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JOURNAL *of* ENDODONTIC MICROSURGERY

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TANTUM VERDE®

QUICK RELIEF FROM PAIN AND INFLAMMATION IN THE MOUTH AND THROAT[1]

AN INTEGRAL COMPONENT OF THE TREATMENT OF PAIN AND INFLAMMATION IN THE ORAL CAVITY IN 60 COUNTRIES WORLDWIDE![2]

- **JAWS FRACTURES[3]**
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Reg. № UA/3920/01/01

LOCAL ANESTHETIC AND ANTI-INFLAMMATORY EFFECT[1]

SUMMARY OF PRODUCT CHARACTERISTICS

NAME OF THE MEDICINAL PRODUCT. Tantum Verde 0.15% mouthwash. QUALITATIVE AND QUANTITATIVE COMPOSITION. Each 100 ml contains: active ingredient: benzydamine hydrochloride 0.15 g (equivalent to 0.134 g of benzydamine). **Therapeutic indications.** Treatment of symptoms such as irritation/inflammation including those associated with pain in the oropharyngeal cavity (e.g. gingivitis, stomatitis and pharyngitis), including those resulting from conservative or extractive dental therapy. **Posology and method of administration.** Pour 15 ml of Tantum Verde mouthwash into the measuring cup, 2-3 times per day, using it either at full concentration or diluted. If diluted, add 15 ml of water to the graduated cup. Do not exceed the recommended dosage. **Contraindications.** Hypersensitivity to benzydamine or to any of the excipient. **PHARMACOLOGICAL PROPERTIES. Pharmacodynamic properties.** Pharmacotherapeutic group: Stomatologic drugs: other agents for local oral treatment, ATC code: A01AD02. Clinical studies demonstrate that benzydamine is effective in relieving suffering from localised irritation of the mouth and pharynx. In addition, benzydamine possesses a moderate local anaesthetic effect. **Pharmacokinetic properties.** Absorption. Absorption through the oropharyngeal mucosa is demonstrated by the presence of measurable quantities of benzydamine in human plasma. These levels are insufficient to produce systemic effects. Distribution. When applied locally, benzydamine has been shown to accumulate in inflamed tissues where it reaches effective concentrations because of its capacity to penetrate the epithelial lining.

Information about medicines. Information for health care professionals for use in professional activities.

1. Інструкція для медичного застосування лікарського засобу Тантум Верде®, розчин для ротової порожнини, РП № UA/3920/01/01, затверджено Наказом Міністерства охорони здоров'я України № 636 від 01.10.2015.
2. http://www.angelinipharma.com/wps/wcm/connect/com/home/Angelini+Pharma+in+the+world/
3. Тимофеев А.А. и др. "Особенности гигиены полости рта для профилактики воспалительных осложнений при переломах нижней челюсти". Современная стоматология 2015;1(75):52–8.
4. 4,5. Tymofieiev O.O. et al"Prevention of inflammatory complications upon surgeries in maxillofacial region". J Diagn Treat Oral Maxillofac Pathol. 2017;1:105–12.

Clinical and CT images are courtesy of: Ievgen Fesenko (Department of Oral & Maxillofacial Surgery, PHEI "Kyiv Medical University", Kyiv, Ukraine), Oleg Mastakov ("SCIEDECE—Scientific Center of Dentistry & Ultrasound Surgery" Kyiv, Ukraine)

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Journal

About the Journal: Aims and Scope

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Official Title

Journal of Endodontic Microsurgery

Acronym

JEM

Official Title in Ukrainian

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Aims and Scope

This annual journal focused on publication of peer-reviewed articles of all types on all topics of endodontic microsurgery.

Editorial Board (EB) Composition

EB shows significant geographic diversity representing 21 specialists from 11 countries: Colombia, Denmark, Egypt, France, Greece, India, Saudi Arabia, Ukraine, United Arab Emirates, United Kingdom, and United States. Most of the EB Members have a discernible publication history in journals with an impact factor and included to Scopus, Web of Science databases. The publication records of all EB members are consistent with the stated scope and published content of the journal.
The journal has full-time professional editor and publisher.
Gender distribution of the editors: 9.52% women, 90.48% men, 0% non-binary/other, and 0% prefer not to disclose.

Frequency

One volume a year with a continuous article publication (CAP).

Publishing Model

The *Journal of Endodontic Microsurgery* is a fully open access online-only and peer-reviewed publication with a CAP.

Open Access

Type of Peer Review

The journal employs “double blind” and open reviewing. This means that each manuscript first undergoes a "double-blind" review and only if the manuscript is accepted for publication the reviewers are listed in the final version of the article.

Article Publishing Charge (APC)

Manuscripts should be submitted online at website: www.jendodmicrosurg.org. After review, if the paper is accepted for publication, authors will be required to pay the APC.
The APC for the **short case report** (3-4 pages article) published in the Journal of Endodontic Microsurgery is $500 USD, excluding taxes:

- For articles submitted between August 23, 2024, and August 23, 2025, there is a 25% introduction discount (i.e., the APC is $375 USD).

The APC for the **long case report**, **original** or **review article** (5-9 pages or more) is $1,373 USD, excluding taxes:

- For articles submitted between August 23, 2024, and August 23, 2025, there is a 25% introduction discount (i.e., the APC is $1,029 USD).

Types of Articles Published by the Journal

Editorials, Guest Editorials, Case Reports/Case Series, Original Articles, Review Articles, Discussions, Review of Articles, Book Reviews, Letters to the Editors, and Viewpoints.

Editorial Office

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November 19, 2021 (Certificate: Серія КВ № 25027-14967 Р [in Ukrainian]).

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- Media identifier: R30-04319. Decision dated April 11, 2024, No. 1225, Protocol No. 13.

Databases and Registers

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- Register of Scientific Publications of Ukraine, Ukraine.
- Vernadsky National Library of Ukraine, Ukraine: http://nbuv.gov.ua/j-tit/JEM

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Editorial Board

VOLUME 4 • DECEMBER 31 • 2025
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TANTUM VERDE®

INFORMATION LEAFLET
for the medicinal product

Composition:
active substance: **benzydamine hydrochloride**;
100 mL of solution contain benzydamine hydrochloride 0.15 g;
excipients: ethanol 96%, glycerol, methyl parahydroxybenzoate (E 218), flavor (menthol), saccharin, sodium hydrocarbonate, Polysorbate 20, Quinoline Yellow (E 104), Patent Blue V (E 131), purified water.

Dosage form. Oromucosal solution.
Basic physical and chemical properties: a clear green liquid with a typical mint flavor.

Pharmacotherapeutic group. Dental preparations. Other agents for local oral treatment.
ATC code: A01A D02.

Pharmacological properties.
Pharmacodynamics.
Benzydamine is a non-steroidal anti-inflammatory drug (NSAID) with analgesic and antiexudative properties.

Clinical studies have shown that benzydamine is effective in the relief of symptoms accompanying localized irritation conditions of the oral cavity and pharynx. Moreover, benzydamine has anti-inflammatory and local analgesic properties, and also exerts a local anesthetic effect on the oral mucosa.

Pharmacokinetics.
Absorption through the oral and pharyngeal mucosa has been proven by the presence of measurable quantities of benzydamine in human plasma. However, they are insufficient to produce any systemic pharmacological effect. The excretion occurs mainly in urine, mostly as inactive metabolites or conjugated compounds.

