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#1 in Endodontic Microsurgery

JOURNAL *of* ENDODONTIC MICROSURGERY

Image courtesy Dr. Castillo

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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.

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UDC 616.314-089.81(051)
Journal

About the Journal: Aims and Scope

VOLUME 3 • DECEMBER 31 • 2024
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Official Title

Journal of Endodontic Microsurgery

Acronym

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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.

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The journal has full-time professional editor and publisher.
Gender distribution of the editors: 20% women, 80% 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.

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.

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The APC for the **short case report** (3-4 pages article) published in the Journal of Endodontic Microsurgery is $500 USD, excluding taxes:

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

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Types of Articles Published by the Journal

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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.

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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.

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

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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.

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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.

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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.

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

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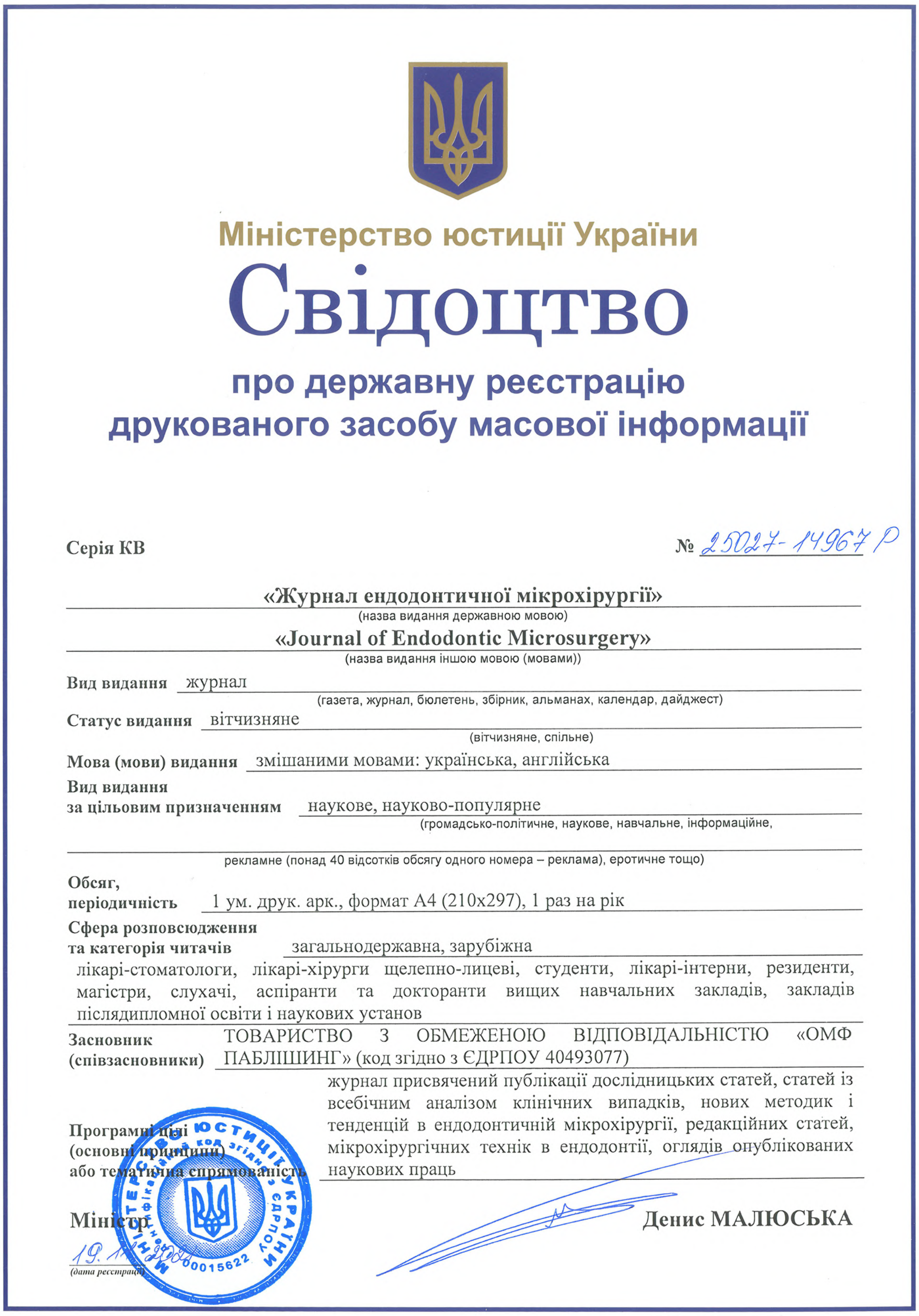

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Вид видання журнал
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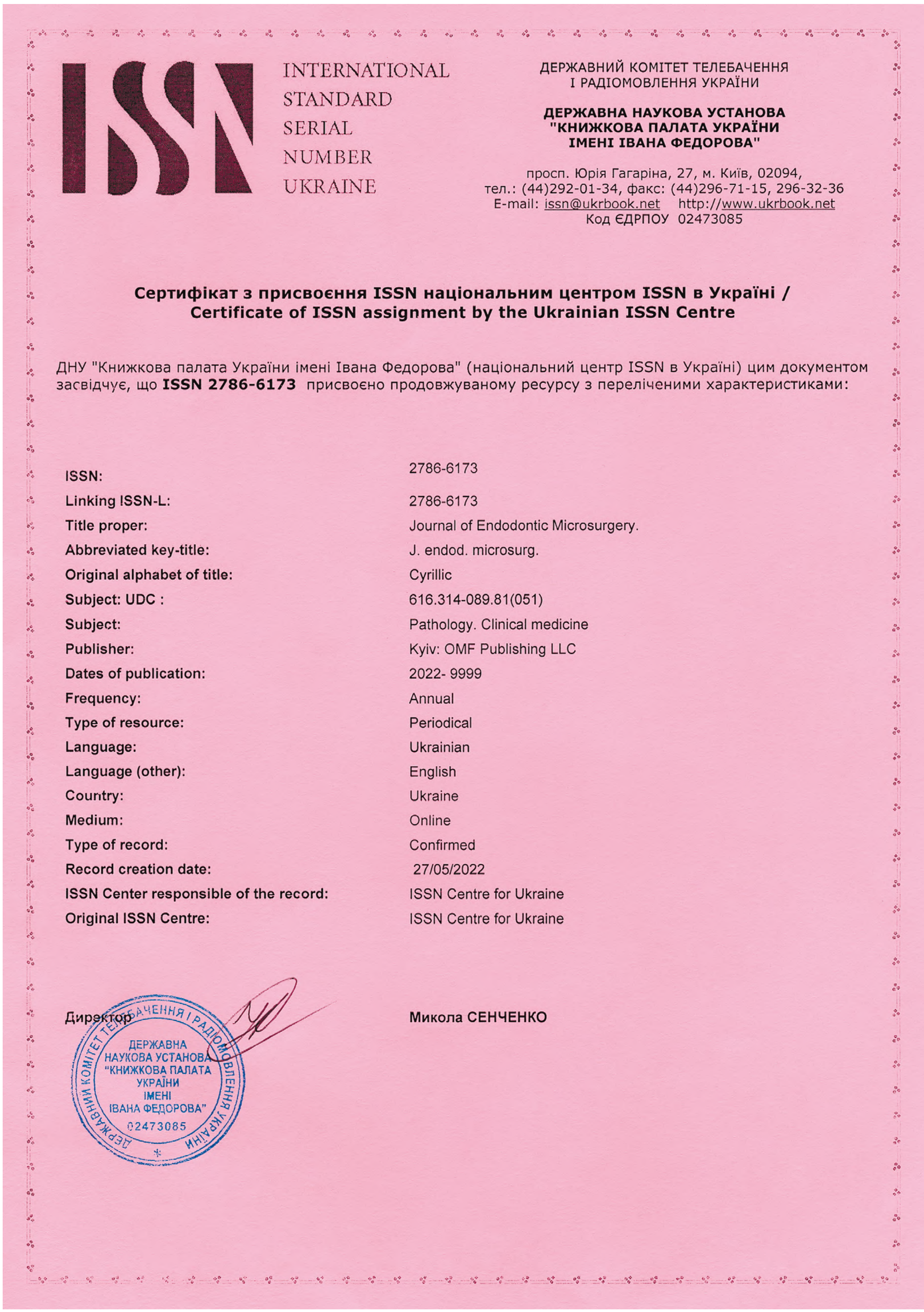

