al., 2019), offering an abundant, renewable, and low-cost raw material base ideally suited to resource-constrained dental healthcare environments. As global dentistry increasingly emphasizes sustainability, circular economy principles, and equitable access to care, jackfruit latex represents a compelling direction for dental biomaterial innovation and may serve as a model for exploring other underutilized tropical plant latex sources as alternatives to petroleum-derived or imported endodontic materials.

Abbreviations

RCT
Root Canal Treatment
GP
GP
AH
Artocarpus heterophyllus
AH
GP-*Artocarpus heterophyllus* GP
SEM
Scanning Electron Microscopy
AFM
Atomic Force Microscopy

EDTA
Ethylenediaminetetraacetic Acid
ZnO
Zinc Oxide
ISO
International Organization for Standardization
MPa
Megapascal
Ra
Average area roughness
EDS
Energy-Dispersive X-ray Spectroscopy
XRF
X-ray Fluorescence

Declarations

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Author Declaration

RKG - Conceptualized research and provided overall guidance

RVG - Provided research guidance and supervised methodology

JN & LK - Conducted experiments, performed analyses, and drafted the manuscript

Ethical Approval Statement

Approved by Dr. Deepa Gurunathan, Member Secretary, Saveetha Dental College- Institutional Human Ethical Committee (SDC-IHEC), Registration No. ECR/1698/Inst/TN/2022.

Clinical Trial

No clinical trial was involved in this study.

Data Availability

The data supporting this study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare no competing interests.