When applied locally, benzydamine has been shown to cumulate in inflamed tissues in an effective concentration due to its ability to permeate through the mucous membrane.

Clinical particulars.
Indications.
Symptomatic treatment of oropharyngeal irritation and inflammation; to relieve pain caused by gingivitis, stomatitis, pharyngitis; in dentistry after tooth extraction or as a preventive measure.
Contraindications.
Hypersensitivity to the active substance or to any other ingredients of the product.

Interaction with other medicinal products and other types of interaction.
No drug interaction studies have been performed.

Warnings and precautions.
If sensitivity develops with long-term use, the treatment should be discontinued and a doctor should be consulted to get appropriate treatment.

In some patients, buccal/pharyngeal ulceration may be caused by severe pathological processes. Therefore, the patients, whose symptoms worsen or do not improve within 3 days or who appear feverish or develop other symptoms, should seek advice of a physician or a dentist, as appropriate.

Benzydamine is not recommended for use in patients hypersensitive to acetylsalicylic acid or other non-steroidal anti-inflammatory drugs (NSAIDs).

The product can trigger bronchospasm in patients suffering from or with a history of asthma. Such patients should be warned of this.

For athletes: the use of medicinal products containing ethyl alcohol might result in positive antidoping tests considering the limits established by some sports federations.

Use during pregnancy or breast-feeding
No adequate data are currently available on the use of benzydamine in pregnant and breastfeeding women. Excretion of the product into breast milk has not been studied. The findings of animal studies are insufficient to make any conclusions about the effects of this product during pregnancy and lactation.

The potential risk for humans is unknown.

TANTUM VERDE should not be used during pregnancy or breast-feeding.

Effects on reaction time when driving or using machines
When used in recommended doses, the product does not produce any effect on the ability to drive and operate machinery.

Method of administration and doses.
Pour 15 mL of TANTUM VERDE solution from the bottle into the measuring cup and gargle with undiluted or diluted product (15 mL of the measured solution can be diluted with 15 mL of water). Gargle 2 or 3 times daily. Do not exceed the recommended dose.

Children.
The product should not be used in children under 12 years due to a possibility of ingestion of the solution when gargling.

Overdosage.
No overdose has been reported with benzydamine when used locally. However, it is known that benzydamine, when ingested in high doses (hundreds times higher than those possible with this dosage form), especially in children, can cause agitation, convulsions, tremor, nausea, increased sweating, ataxia, and vomiting. Such acute overdose requires immediate gastric lavage, treatment of fluid/salt imbalance, symptomatic treatment, and adequate hydration.

Adverse reactions.
Within each frequency group, the undesirable effects are presented in order of their decreasing seriousness.

Adverse reactions are classified according to their frequency: very common (≥ 1/10); common (≥ 1/100 to <1/10); uncommon (≥ 1/1,000 to <1/100); rare (≥ 1/10,000 to <1/1,000); very rare (<1/10,000); frequency unknown (cannot be estimated from the available data).

Gastrointestinal disorders: rare – burning mouth, dry mouth; *unknown* – oral hypesthesia, nausea, vomiting, tongue edema and discoloration, dysgeusia.

Immune system disorders: rare – hypersensitivity reaction, *unknown* - anaphylactic reaction.

Respiratory, thoracic and mediastinal disorders: very rare –laryngospasm; *unknown* – bronchospasm.

Skin and subcutaneous tissue disorders: uncommon – photosensitivity; *very rare* – angioedema; *unknown* – rash, pruritus, urticaria.

Nervous system disorders: unknown – dizziness, headache.

TANTUM VERDE contains methyl parahydroxybenzoate, which can cause allergic reactions (including delayed-type reactions).

Shelf life. 4 years.

Storage conditions.
Do not store above 25°C. Keep out of reach of children.

Packaging.
120 mL of solution in a bottle with a measuring cup; 1 bottle per cardboard box.

Dispensing category.
Over-the-counter medicinal product.

Manufacturer.
Aziende Chimiche Riunite Angelini Francesco A.C.R.A.F. S.p.A., Italy.

Location of the manufacturer and its business address. Via Vecchia del Pinocchio, 22 – 60100 Ancona (AN), Italy.

Date of the last revision of the text.
September 26, 2018.

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Серія КВ № 25027-14967 Р

«Журнал ендодонтичної мікрохірургії»
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(назва видання іншою мовою (мовами))

Вид видання журнал
(газета, журнал, бюлетень, збірник, альманах, календар, дайджест)

Статус видання вітчизняне
(вітчизняне, спільне)

Мова (мови) видання змішаними мовами: українська, англійська

Вид видання за цільовим призначенням наукове, науково-популярне
(громадсько-політичне, наукове, навчальне, інформаційне, рекламне (понад 40 відсотків обсягу одного номера – реклама), еротичне тощо)

Обсяг, періодичність 1 ум. друк. арк., формат А4 (210х297), 1 раз на рік

Сфера розповсюдження та категорія читачів загальнодержавна, зарубіжна
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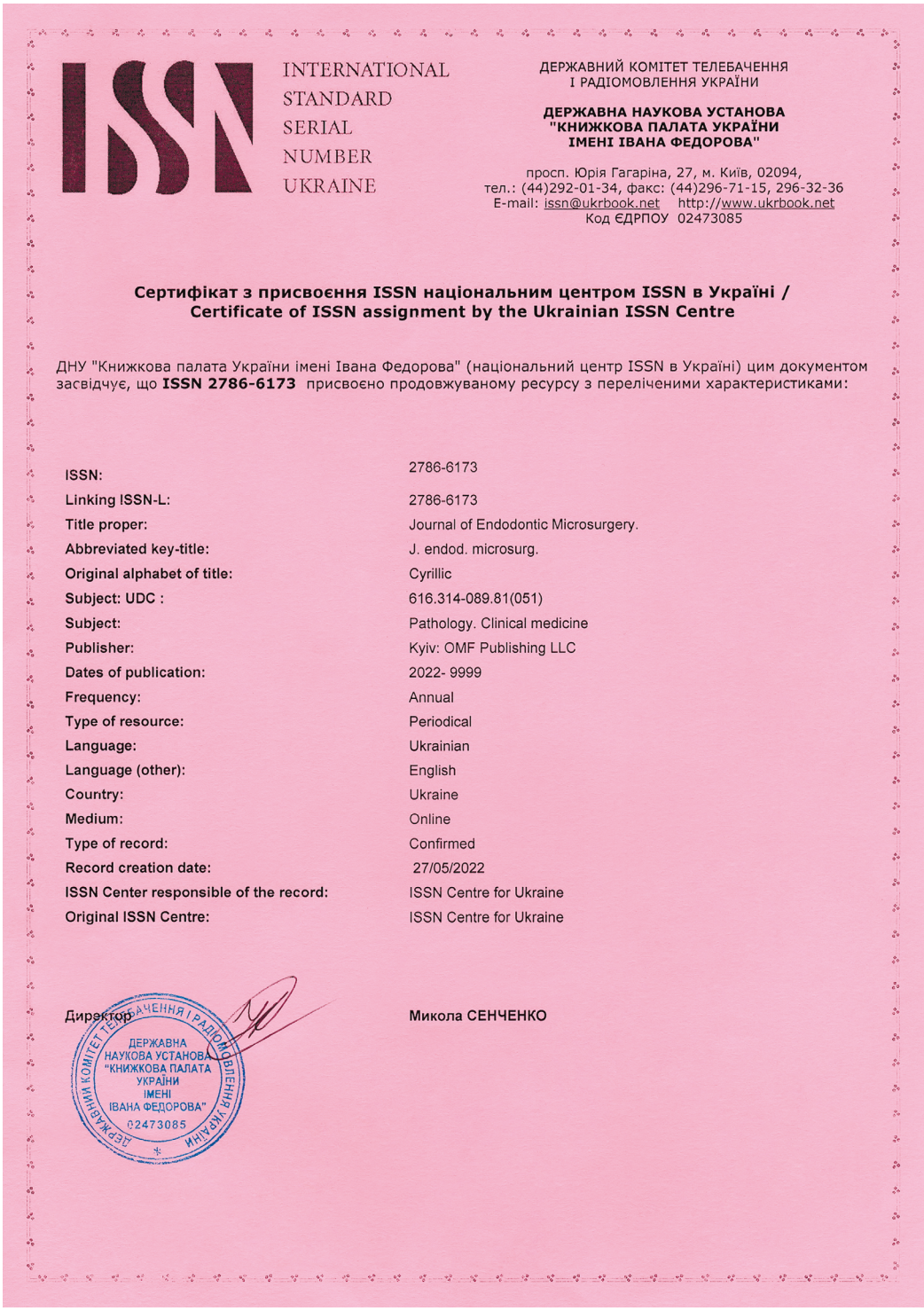
Засновник (співзасновники) ТОВАРИСТВО З ОБМЕЖЕНОЮ ВІДПОВІДАЛЬНІСТЮ «ОМФ ПАБЛІШИНГ» (код згідно з ЄДРПОУ 40493077)