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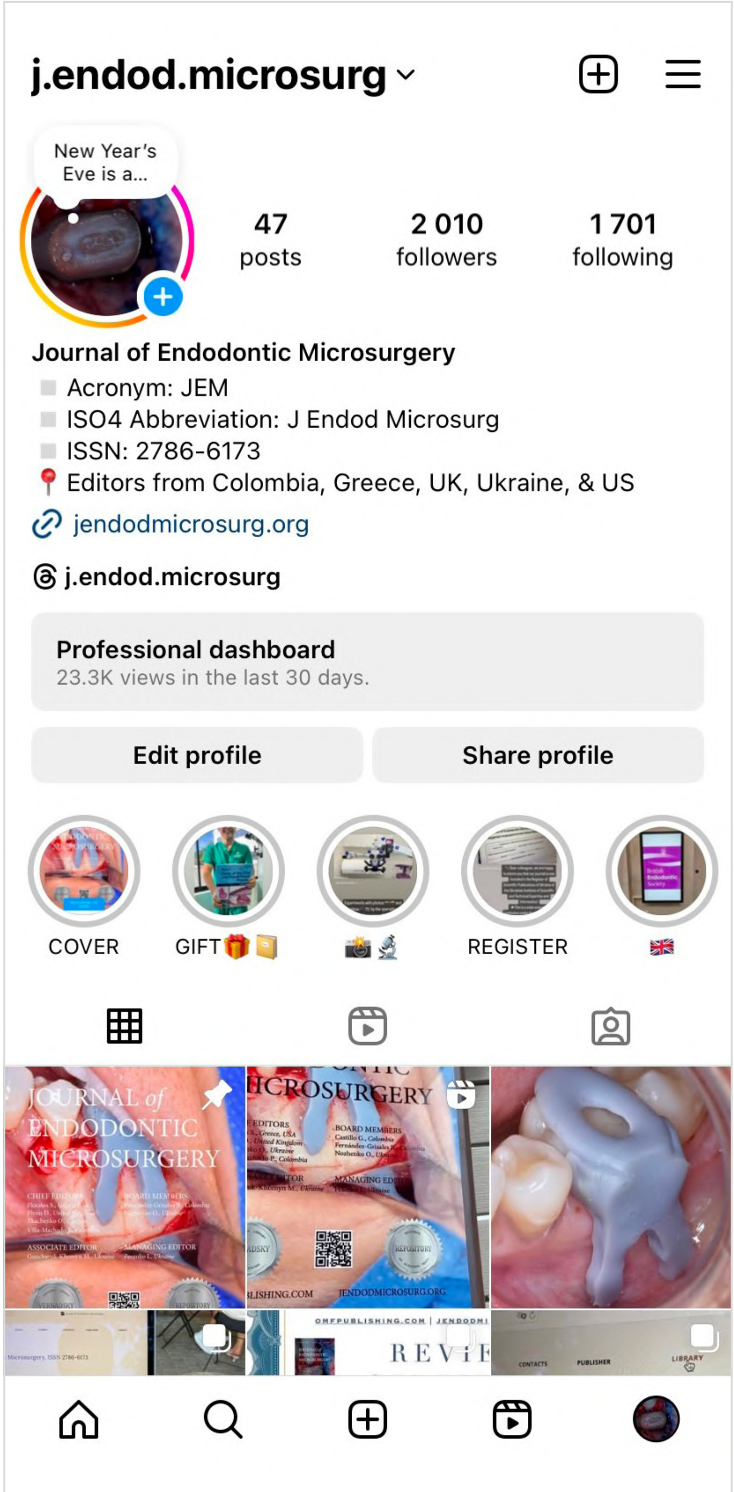

FIGURE. Journal's official Instagram page (@j.endod.microsurg).

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CASE REPORT/TECHNIQUE

GUIDE | WINDOW

Proposal for an Anatomic Guide in Cortical Bone Window Technique for Endodontic Microsurgery: A Case Report

Gustavo A. Castillo[a,*], Silvia A. Restrepo-Méndez[b], Martin F. Gustin[c], & Ingrid X. Zamora[d]

ABSTRACT

This case report describes a novel design for an anatomical guide used in endodontic microsurgery (EM) with the cortical bone window technique. A 60-year-old female patient presented with persistent pain and a radiographic periapical lesion associated with tooth #36 (i.e., lower left first molar). Following a diagnosis of symptomatic apical periodontitis, a treatment plan involving guided EM with static navigation was implemented. Cone-beam computed tomography (CBCT) data was segmented to create a stereolithographic (STL) file of the tooth. This file was aligned and 3D-printed with a biocompatible resin to create a customized anatomical guide. The guide facilitated a precise osteotomy, accurate apex localization, and conservative flap management during surgery. The surgical procedure was completed successfully, with minimal complications. Follow-up CBCT one month later demonstrated excellent adaptation of the bone fragment and apical seal. Using 3D imaging and a customized anatomical guide in EM demonstrates promising outcomes for treating complex cases. The proposed design offers advantages by eliminating the need for guide tubes and facilitating conservative flap management. Further clinical studies are recommended to validate the long-term efficacy of this technique.

KEY WORDS

Bone window; cone-beam computed tomography; endodontic microsurgery; osteotomy; piezoelectric surgery

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The word "Guide" in the upper right icon means that the article contains a description of endodontic microsurgery using an anatomical surgical guide.

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INTRODUCTION

Endodontic microsurgery (EM) is a surgical procedure to treat persistent periapical disease. This involves removing infected and affected tissue surrounding the root tip (periapical area) when previous non-surgical root canal treatment (endodontic therapy) or retreatment has failed [1]. The success rate of EM is currently around 94%. This high success rate can be attributed to various factors, such as the use of cone-beam computed tomography (CBCT), the operative microscope, the preparation of the root-end cavities with the ultrasonic devices, and the development of more biocompatible root-end filling materials, among other advancements [2]. However, this success rate can be reduced for several reasons, including the tooth's position in the mouth [3]. This is why lower molars can have lower success rates compared to teeth in other positions [4]. This is attributed to the difficulty of locating the root apices due to the thickness of the cortical bonhge of the vestibular wall and impediments in access by different anatomical structures, including the inferior alveolar nerve or the mental foramen [4].

For this reason, using three-dimensional (3D) computer-aided design/computer-aided manufacturing (CAD/CAM) guides has recently become common, optimizing the size of osteotomies, and minimizing the possibility of deviation according to the digitally established surgical planning [5, 6]. These guides, despite demonstrating great advantages, have some limitations. Antal et al. (2019) reported the difficulty in taking impressions and scanning in shallow vestibules, the positioning of the guide, and access of instruments due to the size of the mouth of some patients and the impossibility in some cases of performing apical cuts without angulation, situations that can affect the prognosis of the surgery [7].

In this case report, we present a design of an anatomical guide for endodontic microsurgery by use of the cortical bone window technique in a very precise way from the patient's tomography, digital segmentation, and 3D printing.

CASE REPORT

A 60-year-old female patient with no significant medical history was referred for evaluation and treatment of tooth #36 (i.e., lower left first molar) due to a history of pain when chewing. Dental history included endodontic treatment and retreatment performed approximately 6 months ago and persistent periapical lesion. On clinical examination, revealed an adapted occlusal restoration, ≤2 mm of periodontal probing, and painful on vertical percussion. Radiographically, previous endodontic treatment is observed, the mesiobuccal canal is underfilled with apparent transportation in the apical third of the root. A hypodense area in the mesial root is also observed and the buccal cortical bone is intact (Fig 1). Based on the above findings, a diagnosis of previous endodontic treatment and symptomatic apical periodontitis was established. The treatment plan involved guided EM with static navigation, which the patient accepted through informed consent.

FIGURE 1. Preoperative cone-beam computed tomography of the tooth #36 (i.e., lower left first molar): (**A**) sagittal, (**B**) coronal, and (**C**) axial planes. The *yellow arrow* shows the periapical lesion, and the *red arrow* shows the mesiobuccal canal is underfilled with apparent transportation in the apical third. An intact thickness of vestibular cortical bone is present.

The Digital Imaging and Communications in Medicine (DICOM) files of CBCT (Myray Hyperion X9 Tomograph, Imola, Italy) voxel size 75 µm, field of view 60x40mm- were imported into the Mimics software (Materialise NV, Leuven, Belgium) and then the segmentation for the tooth #36 was performed. The stereolithography (STL) file of the tooth was aligned and projected toward the buccal cortical bone plate. Subsequently, a Boolean was added to the occlusal anatomy of the tooth to reproduce the digital position at the time of surgery. This stereolithographic file was printed on a 3D Creality printer (HALOT-MAGE, Shenzhen, China) with a biocompatible resin, Die, and Model 2 from SprintRay (Los Angeles, California, USA) (Fig 2).

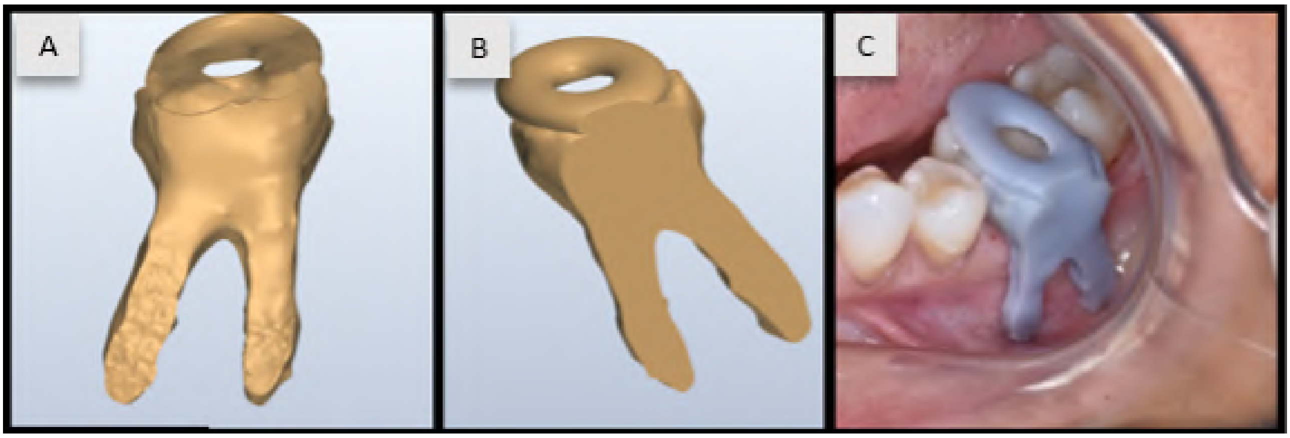

FIGURE 2. (**A**, **B**) Tomographic and clinical sequence (**C**) of the design and performance of the modified "cortical bone window" technique on tooth #36.