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Figures

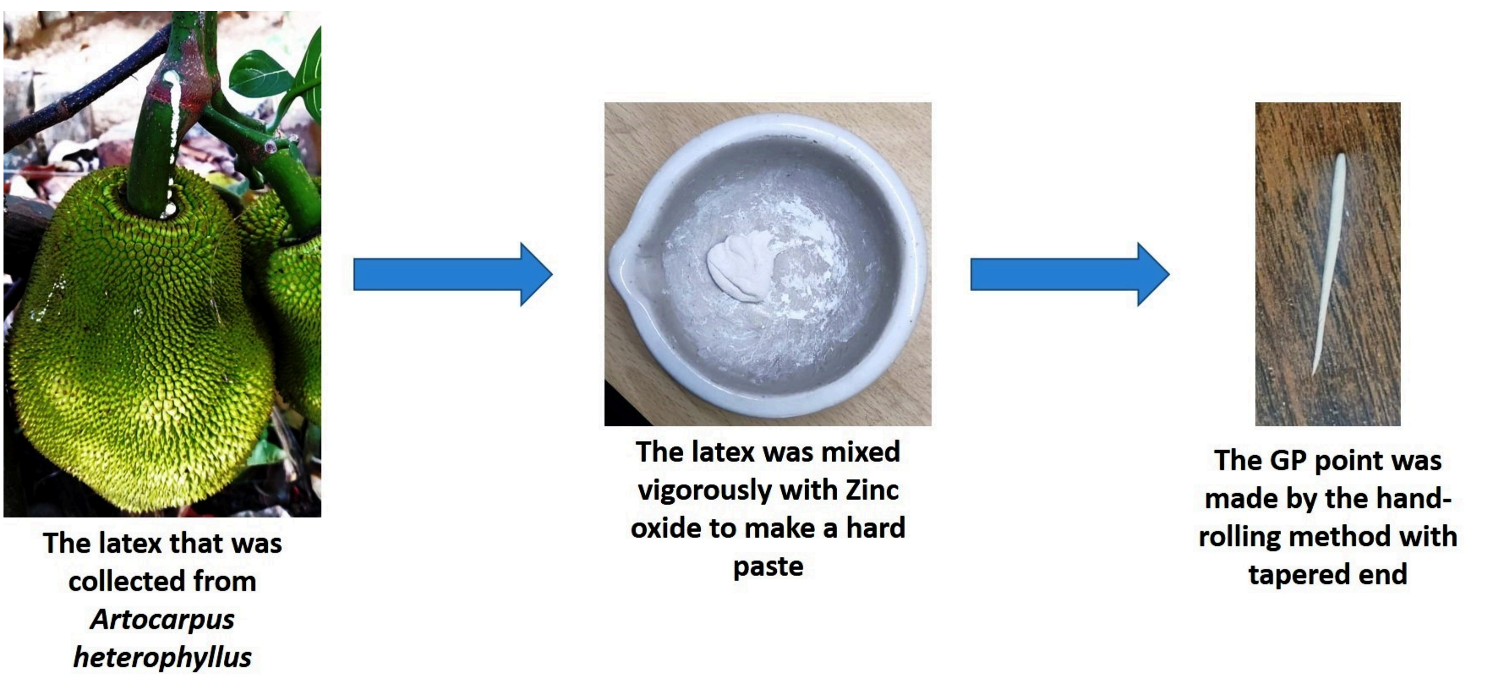

Figure 1

Illustration of the latex collection and AH-GP point fabrication process. (A) Fresh milky latex being collected from *Artocarpus heterophyllus* trunk incision. (B) Latex mixed with zinc oxide powder forming

a homogeneous white putty. (C) Hand-rolled AH-GP points showing tapered morphology like conventional GP points.