Програмні цілі (основні принципи) або тематична спрямованість журнал присвячений публікації дослідницьких статей, статей із всебічним аналізом клінічних випадків, нових методик і тенденцій в ендодонтичній мікрохірургії, редакційних статей, мікрохірургічних технік в ендодонтії, оглядів опублікованих наукових праць

Міністр Денис МАЛЮСЬКА

19.11.2021
(дата реєстрації)

FIGURE. Certificate of state registration of the *Journal of Endodontic Microsurgery* in the Ministry of Justice of Ukraine dated November 19, 2021. Since the Law of Ukraine "On Media" came into force on March 31, 2023, the Journal was re-registered in the National Council of Ukraine on Television and Radio Broadcasting.



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ДЕРЖАВНА НАУКОВА УСТАНОВА "КНИЖКОВА ПАЛАТА УКРАЇНИ ІМЕНІ ІВАНА ФЕДОРОВА"

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FIGURE. Certificate of the International Standard Serial Number (ISSN) assignment to the *Journal of Endodontic Microsurgery*. The ISSN assigned by the Ukrainian ISSN Center, Ivan Fedorov Book Chamber of Ukraine, State Scientific Institution.

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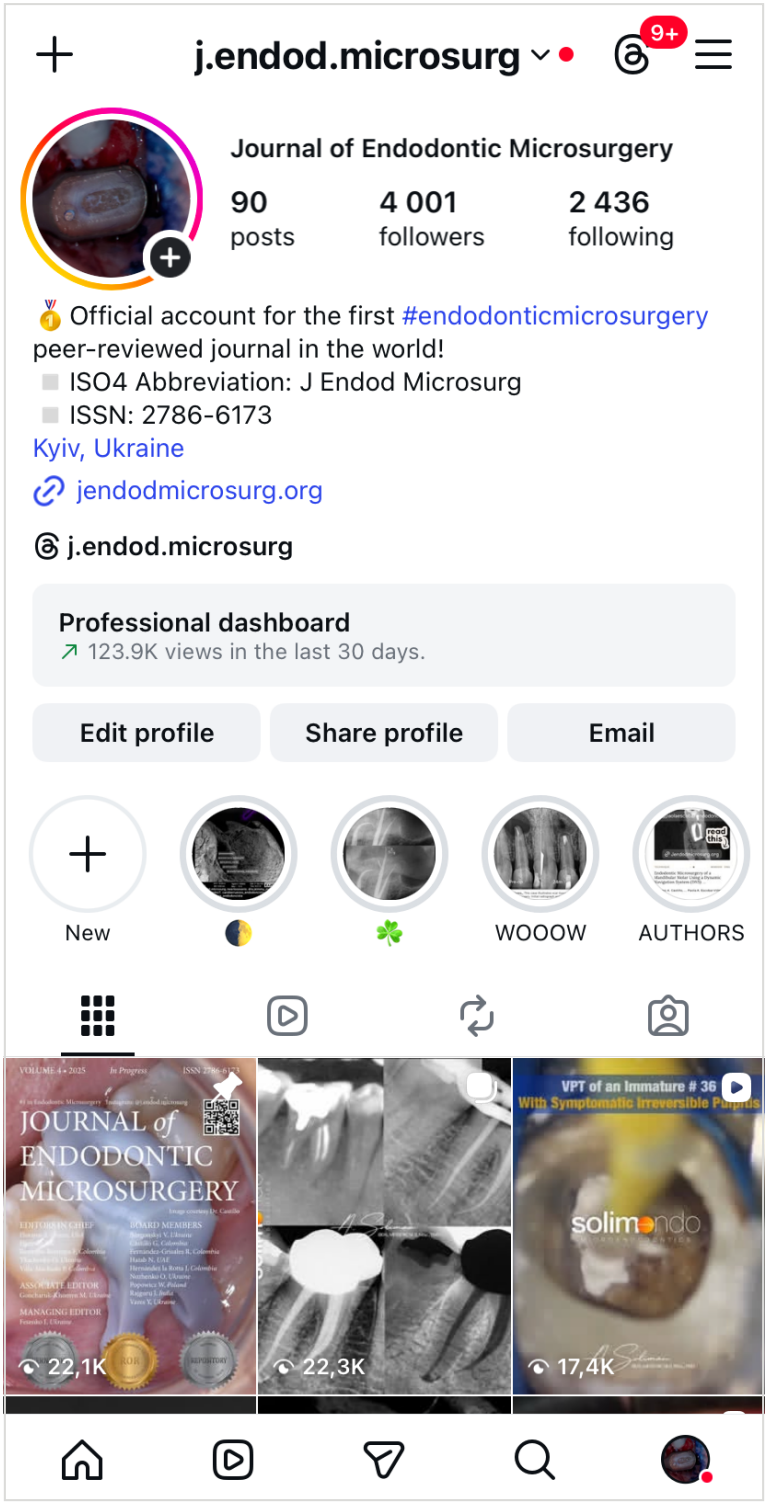

FIGURE. Journal's official Instagram page (@j.endod.microsurg) as of December 27, 2025.