Before the procedure (Fig 3), the patient rinsed with 0.12% chlorhexidine (Clorhexol, Farpag S.A.S., Bogotá, Colombia) for 1 minute. For local anesthesia, 3 cartridges of 2% lidocaine with 1:80,000 epinephrine (New Stetic S.A., Guarne, Colombia) were used: 2 cartridges for inferior alveolar nerve block and 1 cartridge to anesthetize the mental nerve. A rectangular full thickness intrasulcular flap was raised from the mesial aspect of tooth #35 to the distal aspect of tooth #37. After raising the flap, the adaptation of the guide was checked, and the patient was asked to bite on a gauze to secure the printed device (Fig 3B). Next, with the aid of magnification (operative microscope Zumax OMS 2350, Zumax Medical Co., Ltd., Suzhou New District, China), the US3 tip (Ultrasurgic touch, Woodpecker Medical Instrument Co. LTD, Guilin, Guangxi, China) of the Surgic Touch piezoelectric system (Woodpecker Ultrasurgic Touch unit, Guilin Woodpecker Medical Instrument Co. LTD, Guilin, Guangxi, China) was used (Fig 3C, D) to create a 5mm x 3mm surgical bone window using the apex of the anatomical guide as a reference. After lightly marking the outline, the printed device was removed, and the cortical bone was completely cut by applying more pressure to the bone under ample abundant irrigation with saline solution and 7 high-power settings. The bone fragment was removed and placed in a saline solution until the end of the surgical procedure.

The exposed root was examined (Fig 3E), and the accuracy of the guide was verified. An apicoectomy (3 mm) was performed using the same tip, and the apex was removed along with the lesion. The cavity was irrigated with saline solution, and hemostasis was achieved with sterile cotton pellets soaked with adrenaline 1mg/ml solution injectable (B.Braun Surgical, Medellín, Colombia) placed at the bottom of the osteotomy. The root-end preparation was carried out with EM ultrasonic diamond tip a tip (E30LD, NSK/Nakanishi Inc, Tochini, Japan) after a detailed observation with methylene blue and magnification (Fig 3F).

Retrograde obturation was performed with Bio-C Repair bioceramic reparative material (Angelus Indústria de Produtos Odontológicos S/A, Londrina, Brazil). After inspecting the seal, CollaTape® collagen wound dressing (Zimplant & CIA S.A.S, Bogotá, Colombia) was placed in the bone crypt, and the cortical window was repositioned (Fig 3G). The same collagen wound dressing was used to stabilize the bone fragment before repositioning the flap. Figure 4 demonstrate sequence of the surgical steps. Suturing was done with Dafilon 5-0 monofilament suture (B. Braun Surgical S.A., Rubi, Spain). Written recommendations were given to the patient, and she was prescribed Amoxil (GlaxoSmithKline [GSK], London, England) capsules 500 mg #15 every 8 hours and Anexia (Tecnoquímicas S.A., Cali, Colombia) tablets 120mg #5 daily. The patient returned after 7 days for suture removal without any postoperative complications. A CBCT was performed one month later, which showed excellent adaptation of the bone fragment and apical seal (Fig 5).

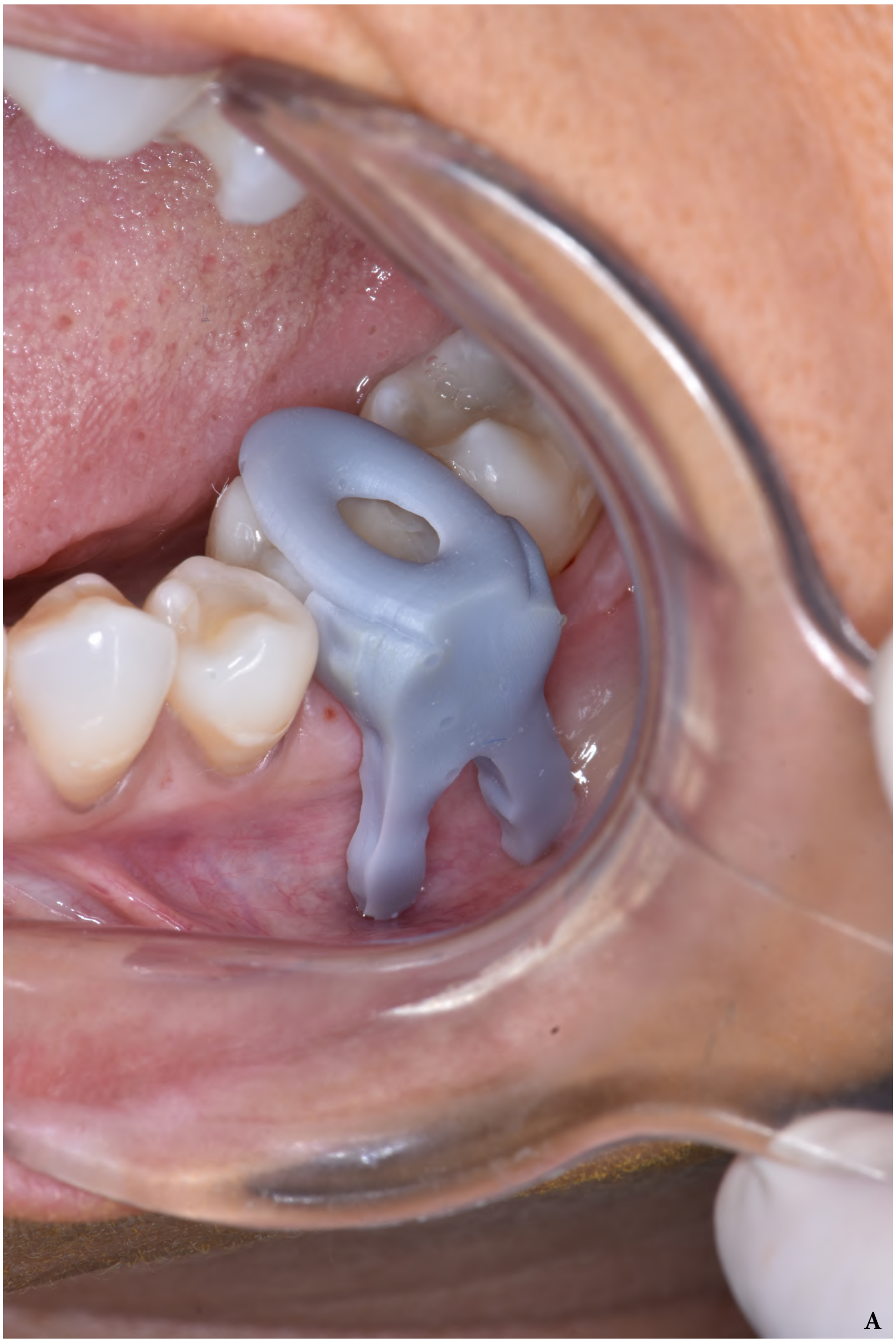

FIGURE 3. Clinical sequence of the anatomic guide in cortical bone window technique on tooth #36. (**A**) Pre- and (**B**) intraoperative positioning of the guide. (**C**, **D**) Piezoelectric cutting with the surgical guide in position. (**E**) the exposed root was examined, and apicectomy (3 mm) was performed using the same tip, (**F**) retrograde obturation was performed with BioC repair cement (Angelus, Londrina, Brazil). (**G**) CollaTape® collagen membrane (Zimplant, Bogotá, Colombia) was placed in the cavity, and the cortical bone fragment was repositioned. **(Fig 3 continued on next page.)**

FIGURE 3 (continued). Clinical sequence of the anatomic guide in cortical bone window technique on tooth #36. (**A**) Pre- and (**B**) intraoperative positioning of the guide. (**C**, **D**) Piezoelectric cutting with the surgical guide in position. (**E**) the exposed root was examined, and apicectomy (3 mm) was performed using the same tip, (**F**) retrograde obturation was performed with BioC repair cement (Angelus, Londrina, Brazil). (**G**) CollaTape® collagen membrane (Zimplant, Bogotá, Colombia) was placed in the cavity, and the cortical bone fragment was repositioned. **(Fig 3 continued on next page.)**