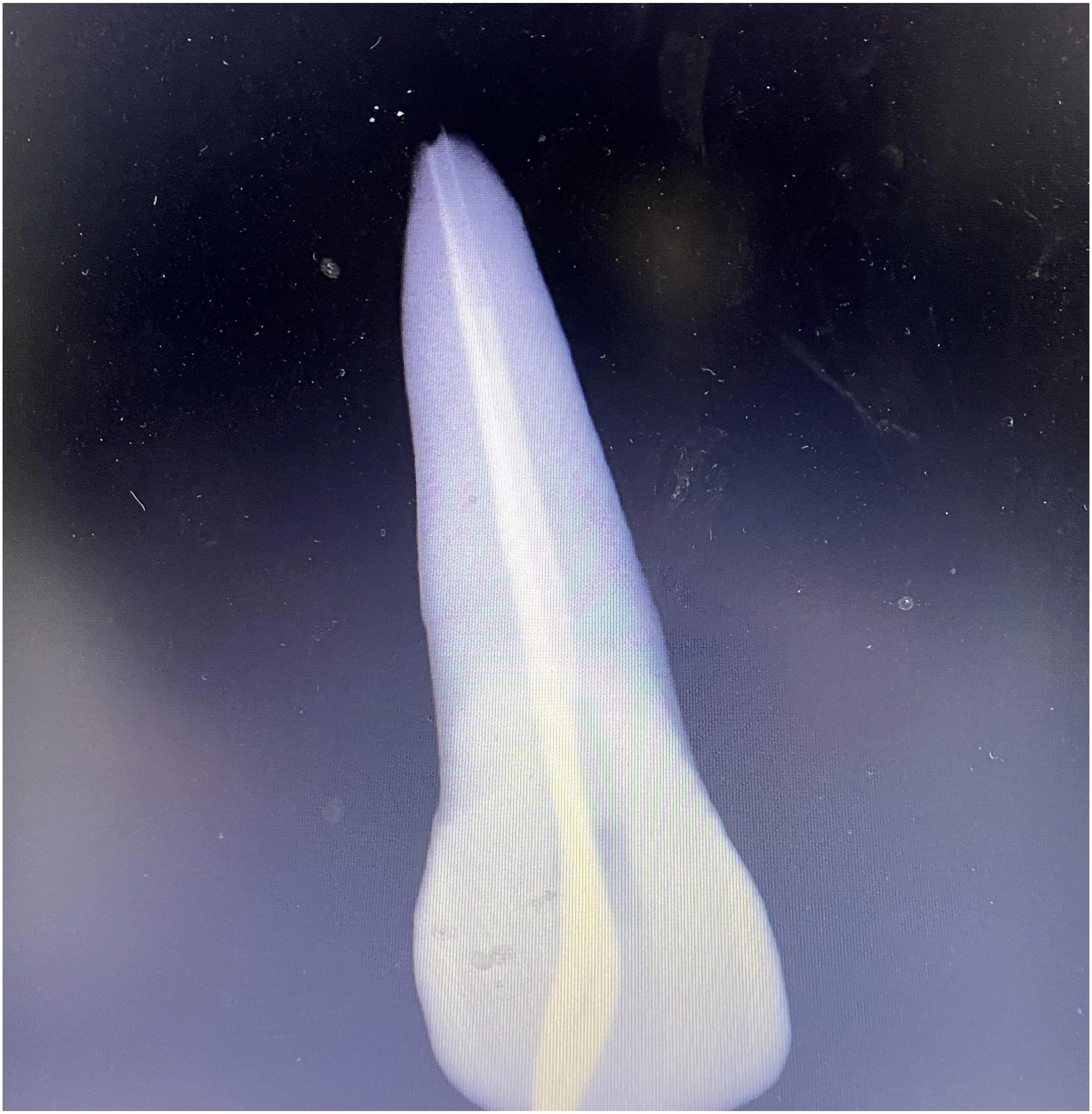

Figure 2

Periapical radiograph demonstrating the natural radiopaque property of AH-GP points made from *A. heterophyllus* latex. The AH-GP point is clearly visible within the root canal system without the addition of barium sulphate or other radiopacifying agents. The uniform radiopacity along the canal length indicates adequate X-ray attenuation for clinical diagnostic purposes.