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COURTESY

Cover image courtesy Dr. Castillo, Cali, Colombia. See article: Castillo et al (2024), 100017.
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CASE REPORT

On the Causes of Persistent Apical Periodontitis. Findings From Endodontic Microsurgery: A Case Report

Mateo José Pesántez-Ibarra[a], Carolina Berruecos-Orozco[b], Jeimmy Katherine Molina-Barrera[c], Néstor Ríos-Osorio[d], & Rafael Fernández-Grisales[e,*]

ABSTRACT

Despite significant advancements in endodontic biomaterials and operative techniques, persistent endodontic infections—frequently attributable to antimicrobial-resistant microorganisms, complex root canal morphology, subobturation of the root canal treatment, or iatrogenic procedural errors—continue to pose a clinical challenge. Orthograde retreatment is generally the preferred intervention; however, when access is precluded by intracanal posts or fixed prosthodontic restorations, endodontic microsurgery (EMS) represents a predictable alternative. This case report details the EMS management of a maxillary central incisor restored with a post and crown, diagnosed as a previously treated tooth with chronic apical abscess. Intraoperative sampling enabled comprehensive histopathological, microbiological, and scanning electron microscopy (SEM) analyses. At eight months following EMS procedure, both radiographic and cone beam computed tomographic (CBCT) assessment demonstrated satisfactory periapical healing.

KEY WORDS

Apicectomy, apical deltas, apical periodontitis, endodontic microsurgery, gutta-percha

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Acronym "SEM" in the upper right icon means that the article contains a description of scanning electron microscopy (SEM).

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INTRODUCTION

Intraradicular infection is the main cause of apical periodontitis (AP). Endodontic treatment aims to eradicate infection and prevent recurrence. Successful treatment is shown by bone repair and reduced periapical radiolucency. However, some lesions persist, termed "endodontic failure" [1, 2]. Common causes include leakage around obturation (30.4%), missed canals (19.7%), underfilling (14.2%), anatomical complexity (8.7%), and other factors (8.8%) [3, 4]. Occasionally, lesions do not heal despite optimal treatment, often due to true cysts or extraradicular biofilm within inflamed periapical tissue, which may hinder healing [1, 3, 4].

The quality of obturation is crucial for endodontic success. Although gutta-percha and sealer are the standard materials used for root canal filling, overextension beyond the apical foramen can delay periapical healing due to foreign body reactions and inflammation. Untreated canal ramifications, such as apical deltas, lateral canals and isthmuses, serve as bacterial reservoirs and sustain the persistence of AP (PAP) [4]. Kim and Kratchman reported that resection of at least 3 mm of the root apex by endodontic microsurgery (EMS) can eliminate up to 98% of apical ramifications and 93% of lateral canals [5]. In contrast, recurrent apical periodontitis (RAP) refers to the reappearance of the lesion after a period of apparent healing, related to the percolation of tissue fluids or the ingress of bacteria through coronal leakage or root fractures [6, 7].

The present clinical case describes the management of a maxillary incisor using EMS in a patient diagnosed with a previously treated tooth exhibiting a chronic apical abscess. Histopathological, microbiological, and scanning electron microscopy (SEM) analyses indicated that the persistence of microorganisms within untreated apical deltas, as well as in transapical gutta-percha, were predisposing factors contributing to the failure of the initial endodontic treatment.

CASE REPORT

This case report has been written according to Preferred Reporting Items for Case reports in Endodontics (PRICE) 2020 guidelines [8].

A 76-year-old male with no relevant medical history was referred to the postgraduate endodontics program (CES University Dental Clinic, Sabaneta, Colombia) for evaluation and management of tooth #21. Clinical examination showed a well-fitted metal-ceramic crown, normal probing, grade I mobility, tenderness to palpation and percussion, and fistula on the buccal mucosa. Cone beam computed tomography (CBCT) (J. Morita R100, Kyoto, Japan) at 90 mA, 8 kV, FOV 4 cm x 4 cm, and voxel size 0.5 mm showed a single canal with a post in the middle third of the root and extruded obturation material beyond the apex. The periapical lesion was visible on CBCT but not on periapical radiograph (Fig 1 A-B). The established diagnosis was a previously treated tooth with chronic apical abscess affecting tooth #21 (Fig 2-A). The proposed treatment plan was EMS, which was accepted by the patient after obtaining informed consent.

Under local anesthesia, three cartridges of 4% articaine with 1:100.000 epinephrine (Septodont, Saint-Maur-des-Fossés, France) were infiltrated for nerves block (anterior superior alveolar and nasopalatine) at tooth #21. Incisions were marked with a periodontal probe (Hu-Friedy, Chicago, USA) (Fig 2-B), and using an operating microscope (ZUMAX OMS 2350, Zumax Medical, Suzhou New District, China) at 8x magnification, a full-thickness submarginal triangular flap was raised between teeth #21 and #22 with a #15C scalpel blade (Zhejiang Mediunión Healthcare Group Co., Ltd, Zhejiang, China) (Fig 2-C). Once the flap was elevated with a mini-busser (Marthe®, Bucaramanga, Colombia), transapical gutta-percha (Fig 2-D) and periapical inflammatory tissue were identified and removed with Lucas and Gracey curettes (Hu-Friedy, Chicago, USA) for histopathological analysis.

The root surface was stained with methylene blue (ADS Pharma, Bogotá, Colombia), and at 16x magnification, the absence of fracture was confirmed. Subsequently, a 3 mm apicectomy was performed (Fig 2-E) with a piezoelectric device (Acteon, Satelec, France) at medium power and copious irrigation using distilled water. The apical fragment was immediately immersed in 2.5% glutaraldehyde solution in a sterile container and stored under aseptic conditions until processing for SEM analysis. Local haemostasis was achieved with epinephrine pellets [0.55 mg] (Racellet #3 Pascal, Washington, USA), and after staining the resected root surface with methylene blue, the previously treated root canal was located (Fig 2-F) and retro-prepared to a depth of 3 mm using an E32D

ultrasonic tip (NSK, Tokyo, Japan) operated with the Acteon P5 Newtron ultrasonic unit (Satelec, France) (Fig 2-G) at power setting 10 with copious irrigation.

After confirming retro-preparation with a round micro-mirror MM4 (Hu-Friedy, Chicago, USA) at 16x magnification, the cavity was disinfected with 2% chlorhexidine (Wescohex, La Estrella, Colombia) for 15 seconds using a 5 ml syringe and 30 G monojet needle (Ultradent, South Jordan, USA) (Fig 2-H), then dried with a capillary tip (Azdent, Zhengzhou, China) (Fig 2-I) and inspected prior to retro-obturation (Fig 2-J). For this purpose, Bio-C Repair bioceramic cement (Angelus, Londrina, Brazil) was placed using a mini FP3 (Marthe, Bucaramanga, Colombia) (Fig 2-K) and compacted to achieve complete obturation (Fig 2-L).

Finally, guided tissue regeneration was carried out using [1g] Quirubone bone graft with particle size [0.25-0.5 mm] (Cellstech, Itagüí, Colombia) and Quirumatriz membrane [15 x 20 mm] (Cellstech, Itagüí, Colombia) (Fig 2-M and 2-N). The flap was repositioned and sutured with resorbable Vicryl 5/0 (Vicryl Plus, Ethicon, India) (Fig 2-O). Postoperative care included amoxicillin [875mg/12h/5days], meloxicam [7.5mg/12h/3days], and mouth rinses with chlorhexidine [0.2%] (Clorhexol, Farpaq, Cali, Colombia) 10 ml-rinse for 60 s twice-a-day (every 12 h) for 7 days. Radiographic and tomographic assessment at eight months demonstrated ongoing healing of the affected periapical tissues. Furthermore, it was observed that the ultrasonic retropreparation did not follow the original trajectory of the root canal, as a slight deviation towards the distal wall was noted. In addition, the retrograde obturation material remained well positioned throughout the follow-up period, thereby supporting the favourable progression of periapical tissue repair (Fig 3 A-B).