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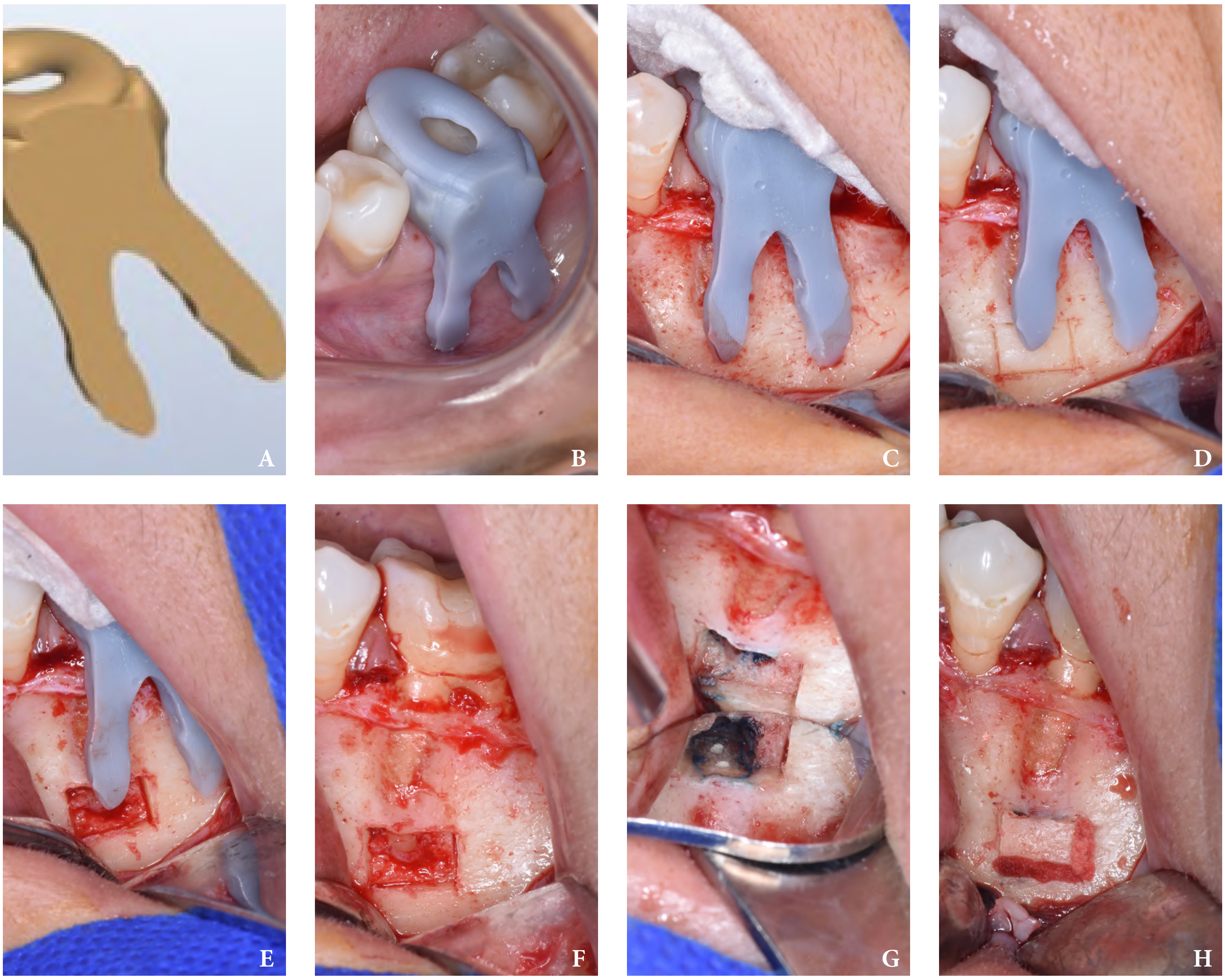

FIGURE 4. (**A**) Virtual planning and (**B–H**) clinical sequence of the anatomic guide in cortical bone window technique on tooth #36. (**B**) Pre- and (**C**) intraoperative positioning of the guide. (**D**, **E**) Piezoelectric cutting with the surgical guide in position. (**F**) the exposed root was examined, and apicectomy (3 mm) was performed using the same tip, (**G**) retrograde obturation was performed with BioC repair cement (Angelus, Londrina, Brazil). (**H**) CollaTape® collagen membrane (Zimplant, Bogotá, Colombia) was placed in the cavity, and the cortical bone fragment was repositioned.

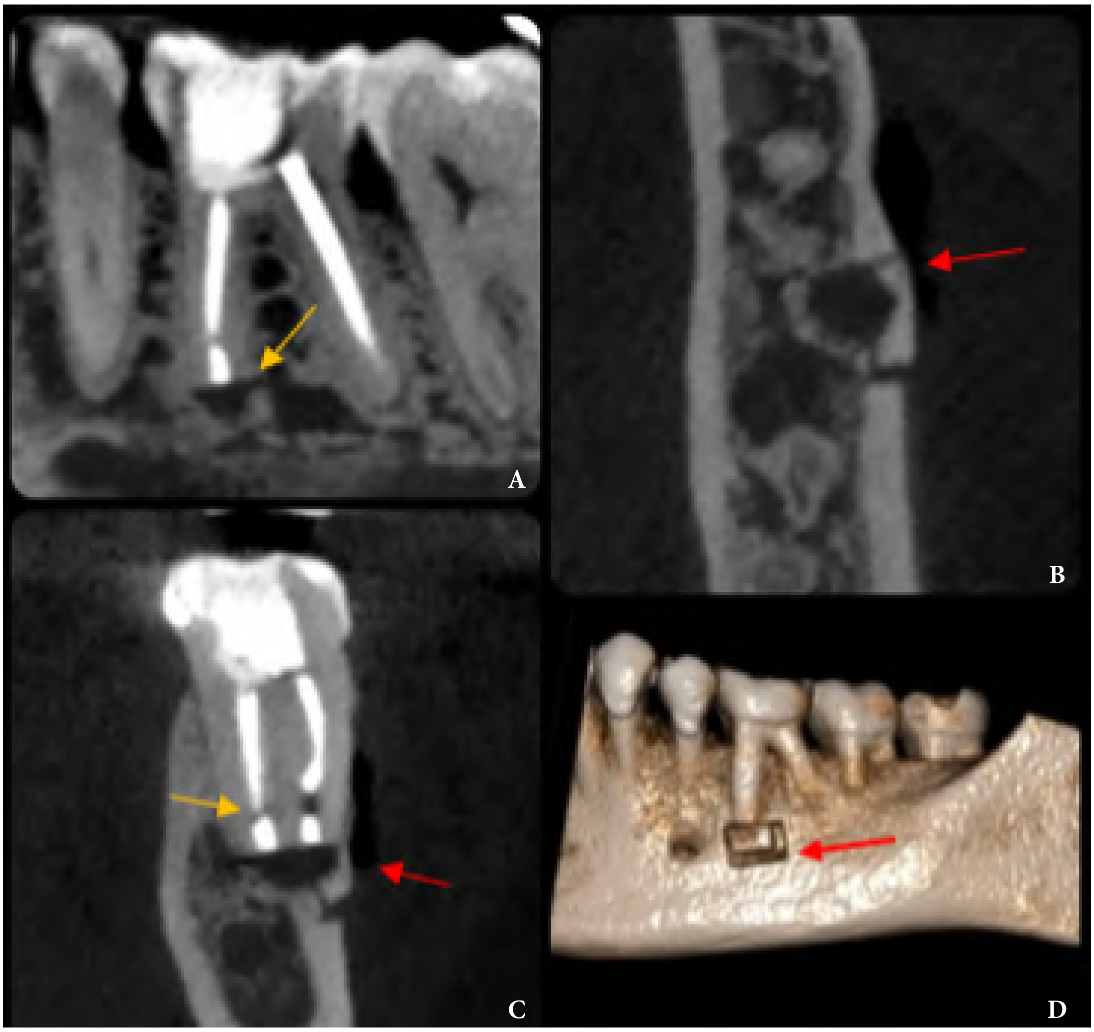

FIGURE 5. Postoperative (one month after the EM) CBCT of tooth #36: (**A**) Sagittal plane, (**B**) axial plane, (**C**) coronal plane of mesial root), and (**D**) volumetric reconstruction. The *yellow* and *red arrows* show the excellent adaptation of the bone fragment and apical seal.

DISCUSSION

The current trend for resolving complex cases in endodontic clinical practice is based on the use of 3D images for the visualization of anatomical structures, diagnosis, and precise planning of surgical treatments, such as the specific case of designing guides for complex procedures, whose characteristics potentially allow reducing the surgical intervention time and postoperative complications [8, 9].

The use of these surgical guides with the management of piezo-surgery allows for precise osteotomy with immediate apex location, improving visibility, and reducing bleeding, since they provide a precise and safe approach through the selective cutting of mineralized tissues such as bone and the preservation of soft tissues such as blood vessels, nerves, and mucous membranes. Improving postoperative effects during the healing time for the patient [6, 10-14].

Multiple designs and different software for the manufacturing of guides have been widely documented [15, 16]. In the technique presented, a compact and personalized design is involved, without the help of guide tubes that allows obtaining the outline of the tooth to be treated, superimposed on itself and soft tissues or the same underlying intact bone, facilitating the lifting of a conservative flap and without the need to perform an aggressive retraction of the mouth, also achieving the precise location of the root apex.

Considering the limitations of this technical report, the result of the guided surgical approach presented above is promising; it makes it possible to perform a guided osteotomy, apex location, and resection of the root apex according to digital planning, of course, considering and respecting the recommended guidelines for contemporary endodontic surgical procedures. To confirm the reliability of this method in the future, it is recommended to carry out clinical studies to test and confirm its viability and precision.

CONCLUSION

The utilization of 3D imaging and customized anatomical guides in EM presented in this case report demonstrates promising outcomes for treating complex cases. The guided approach facilitated precise osteotomy, accurate apex localization, and conservative flap management, potentially reducing surgical time and postoperative complications. Further clinical studies are recommended to validate the reliability and efficacy of this technique across a larger patient population.