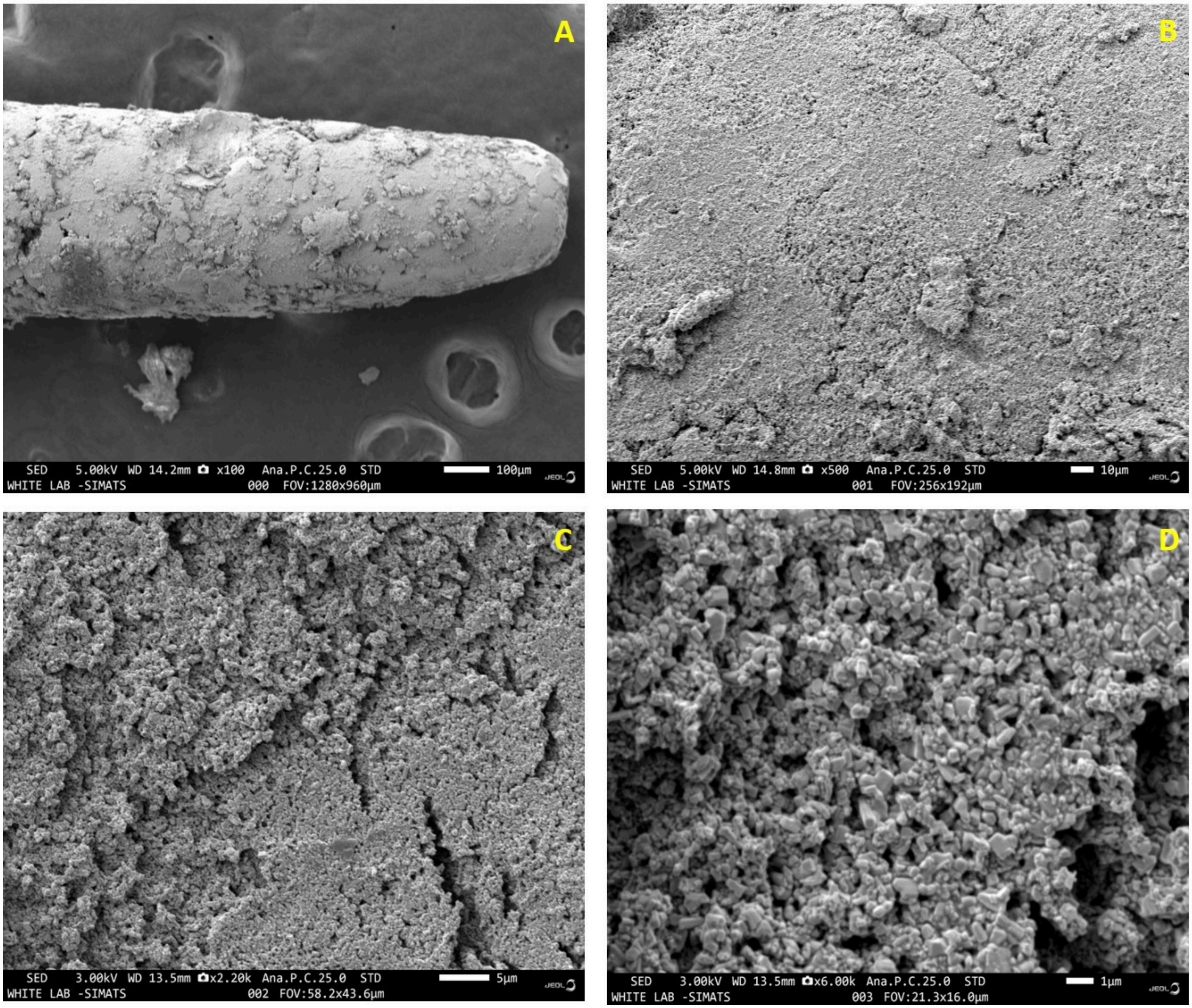

Figure 3

Scanning electron microscopy images of AH-GP points at various magnifications. (A) Low magnification (×100) showing the tapered tip with relatively smooth surface architecture. (B) Intermediate magnification (×500) revealing overall surface smoothness with minor irregularities consistent with hand fabrication. (C) Higher magnification (×1000) demonstrating semi-crystalline polymeric structure. (D) High magnification (×5000) showing uniformly distributed rectangular zinc oxide particles (approximately 1 µm) embedded within the latex matrix.