PROTOCOL FOR HISTOPATHOLOGICAL EVALUATION OF PERIAPICAL TISSUE

Excised periapical tissue was immediately fixed in 10% neutral buffered formalin to preserve cellular and tissue architecture; subsequently, following fixation, the specimens were dehydrated through graded alcohols, cleared in xylene, and embedded in paraffin wax. Thereafter, paraffin blocks were sectioned at a thickness of 3-5 µm using a microtome, and the resulting sections were routinely stained with haematoxylin and eosin (H&E) to facilitate the assessment of general morphology, the identification of inflammatory cell infiltrates and granulomatous tissue, as well as the determination of the presence or absence of an epithelial lining.

PROTOCOL FOR SCANNING ELECTRON MICROSCOPY (SEM)

The resected apex and the extruded gutta-percha were dehydrated in increasing ethanol concentrations (10-99.6%) (Freire Mejía, Cuenca, Ecuador). Subsequently, samples were coated with gold-palladium using a Sputter Coater model SC7620 (Quorum Tech, UK) for 180 seconds to achieve a 5-10nm layer, and examined with an EVO 10 microscope (Carl Zeiss, Weimar, Germany) under the following operating conditions: acceleration voltage 20,000 KV, temperature 20°C, and humidity 65% (Fig 4 A-F).

PROTOCOL FOR MICROBIOLOGICAL ANALYSIS

Five samples—root apex, gutta-percha, and three from the lesion were stored in BHI broth and Stuart medium for multi-species microbiological analysis. Cultures were grown on McConkey, blood, and soy agar under aerobic and anaerobic conditions at 37°C in an incubator for 24 hours. Colonies were identified, heat-fixed, and Gram stained for microscopic examination (Fig 5 A-F).

RESULTS FROM HISTOPATHOLOGICAL, MICROBIOLOGICAL, AND SEM ANALYSES

Histopathological Findings

Microscopic examination of the periapical tissue revealed granulomatous inflammation, predominantly composed of lymphocytes, plasma cells, and macrophages, without evidence of epithelial lining.

SEM Findings

SEM analysis identified multiple apical foramina harbouring bacterial colonies, as well as microcracks and areas of external root resorption on the resected apex and extruded gutta-percha.

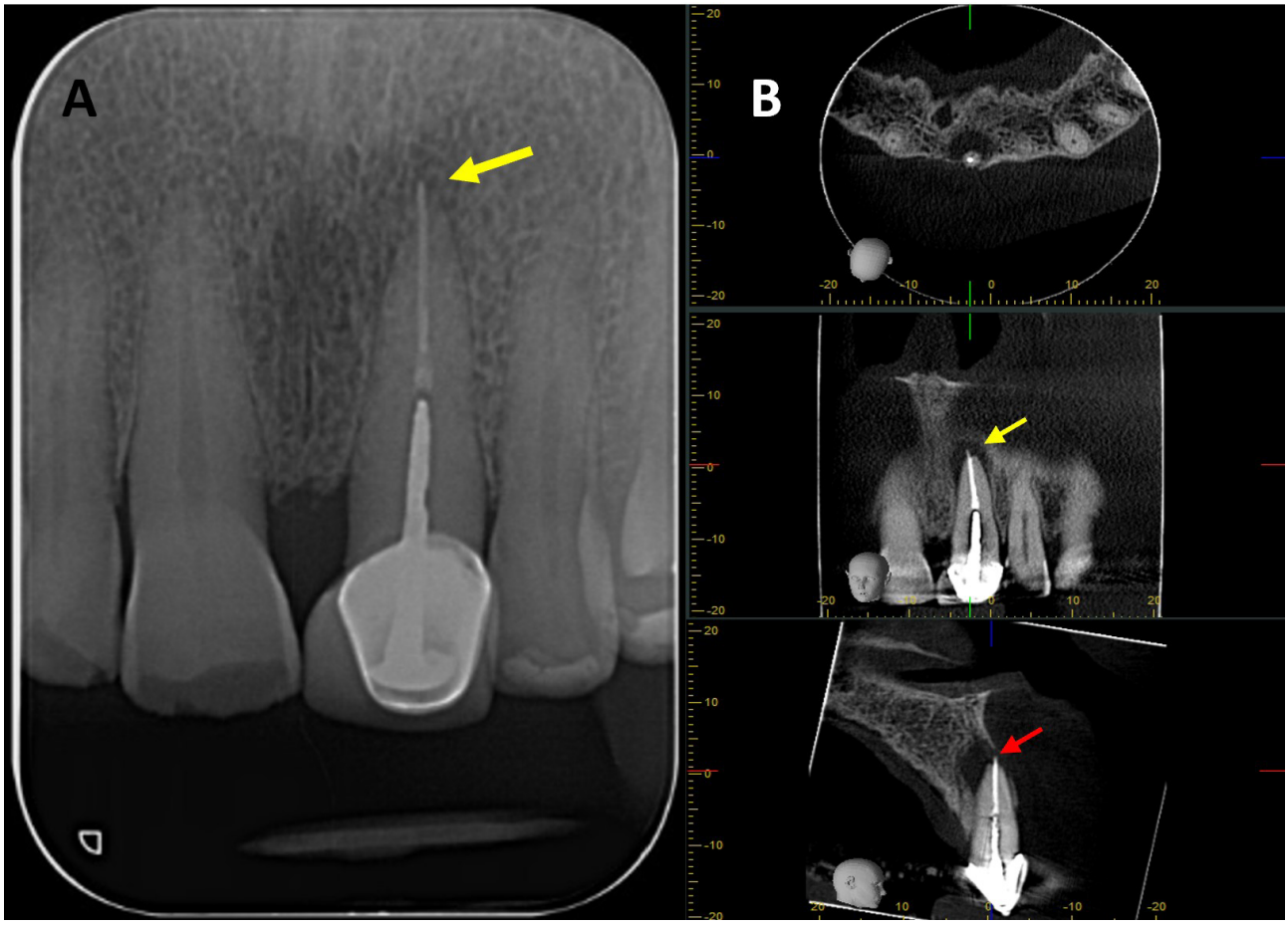

FIGURE 1. (**A**) Preoperative periapical radiograph of tooth #21, which the presence of a periapical radiolucency is not clearly. (**B**) Preoperative CBCT of tooth #21, presented in axial, coronal, and sagittal sections, reveals a hypodense area at the apical region consistent with a periapical lesion. The sagittal section demonstrates vestibular bone fenestration, as indicated by the *red arrow*. The *yellow arrow* denotes the presence of transapical obturation material in both the periapical radiograph and CBCT, as well as the existence of a post and prosthetic crown.