AUTHOR CONTRIBUTIONS

Conceptualization: Gustavo A. Castillo, Martin F. Gustin Data acquisition: Gustavo A. Castillo, Silvia A. Restrepo Mendez, Martin F. Gustin, Ingrid X. Zamora Data analysis or interpretation: Gustavo A. Castillo, Silvia A. Restrepo Mendez, Martin F. Gustin, Ingrid X. Zamora Drafting of the manuscript: Gustavo A. Castillo Silvia A. Restrepo Mendez, Martin F. Gustin, Ingrid X. Zamora Critical revision of the manuscript: Gustavo A. Castillo, Ingrid X. Zamora. Approval of the final version of the manuscript: all authors.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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ЗВІТ ПРО ВИПАДОК/МЕТОДИКА

UKRAINIAN LANGUAGE

Пропозиція щодо анатомічного шаблону при ендодонтичній мікрохірургії для методики кортикального кісткового вікна: звіт про випадок

Густаво Кастільо[a,*], Сільвія Рестрепо-Мендес[b], Мартін Густін[c] та Інгрід Самора[d]

АНОТАЦІЯ

У цьому звіті про випадок описано нову конструкцію анатомічної направляючої, яка використовується в ендодонтичній мікрохірургії (ЕМ) з технікою кортикального вікна кістки. 60-річна пацієнтка звернувся з постійним болем і рентгенологічним періапікальним ураженням, пов'язаним із зубом 36 (тобто нижнім лівим першим моляром). Після встановлення діагнозу симптоматичного апікального періодонтиту було впроваджено план лікування, що включає керовану ЕМ зі статичною навігацією. Дані конусно-променевої комп'ютерної томографії (КПКТ) були сегментовані для створення стереолітографічного (STL, абревіатура англомовного терміну "stereolithography") файлу зуба. Цей файл було вирівняно та надруковано на 3D-принтері за допомогою біосумісної смоли, щоб створити індивідуальний анатомічний шаблон. Шаблон полегшив точну остеотомію, точну локалізацію верхівки та консервативне управління клаптем під час операції. Оперативне втручання пройшло успішно, з мінімальними ускладненнями. Контрольна КПКТ через місяць продемонструвала чудову адаптацію кісткового фрагмента та апікального ущільнення. Використання 3D-зображень і індивідуального анатомічного шаблону в ЕМ демонструє багатообіцяючі результати для лікування складних випадків. Запропонована конструкція

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Слово «Шаблон» у верхньому правому значку означає, що стаття містить опис ендодонтичної мікрохірургії з використанням анатомічного хірургічного шаблону.

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має переваги, оскільки усуває потребу у направляючих трубках і полегшує консервативне управління клаптем. Рекомендуються подальші клінічні дослідження для підтвердження довгострокової ефективності цієї методики.

КЛЮЧОВІ СЛОВА

Кісткове вікно; конусно-променева комп'ютерна томографія; ендодонтична мікрохірургія; остеотомія; п'єзоелектрична хірургія

CASO CLÍNICO/TÉCNICA

SPANISH LANGUAGE

Propuesta de una guía anatómica en la técnica de ventana ósea cortical para microcirugía endodóncica: reporte de un caso

Gustavo A. Castillo[a,*], Silvia A. Restrepo-Méndez[b], Martin F. Gustin[c] y Ingrid X. Zamora[d]

RESUMEN

Este informe de caso describe un diseño novedoso para una guía anatómica utilizada en microcirugía endodóncica (ME) con la técnica de ventana de hueso cortical. Una paciente de 60 años presentó dolor persistente y una lesión periapical radiográfica asociada con el diente 36 (es decir, el primer molar inferior izquierdo). Luego de un diagnóstico de periodontitis apical sintomática, se implementó un plan de tratamiento que incluía ME guiada con navegación estática. Los datos de la tomografía computarizada de haz cónico (TCHC) se segmentaron para crear un archivo estereolitográfico (STL, abreviatura del término inglés "stereolitography") del diente. Este archivo se alineó e imprimió en 3D con una resina biocompatible para crear una guía anatómica personalizada. La guía facilitó una osteotomía precisa, una localización precisa del ápice y un manejo conservador del colgajo durante la cirugía. El procedimiento quirúrgico se completó con éxito, con complicaciones mínimas. La TCHC de seguimiento un mes después demostró una excelente adaptación del fragmento óseo y el sellado apical. El uso de imágenes en 3D y una guía anatómica personalizada en ME demuestra resultados prometedores para el tratamiento de casos complejos. El diseño propuesto ofrece ventajas al eliminar la necesidad de tubos guía y facilitar el manejo conservador del colgajo. Se recomiendan estudios clínicos adicionales para validar la eficacia a largo plazo de esta técnica.

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La palabra "Guía" en el icono superior derecho significa que el artículo contiene una descripción de la microcirugía endodóntica utilizando una guía quirúrgica anatómica.

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CASE REPORT/TECHNIQUE GTR

Microsurgical Treatment of a Large Through-and-Through Periapical Lesion with Apicomarginal Defect using Guided Tissue Regeneration (GTR): A Case Report of a Four-Year Follow-Up

Witold Popowicz [a,*] & Oleksandr Tkachenko[b]

ABSTRACT

In case of a long-term periapical lesion, destruction of both vestibular and oral cortical plates is sometimes observed and even a through-and-through periapical lesion occurs. The success of the treatment decreases when an apicomarginal defect is added to the through-and-through periapical lesion. Large periapical lesions should be treated initially by orthograde root canal therapy. When the signs and symptoms of the infection don't recede after the treatment, then surgical approaches should be considered. In this case report, a 22-year-old female with previously initiated therapy was referred for an endodontic microsurgery of tooth 22 (i.e., upper left lateral incisor). After the endodontic treatment the patient was referred to the oral surgeon for apicoectomy with augmentation of the bone defect. The sinus tract in the apex area of the tooth 22 remained active since the surgical intervention. Endodontic microsurgery and guided tissue regeneration were performed. The article presents diagnostic data, namely pre- and post-operative images of cone beam computed tomography (after 2 and 4 years), as well as pre-, intra- and post-operative clinical images. All pre- and intraoperative procedures and stages are detailed. In particular, separation of platelet-rich fibrin (PRF) from venous blood, retrograde

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The acronym 'GTR' at the upper right icon means that article contains a description of the technique of guided tissue regeneration (GTR) during endodontic microsurgery.

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preparation with an ultrasonic tip and a device using a dental operating microscope and the use of a collagen membrane. After two- and four-year follow-up, radiographic examination revealed significant bone healing, and clinical signs and symptoms were absent. The patient hasn't reported any symptoms since. The paper also analyzes scientific sources on the use of PRF and collagen membranes in bone defects of the jaws. Attention is also paid to the formation of a flap during operations of this type. The main six success factors in the treatment of such complex cases are highlighted. Rethinking the previously performed surgery (apicoectomy) in this patient, attention was paid to the main five factors that could contribute to the failure.

KEY WORDS

Through-and-through periapical lesion, apicomarginal defect, sinus tract, endodontic microsurgery, guided tissue regeneration (GTR)

INTRODUCTION

The main cause of unsuccessful periapical healing after primary endodontic therapy or retreatment is the persistence of bacteria and infected tissue in the endodontic space [1]. The anterior region of the maxilla (especially lateral incisors) is the most common involved area [2]. In instances where nonsurgical retreatment cannot solve the problem a significant number of persistent nonhealing cases can be saved by endodontic microsurgery with a predictably favorable prognosis [3]. According to meta-analysis of the literature the success rate for traditional root-end surgery is 59% and for endodontic microsurgery 94% respectively [4, 5]. By removing the diseased tissue, debriding the canal system, and sealing the defect or cavity, the surgeon prevents or reduces the spread of microorganisms within the periradicular tissues.

Regeneration of periapical defects may have a significant problem in periradicular surgery. In such circumstances, the gingival connective tissue can proliferate, or the oral epithelium can migrate into the defect, preventing the development of normal trabecular bone. Hard tissue can be restored using guided tissue regeneration (GTR) [6].

An apicomarginal defect is a mix of two communicating bone defects: a periapical bone defect plus a total root dehiscence [7]. These defects are associated with relatively lower success rates after endodontic surgery [8, 9]. It has been reported [10, 11] that, when the apex of the root is totally surrounded by bone, the success rate is higher than when there is a lack of one cortical bone plate (it decreases to 37%) [9] or two cortical bone plates (to 25%) [8].

Treatment of large periapical defects using GTR increases overall treatment success [12]. Use of GTR in endodontic surgery of through-and-through lesions that involve both the buccal and palatal alveolar cortical plates is recommended [13].

CASE REPORT

A 22-year-old female patient was referred for an endodontic microsurgery. Tooth 22 (i.e., upper left lateral incisor) was symptomatic, luxated (II degree). A sinus tract observed above the apex contained purulent exudation and xenograft debris (Fig 1). Periodontal probing depths around teeth 21, 22, 23 were within the normal range. The patient had orthodontic treatment (fixed braces), but tooth 22 hadn't been involved.