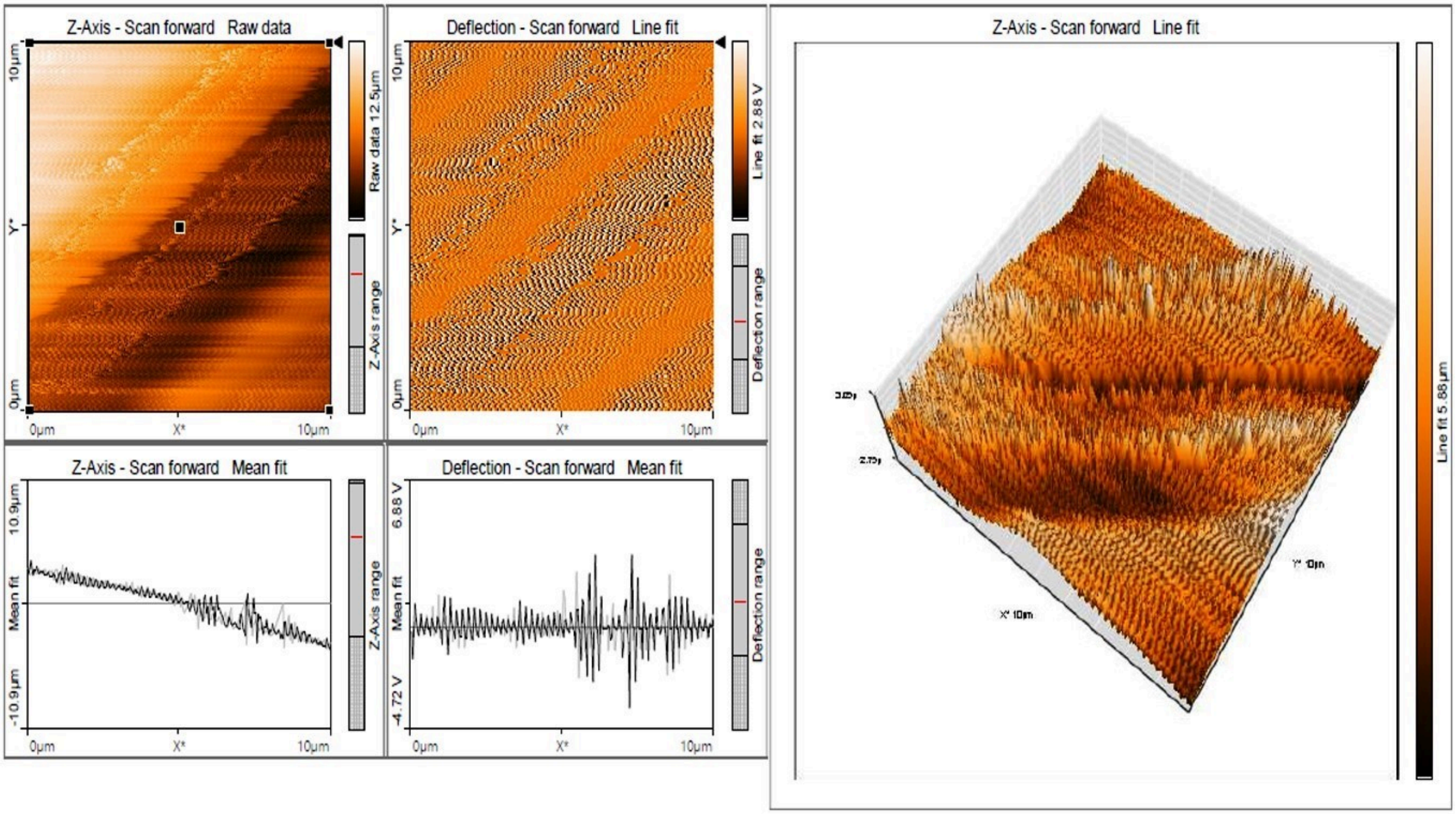

Figure 4

Atomic force microscopy analysis of AH-GP point surface topography. (A) Three-dimensional topographical map showing surface elevation variations over a 10 µm² scan area. (B) Color-coded height map indicating gentle undulations rather than sharp peaks and valleys. Quantitative analysis revealed average area roughness (Ra) of 3.28 µm and average line roughness of 2.29 µm, indicating favorable surface characteristics for endodontic applications.