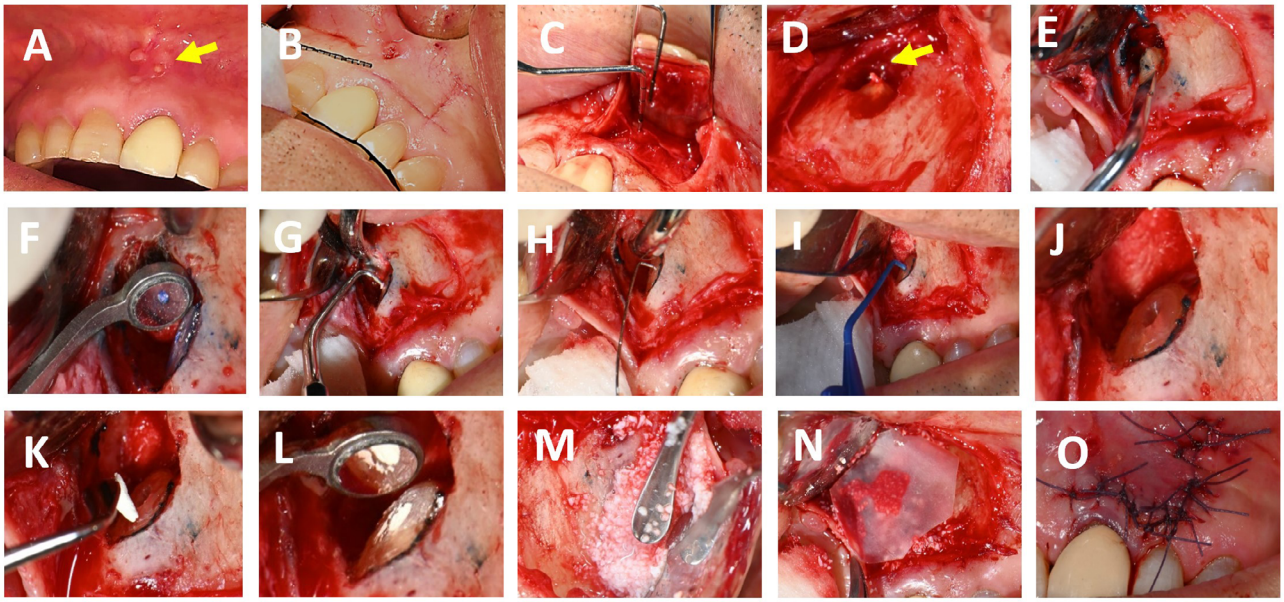

FIGURE 2. (**A**) Tooth #21 presenting with a sinus tract extending towards the upper labial frenum (indicated by the *yellow arrow*). (**B**) Delineation of the flap design on the gingival tissue using a periodontal probe prior to incision. (**C**) Elevation of a full-thickness mucoperiosteal flap; the periodontal probe is positioned over the apical lesion of tooth #21. (**D**) Identification of extruded gutta-percha at the apical region (*yellow arrow*). (**E**) Placement of the piezoelectric surgical unit with a V-BS5 tip to perform apicectomy. (**F**) Inspection of the resected root surface, after staining with methylene blue to enhance visualisation. (**G**) Retrograde cavity preparation using ultrasonic tips. (**H**) Retrograde cavity Irrigation with 2% chlorhexidine. (**I**) Drying of the retrograde cavity using a capillary tip to ensure optimal conditions for obturation. (**J**) Evaluation of the retrograde cavity following irrigation and drying procedures. (**K**) Placement of obturation material (BIO C REPAIR) into the apical cavity using a Mini FP3 instrument. (**L**) Apical cavity retrofilled. (**M**) Application of Quirubone bone graft to the surgical site. (**N**) Adaptation of a Quirumatriz membrane over the grafted area to facilitate guided tissue regeneration. (**O**) Repositioning of the flap and closure with simple interrupted sutures.

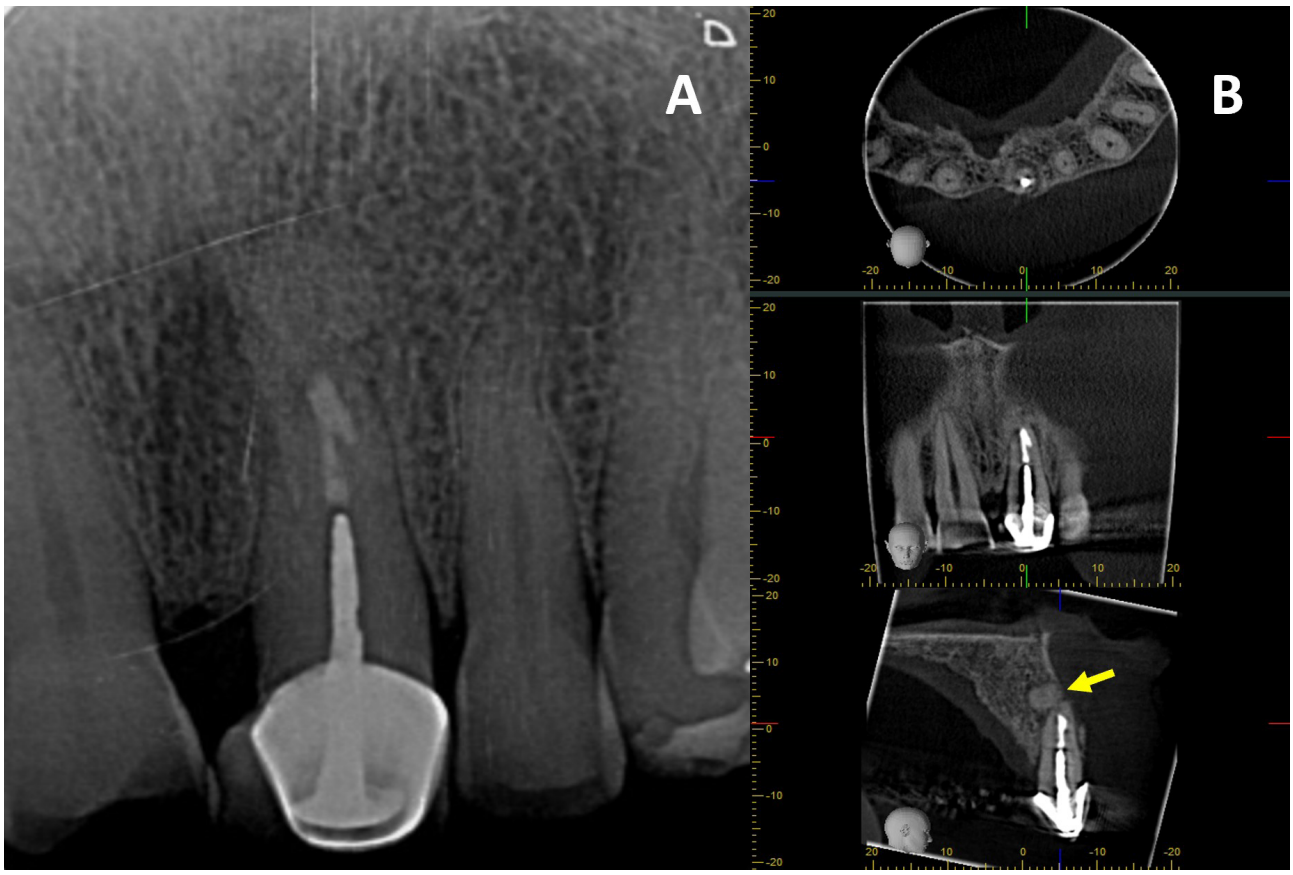

FIGURE 3. Healing findings: (**A**) Periapical radiograph at four months of follow-up; (**B**) Cone-beam computed tomography (CBCT) at eight months of follow-up. The sagittal section reveals a hyperdense image in the apical region, compatible with bone graft material (*yellow arrow*).