In anamnesis it was indicated that the patient had endodontic treatment of extensive lesion of tooth 22 on 23 August, 2018 (Fig 2). After it the patient was referred to the oral surgeon for apicoectomy with augmentation of the bone defect. The sinus tract in the apex area of tooth 22 remained active since the surgical intervention.

The cone beam computed tomography (CBCT) analysis as of 2020 revealed partial bone reconstruction in the palatal part of the defect in the apex area of tooth 21 (tooth is vital). The bone defect was filled with heterogeneous, contrasting material (xenograft) (Fig 3).

Preoperative Procedure

Before the surgical procedure, the patient's venous blood (20 ml) was drawn via venipuncture of the antecubital vein. It was collected in four 10-ml sterile glass tubes coated with an anticoagulant (acidcitrate dextrose). The blood was centrifuged with Centurion PRO-PRP S (Centurion Scientific Limited, Chichester, West Sussex, UK) at the speed of 2700 rpm for 10 minutes to separate platelet-rich fibrin (PRF) from platelet-poor plasma. PRF was stored in a PRF box (Doctor Tools, Vladimirescu, Romania). A presurgical rinse with 0.2% solution of chlorhexidine (Eludril Classic; Pierre Fabre Group, Paris, France) was performed.

Surgical Procedure

The entire surgical procedure (W.P.) was performed using a dental operating microscope (Microscope Carl Zeiss EXTARO 300, Germany). Anesthesia was achieved with buccal infiltration of 3 capsules (5.4 ml) of 2% lidocaine hydrochloride with 1:50,000 epinephrine (Xylodont; Molteni Stomat, Florence, Italy). The full-thickness triangular flap was raised with vertical incision in frenulum and horizontal sulcular incision from tooth 21 to 24.

The bone defect was cleaned from a substantial amount of granulation soft tissue and loosed xenograft granules (Fig 4). An apicomarginal bone defect was detected (class 2B), purely endodontic origin, according to apicomarginal defects classification [14].

After cleaning the root section surface with a surgical bur (Lindemann H254E, Komet, Germany), the lack of retrofilling was identified. The vertical root fracture wasn't identified with the help of dying with 1% aqueous solution of methylene blue Canal detector (Cerkamed, Poland) (Fig 5A). 3 mm-deep retrograde preparation with an ultrasonic tip and device was performed (E11D, Woodpecker, Guilin Zhuomuniao Medical Devices Co., China). The root canal was filled with MTA+ (Cerkamed, Poland).

The bone defect was filled with a PRF plug (Fig 5B) and covered with a collagen membrane (SinossMem, B&B Dental Implant Company, Italy) (Fig 5C). It was covered with a PRF membrane and the wound was sutured with polypropylene (Luxylene 6/0, Lux-sutures S. A. Luxembourg) (Fig 5D).

After the microsurgery X-ray was performed on 17 August, 2020 (Fig 6).

A follow-up which was carried out in 5 days revealed a sinus tract with serous exudation (Fig 7). The sutures were removed.

During subsequent visits gradual decrease of the sinus tract was observed. After 4 months the sinus tract closed completely (Fig 8).

The CBCT made after 2 (i.e., in 2022) and 4 years (i.e., in 2024) revealed significant bone reconstruction (Figs 9 and 10). The patient hasn't reported any symptoms since. Intraoral view four years (i.e., in 2024) after the endodontic microsurgery shows no signs of inflammation or sinus tract (Fig 11).

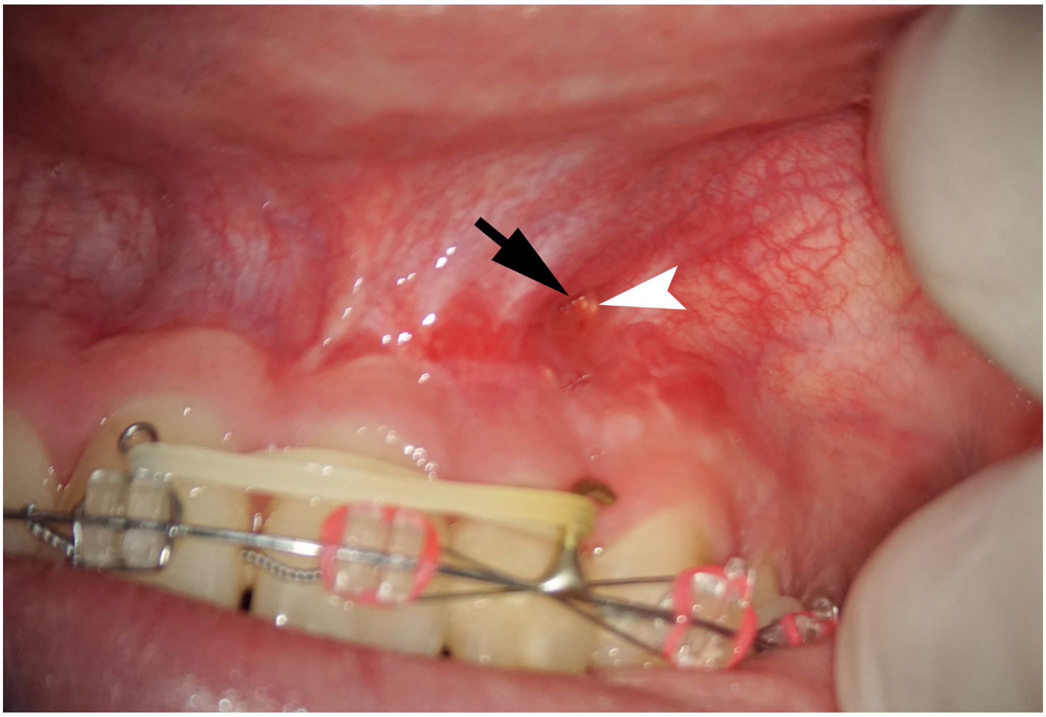

FIGURE 1. A sinus tract (*arrow*) observed above the apex of tooth 22 contained purulent exudation and and xenograft debris (*arrowhead*). Photography as of 2020.

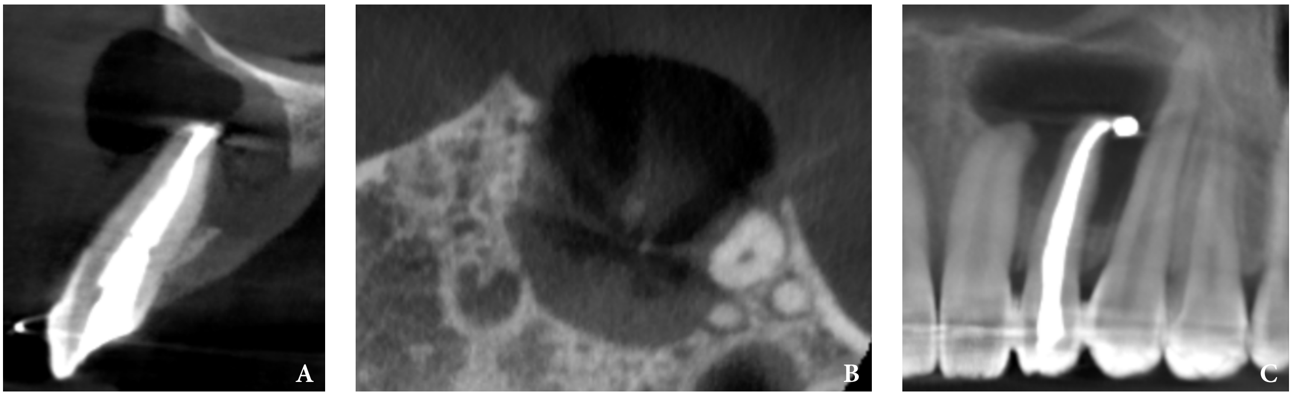

FIGURE 2. Cone beam computed tomography (CBCT) of tooth 22 (upper left lateral incisor). (**A**) sagittal plane; (**B**) axial plane; (**C**) panoramic view from CBCT. CBCT as of 2018.

FIGURE 3. CBCT of the tooth 22. (**A**) sagittal plane; (**B**) axial plane; (**C**) panoramic view from CBCT. CBCT as of 2020.

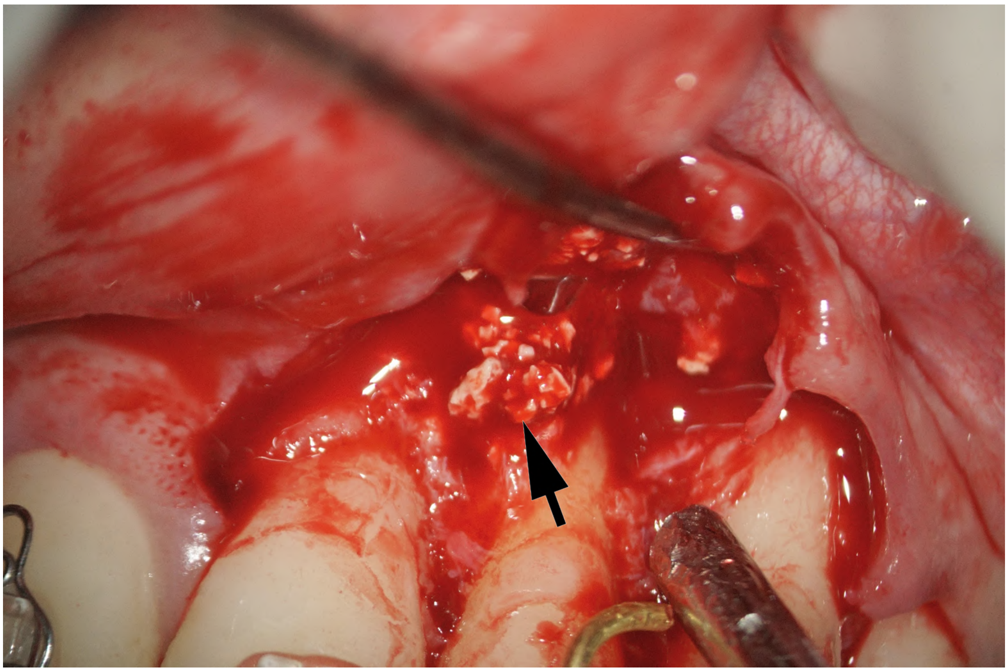

FIGURE 4. The full-thickness triangular flap was raised with vertical incision in frenulum and horizontal sulcular incision from tooth 21 to 24. The bone defect was cleaned from a substantial amount of granulation soft tissue and loosed xenograft granules (*arrow*).