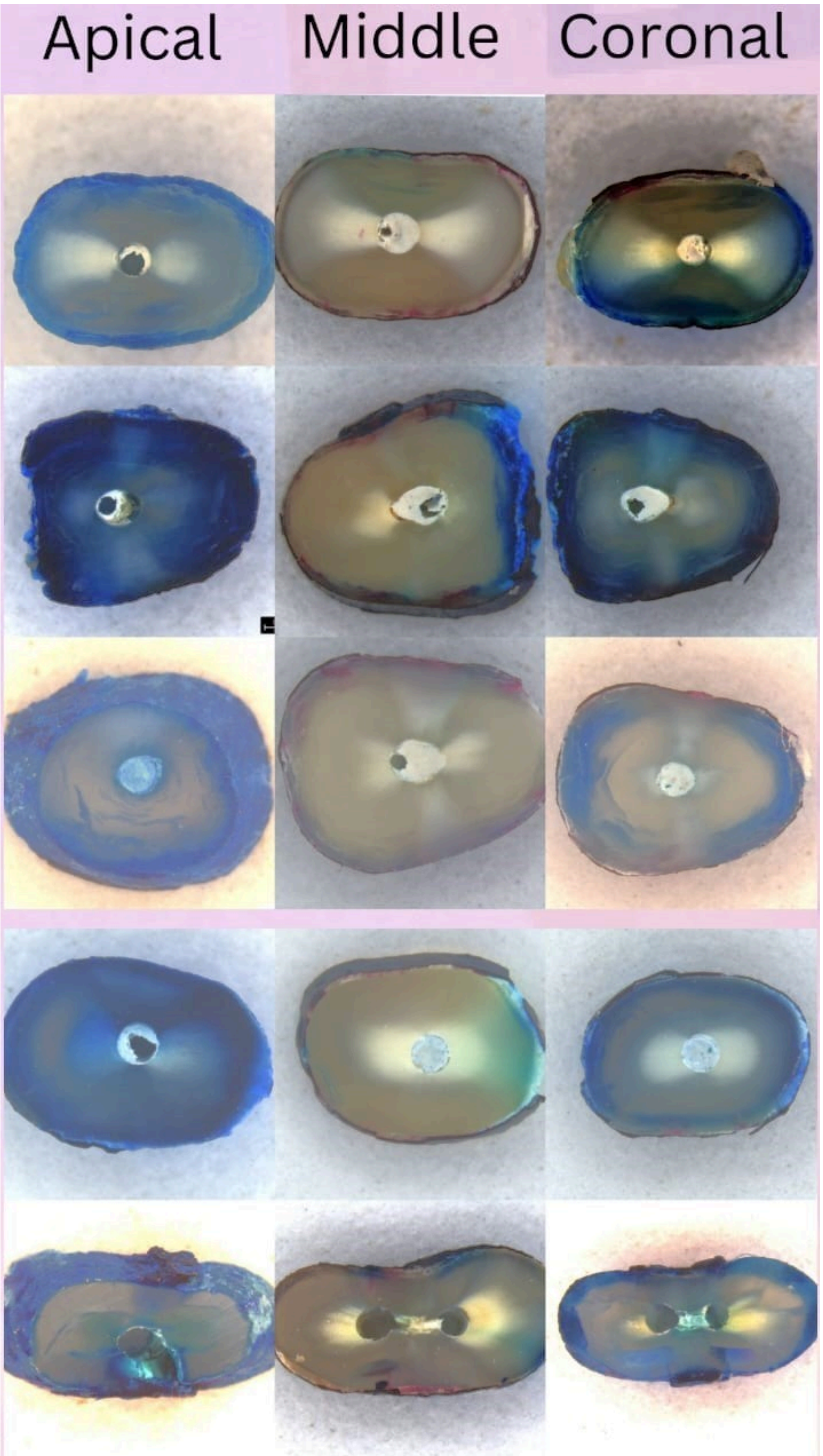

Figure 5

Micro-leakage analysis using methylene blue dye penetration method. Representative images showing longitudinally sectioned teeth after root canal obturation with AH-GP points. Three sections from each tooth show the apical, middle, and coronal regions. (A-B) Samples demonstrate excellent sealing with no visible blue dye penetration at any level. (C-D) Samples showing minimal apical leakage (1-2 mm)

complete serving in middle and coronal regions. (E) Sample exhibiting more extensive apical leakage but maintained sealing in coronal regions.

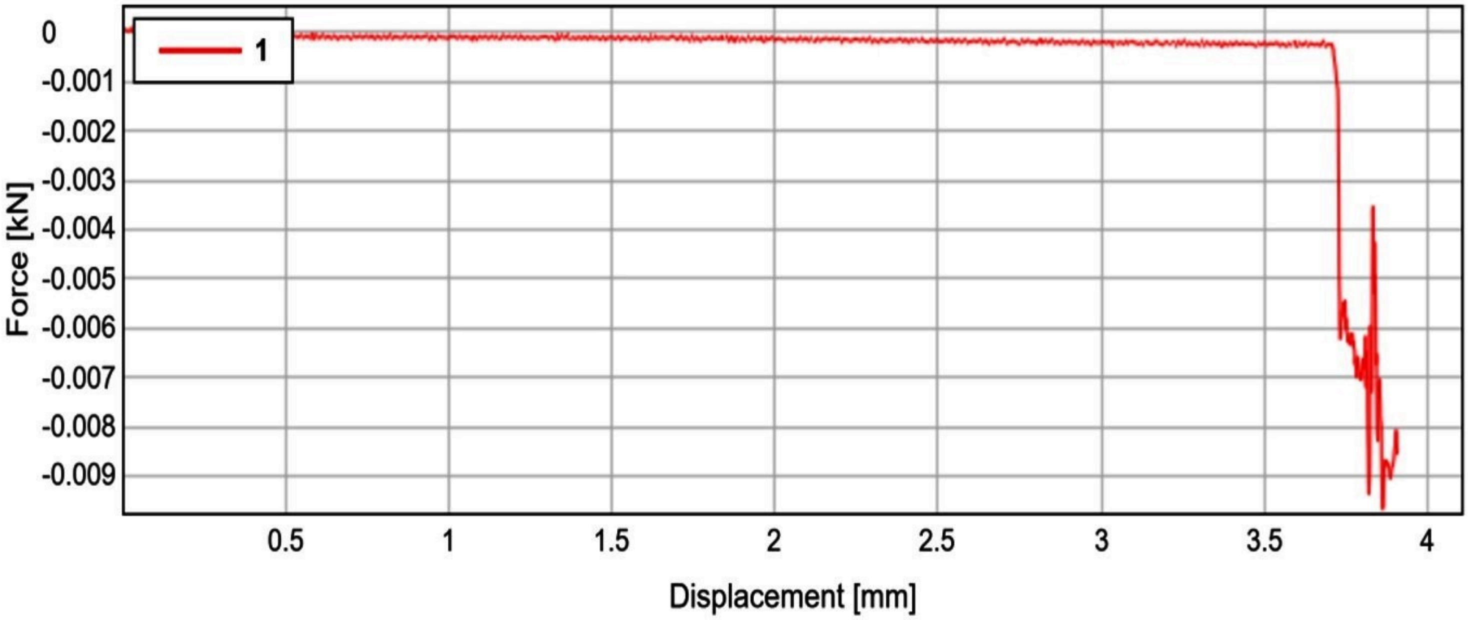

Figure 6

Tensile testing results of AH-GP points using universal testing machine, the average tensile strength: 0.06 MPa; Maximum force at break: 0.08 N; Average displacement at break: 9.76%.