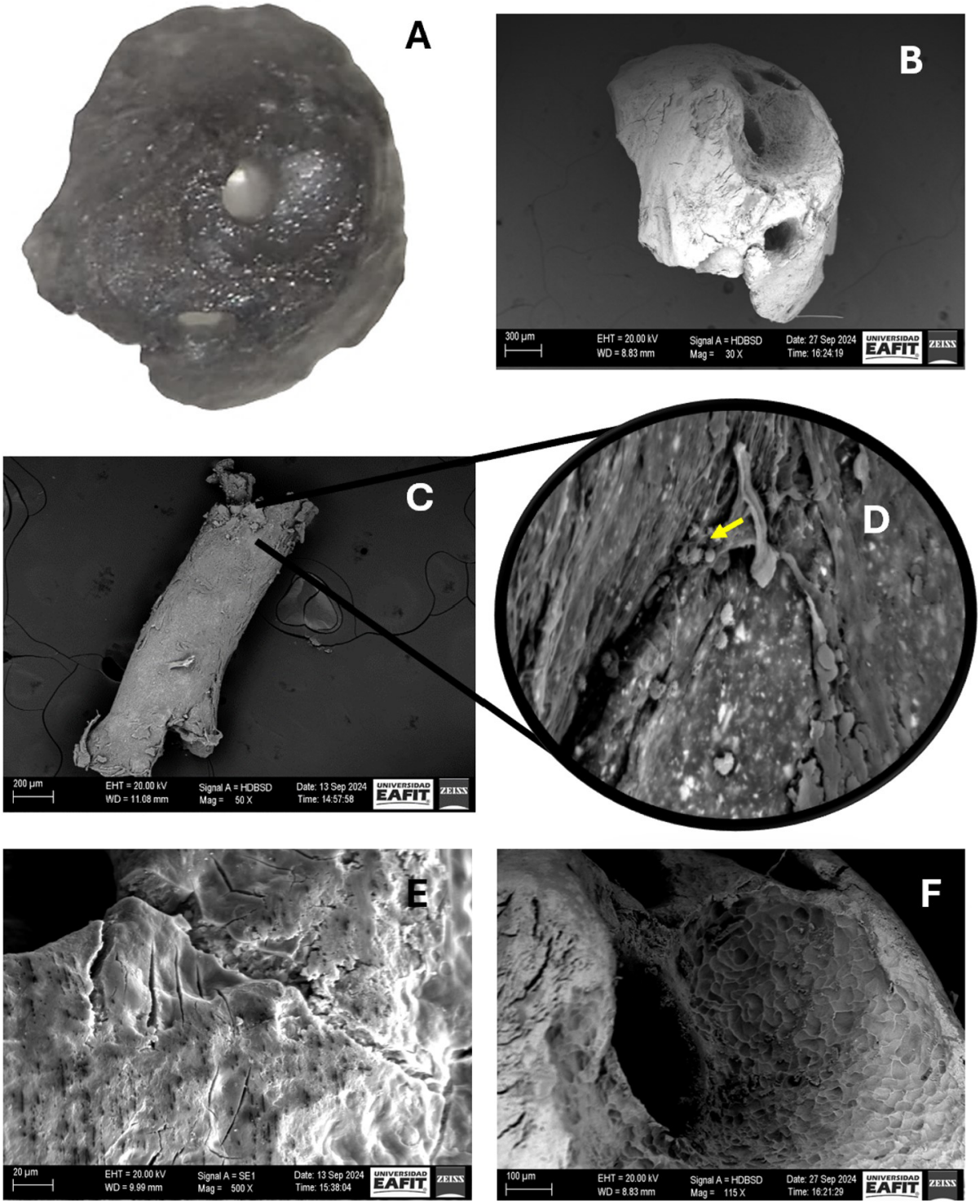

FIGURE 4. Apical fragment visualised by (**A**) surgical microscope at 30x magnification and by (**B**) scanning electron microscopy (SEM) at 30x magnification. (**C**) Transapical gutta-percha visualised at 50x magnification. (**D**) Overview of image **C** at 1000x magnification (*yellow arrow* indicates the presence of coccoid-shaped bacteria). (**E** and **F**) indicate the presence of microfissures and external root resorption in the apical portion, respectively.

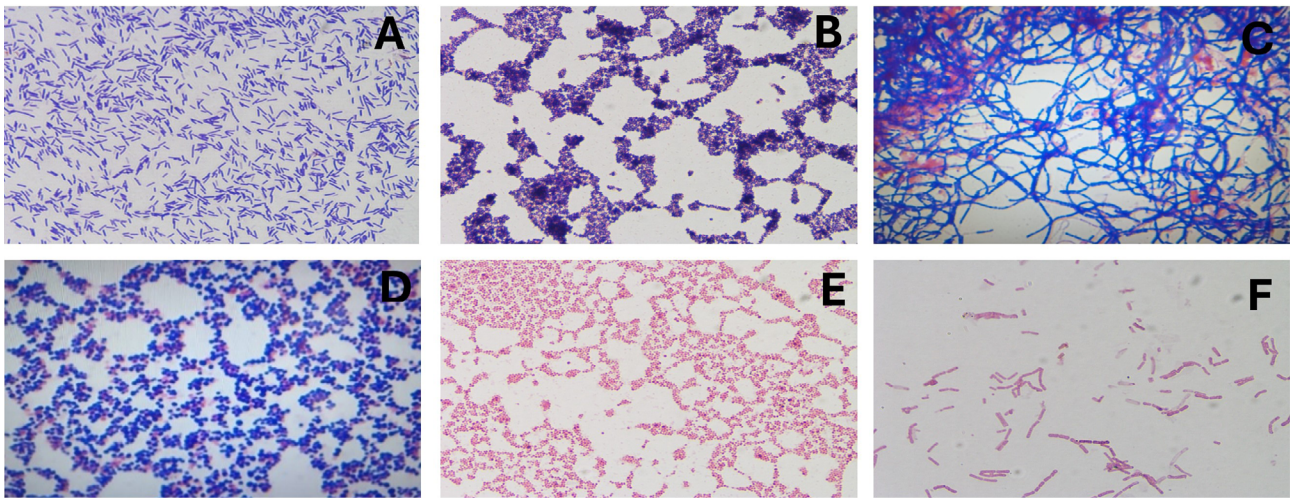

FIGURE 5. Microbiological findings. (**A**) Gram-positive bacilli; (**B**) Gram-positive staphylococci; (**C**) At the root apex, Gram-positive microbiota, streptobacilli, and streptococci were identified; (**D**) In the sample obtained by aspiration of periapical exudate under aerobic conditions, (**E**) Gram-negative staphylococci and (**F**) Gram-negative streptobacilli.

Microbiological Findings

Cultures from the root apex, extruded gutta-percha, and periapical lesion yielded mixed populations of Gram-positive and Gram-negative bacteria, including streptococci and staphylococci, under both aerobic and anaerobic conditions.

DISCUSSION

EMS is a recognised treatment option for teeth with PAP when conventional endodontic treatment or retreatment is not possible [5]. In the present case, EMS was selected over orthograde retreatment due to the presence of a well-adapted prosthetic crown and a long intraradicular post, which would have made post removal technically demanding, time-consuming, and increased the risk of root fracture. By contrast, EMS provided direct access to the apical region, enabling effective debridement while preserving the existing restoration. This decision is supported by evidence reporting success rates for EMS ranging from 85% to 97.6% over follow-up periods of 1.5 to 5 years [9], particularly in cases where orthograde retreatment is impractical. Although the follow-up period in this case was shorter, the absence of clinical symptoms and radiographic findings indicated periapical healing in process, as confirmed by periapical radiographs and CBCT.