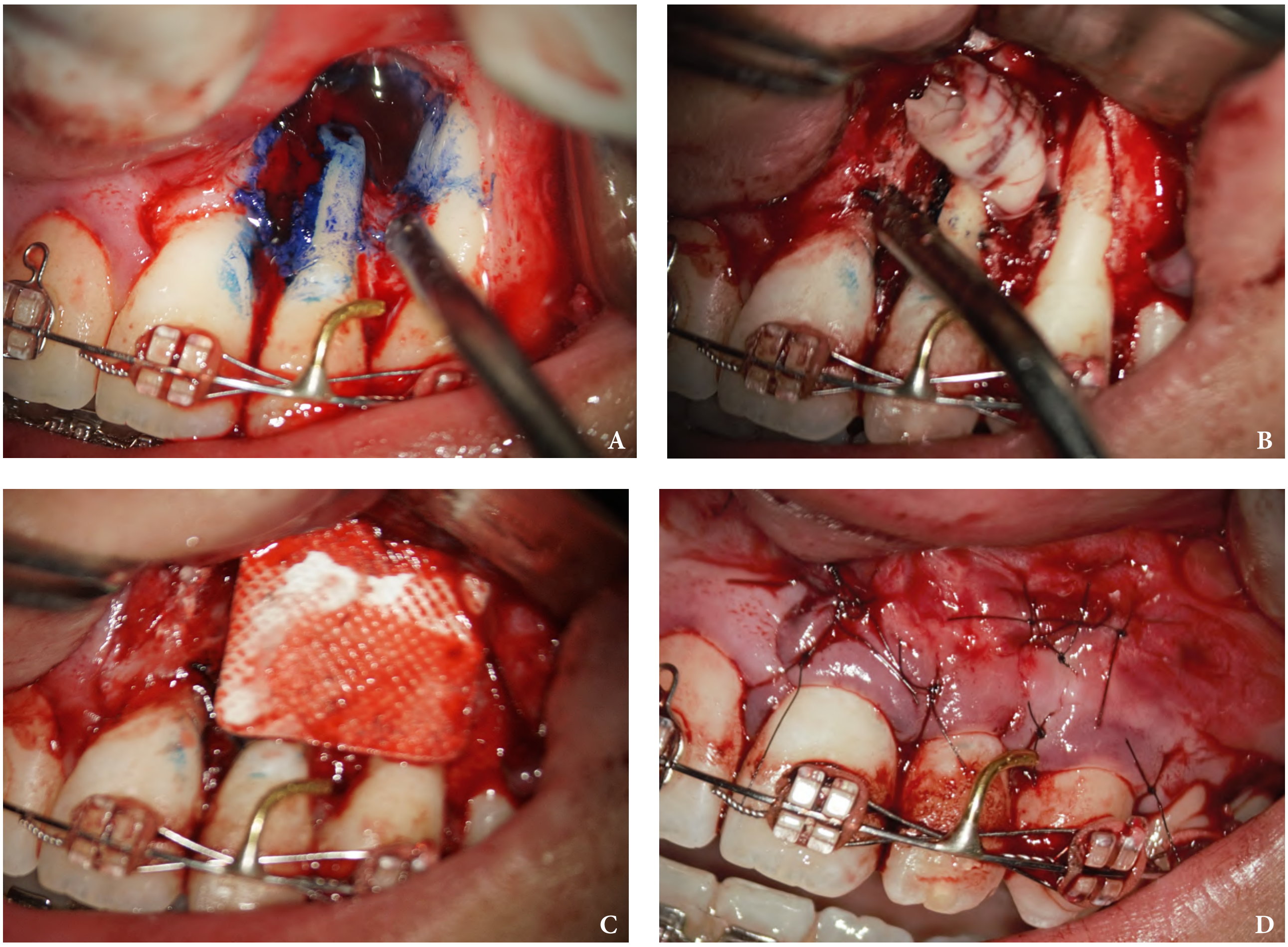

FIGURE 5. The vertical root fracture wasn't identified with the help of dying with 1% aqueous solution of methylene blue Canal detector (Cerkamed, Poland) (**A**). The bone defect was filled with a PRF plug (**B**) and covered with a collagen membrane (SinossMem, B&B Dental Implant Company, Italy) (**C**). It was covered with a PRF membrane and the wound was sutured with polypropylene (Luxylene 6/0, Lux-sutures S. A. Luxembourg) (**D**).

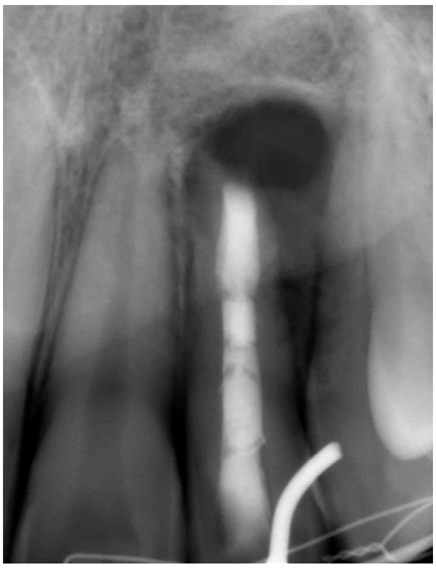

FIGURE 6. After the microsurgery, X-ray was performed on 17 August, 2020.

FIGURE 7. A follow-up which was carried out in 5 days after the microsurgery revealed a sinus tract with serous exudation.

FIGURE 8. During subsequent visits gradual decrease of the sinus tract was observed. After 4 months the sinus tract closed completely.

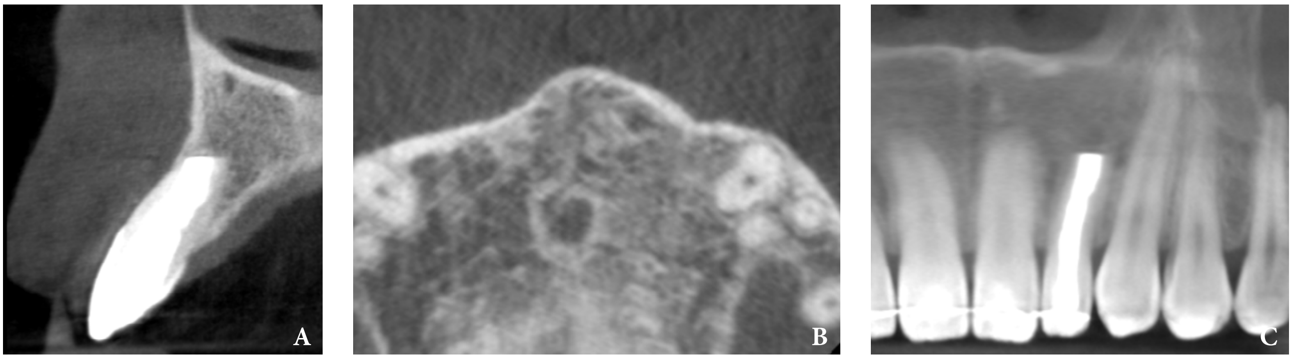

FIGURE 9. A 2-year follow-up CBCT of the tooth 22. (**A**) sagittal plane; (**B**) axial plane; (**C**) panoramic view from CBCT. CBCT as of 2022.

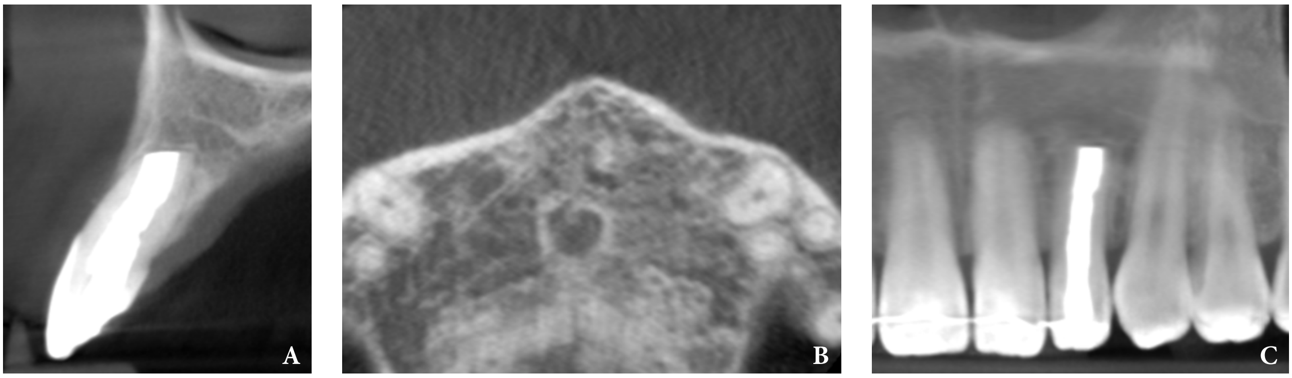

FIGURE 10. A 4-year follow-up CBCT of the tooth 22. (**A**) sagittal plane; (**B**) axial plane; (**C**) panoramic view from CBCT. CBCT as of 2024.