CBCT has been recommended for the diagnosis, planning and follow-up in endodontics, due to its three-dimensional imaging, which overcomes the limitations of traditional periapical radiograph (PR) [10, 11]. In this case, CBCT identified a periapical lesion that was not visible on PR and enabled more precise surgical planning. Furthermore, the tomographic follow-up findings suggested ongoing periapical healing. Compared to PR, it may have been mistakenly considered a complete healing, which supports the use of CBCT for longer-term follow-up of this case.

In addition to its superior spatial resolution, CBCT provides volumetric data that allow clinicians to assess the extent and morphology of periapical lesions with greater accuracy. This is particularly valuable in cases where conventional radiographs fail to reveal subtle changes in bone density or lesion progression. The ability to visualise anatomical structures in multiple planes enhances diagnostic confidence and facilitates the identification of complex root canal systems, accessory canals, and bone fenestrations. Moreover, CBCT is instrumental in monitoring the healing process post-operatively, as it can detect early signs of bone regeneration and residual pathology that may not be apparent on two-dimensional images. The literature consistently supports the integration of CBCT into routine endodontic practice, especially for cases requiring detailed assessment and long-term follow-up, thereby improving clinical outcomes and reducing the risk of misdiagnosis [11].

Natural ramifications of the main root canal, including lateral, accessory, and secondary canals, as well as apical deltas, are recognised as significant contributors to PAP. These anatomical complexities are especially prevalent in maxillary central incisors, with reported frequencies ranging from 46% to 62%, predominantly located within the final millimetres of the apical canal [1, 14]. The presence of such intricate canal networks poses a considerable challenge to conventional endodontic therapy, as these regions often harbour microbial communities that are inaccessible to standard instrumentation and irrigation techniques [4, 12, 13]. Consequently, bacteria may persist within these untreated ramifications, leading to ongoing periapical inflammation and failure of root canal treatment.

To address this anatomical challenge, a 3 mm apical resection during EMS is advocated, as it has been demonstrated to effectively remove most apical ramifications and thereby reduce the risk of persistent infection [5]. In the present case, SEM findings confirmed the existence of four apical foramina containing microorganisms that had not been eliminated by the initial endodontic procedure. This observation underscores the importance of recognising and surgically managing complex apical anatomy to achieve successful treatment outcomes. Failure to adequately address these anatomical features may result in continued periapical disease, even when other aspects of the treatment are performed to a high standard.

Preoperative PR and CBCT showed extruded endodontic obturation material. Subsequent SEM analysis identified bacterial colonisation on the gutta-percha. Although gutta-percha is widely regarded as a biocompatible material, insufficient disinfection prior to obturation has been recognised as a prognostic factor that may negatively influence treatment outcomes—a circumstance that appears relevant in this case [4, 11]. Furthermore, Ørstavik's findings demonstrated that the success rate of endodontic treatment is significantly affected by the position of the root canal filling: when obturation ended within 2 mm of the radiographic apex, the success rate reaches 94%, whereas overextension of the filling material beyond the apex reduces the success rate to 76% [15]. These observations underscore the importance of precise obturation and stringent infection control protocols in achieving optimal periapical healing.

Follow-up PR and CBCT confirmed the presence of retrofilling material. Bio-C Repair, a bioceramic cement containing tricalcium silicate, dicalcium silicate, tricalcium aluminate, calcium oxide, silicon oxide, zirconium oxide, polyethylene glycol, and iron oxide, was used. Its bioactivity encourages reparative cell growth and supports periapical healing [16]. Bio-C Repair is highly biocompatible and forms hydroxyapatite when in contact with tissue fluids, promoting osteoinduction and osteoconduction, and facilitating bone regeneration and repair of periapical tissues after endodontic microsurgery. Its ready-to-use presentation and expansion on setting improve adaptation and chemical sealing to dentine, reducing leakage and reinfection risk [16, 17]. Although a slight deviation of retropreparation was observed, this variation is not considered clinically significant as it did not compromise the adaptation or sealing ability of the retrofilling material, nor the biological processes essential for periapical healing [5].

In this case, AP was diagnosed as a periapical granuloma, a common lesion linked to pulpal necrosis and chronic periapical inflammation [4]. Histologically, it consists of granulomatous tissue with fibroblasts, endothelial cells, and mainly inflammatory cells like lymphocytes, plasma cells, macrophages, and sometimes multinucleated giant cells. The absence of epithelial lining allows differentiation from periapical cysts, which is important for therapeutic management [18]. Clinically, periapical granulomas are usually asymptomatic early on, but may cause mild pain, percussion tenderness, or a sinus tract if inflammation is exacerbated. Radiographically, they appear as poorly defined radiolucent lesions at the tooth apex and may show bone resorption [5]. The reported prevalence of periapical granuloma varies greatly, from 9.3% to 87.1% of periapical lesions, depending on the population and diagnostic criteria. Multicenter studies confirm that most chronic periapical lesions are granulomas, followed by cysts and abscesses [4, 18]. Treatment involves removing the infection through conventional endodontics or EMS, allowing periapical tissue repair. Success relies on thorough canal disinfection and filling with biocompatible materials. Ongoing clinical and radiographic reviews are essential to confirm healing and detect recurrence [5, 18].

SEM images showed microcracks within the apical region, most plausibly attributable to mechanical stresses induced during canal instrumentation or to artefacts arising from sample dehydration during specimen processing [19, 20]. The identification of these microstructural defects, together with evidence of external root resorption, is of considerable clinical significance. Such alterations in the root surface architecture may facilitate the ingress of pathogenic microorganisms into the periapical tissues, thereby compromising the healing process, prolonging inflammation, and substantially increasing the likelihood of endodontic treatment failure. Accordingly, the meticulous execution of operative procedures, combined with a rigorous correlation of SEM findings with clinical and radiographic assessments, is imperative to ensure precise diagnosis and optimal management of PAP [21, 22].

Microbiological analysis of persistent apical periodontitis showed a range of bacteria, mainly Gram-positive and Gram-negative types, especially streptococci and facultative anaerobes. *Enterococcus faecalis* has been identified as one of the principal agents in persistent cases, owing to its ability to survive in nutritionally adverse environments and to form resistant biofilms. The formation of bacterial biofilms, both intra- and extraradicular, complicates the complete elimination of microorganisms by conventional treatments and significantly contributes to endodontic failure and lesion recurrence [4, 23, 24]. Although only bacterial genera were identified in this case, the findings match existing literature, highlighting the need for advanced therapies and proper microbiological monitoring to improve outc omes.

CONCLUSION

The identification of bacterial colonization within uninstrumented apical canal ramifications, as well as the presence of adherent extruded gutta-percha, clarifies the pathogenesis underlying the initial endodontic failure. These observations underscore the clinical significance of recognising apical ramifications as potential reservoirs for persistent infection, highlight the importance of meticulous control over material extrusion during treatment, and emphasise the value of multimodal analysis in complex diagnostic scenarios. Collectively, these findings reinforce the relevance of EMS in managing anatomically challenging or refractory cases of apical periodontitis, particularly when conventional orthograde retreatment is contraindicated or impracticable due to intracanal posts or fixed prosthodontic restorations.

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Conflict of Interest Statement

The authors deny any conflicts of interest. The authors alone are responsible for the content and writing of the article.

Informed Consent

Informed consent was obtained from the patient.

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