FIGURE 11. Intraoral view four years (i.e., in 2024) after the endodontic microsurgery shows no signs of inflammation or sinus tract.

DISCUSSION

This case perfectly shows that a success in treatment of such complex cases depends on many factors. The main ones are:

1. Understanding the cause-and-effect relationships in the development of inflammation and why failure occurred after the first surgical treatment.
2. Analysis of evidence-based articles and guidelines that provide recommendations on how to conduct treatment according to the patient's problem.
3. Technical provision of all necessary tools, materials and equipment for endodontic microsurgery.
4. Clinical experience and good manual skills of a surgeon.
5. Use of materials and methods of treatment that have the highest success rate according to the scientific evidence-based literature.
6. Factors that depend on a patients themselves (health condition, complexity of a clinical case, their responsibility, a desire to save a tooth).

Analyzing the first performed surgical manipulation (apicoectomy), we should pay attention to the main factors that contribute to the failure:

1. Insufficient cleaning and tightness of the filling mass in the root canal. The most common cause of failure in nonsurgical endodontic treatment is a leaky canal (30.4%) [15].
2. Resection of the root tip was performed without retrograde preparation and filling. Song et al. [16] determined that no root-end filling and incorrect root-end preparation were the most common causes of failure, followed by missing or leaky canals and unidentified isthmuses.
3. Absence of membranes in case of a through-and-through bone defect. Application of barrier membranes in through-and-through bony crypts after endodontic surgery might create a microenvironment, which is conducive for osteogenesis in a short-term experimental observation or clinical follow-up as compared to without barrier membranes [17]. Based on limited information in the literature, through-and-through bone defects could benefit from application of GTR technique using bioabsorbable barrier membranes after endodontic surgery to improve the rate of new bone formation in short-term observation [18–20].
4. Improper use of bone-plastic material that sometimes masked chronic inflammation for a long time. Radiographically, the problem of using bone graft substitutes in endodontic surgery is the difficulty of differentiating incomplete healing (scar tissue) from uncertain healing (no healing) because bone graft substitutes are radiopaque [21].
5. Absence of control observations of clinical symptoms after the operation, the condition of the sinus tract, and the lack of control X-rays by a doctor who previously performed apicoectomy.

In periapical surgery the sulcular full thickness flap is often used [22]. The main disadvantage of the sulcular full thickness flap is recession and, especially, unpredictable shrinkage of the papilla during healing [23]. The risks of these complications are greater, especially when surrounding bone tissue is lost.

When discussing the issue of the rationality of filling a bone defect, it is worth noting the scientific data related to the use of PRF. Platelet-rich plasma (PRP), bone morphogenic proteins (BMPs), platelet-derived growth factor (PDGF), parathyroid hormone (PTH), and enamel matrix proteins (EMD) have been locally applied to promote the healing potential of the surgical site [24]. It has been advocated that PRF can be considered a healing biomaterial because it is constituted by a fibrin network in which platelets, leukocytes, cytokines and stem cells are enmeshed [25]. Moreover, the platelets in the PRF network are capable of slowly releasing PDGF and insulin-like growth factor (IGF) [26, 27], even up to one week [28]. The osteogenic potential of these molecules has been already demonstrated [29, 30]. PRF can be thought as a grow factor reservoir that can be employed without exposing the patient to any immunogenicity or infection risk [31].

A collagen graft can be another alternative; however, PRF has been proven to have a beneficial effect in regeneration [32–34].

The article [35] analyzes the use of PRF in endodontic microsurgery. A control group of four patients (without PRF) and a test group of seven patients (with PRF) were involved. After endodontic microsurgery, the results of both groups were compared. Then the assessment was carried out according to three important indicators: the speed of healing, the intensity of pain and the amount of swelling. In the group where PRF was used, a statistically significant differences in the three criteria were observed: the speed of periapical healing accelerated, the intensity of postoperative pain and the severity of postoperative swelling decreased.

Sometimes scar tissue formation with through-and-through periapical lesions during tissue repair is observed [36–38].

Ingrowth of connective tissue into the osseous defect prevents periapical bone regeneration. It can result in periapical scarring, which is often misdiagnosed as pathology and may lead to unnecessary surgical reentry by a practitioner who is not fully aware of the history. When the barrier membranes are placed over bony defects and closely adapted to the surrounding bone surface, an environment that prevents invasion of competing nonosteogenic cells from the overlying soft tissues can be created. This environment provides the bony defect time to heal [39]. The use of GTR principles [40] enhanced the quality and quantity of bone regeneration in large periapical defects, especially in through-and-through lesions [41].

Summing up this article, we would like to show in Figure 12 a comparison of sagittal CBCT scans of tooth 22 with different treatment by different doctors with an assessment of long-term results and four years after microsurgical treatment.

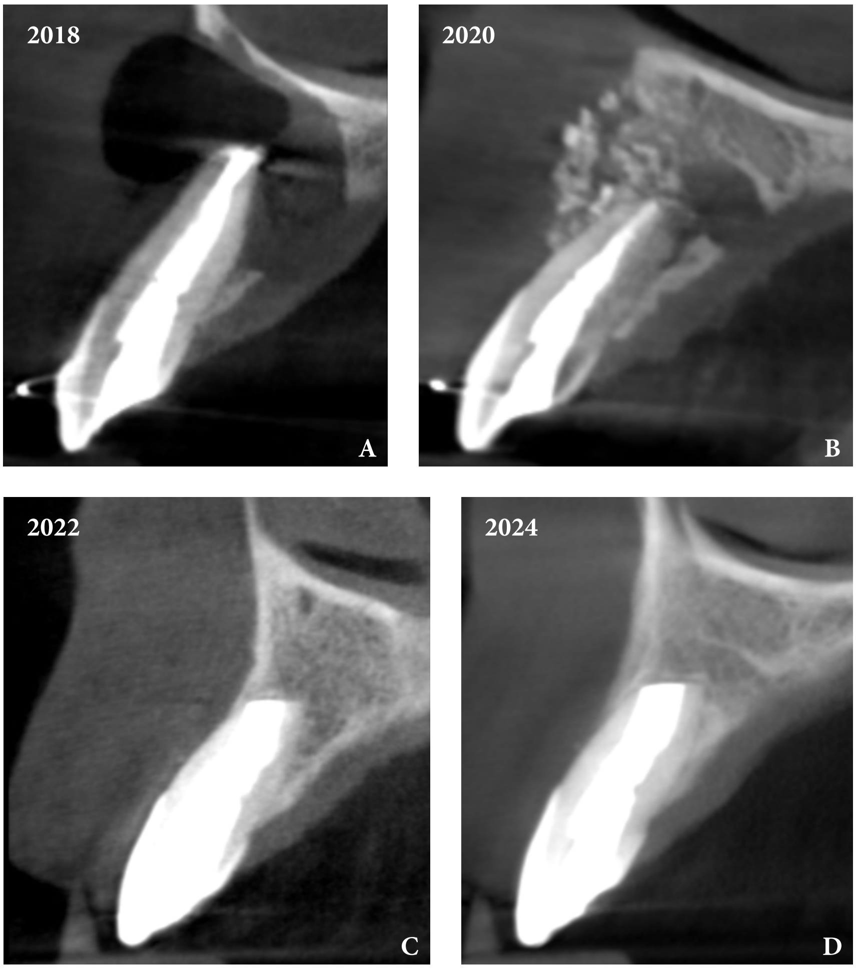

FIGURE 12. Comparison of sagittal CBCT scans of the tooth 22 upon different treatment by different doctors with assessment of long-term results (**C**) two and (**D**) four years after the microsurgery. (**A**) 2018; (**B**) 2020; (**C**) 2022; (**D**) 2024.

CONCLUSION

The presented case report describes a difficult case that was resolved by endodontic microsurgery a positive outcome of which was enhanced by a two- and four-year follow-up. The use of PRF as an autologous graft in combination with a collagen membrane ensured complete healing, a good aesthetic result of soft tissues and the absence of any clinical signs and symptoms. Future long-term clinical observations and studies are needed to prove the effectiveness, predictability and success of this technique.

CONFLICT OF INTEREST

The authors declare that they don't have any conflicts of interest.

AUTHOR CONTRIBUTIONS

WP and OT: Writing – original draft. WP and OT: Writing – review & editing.

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ЗВІТ ПРО ВИПАДОК/МЕТОДИКА UKRAINIAN LANGUAGE

Мікрохірургічне лікування великого наскрізного періапікального ураження з апікомаргінальним дефектом із застосуванням керованої тканинної регенерації (КТР): звіт про випадок із чотирирічним спостереженням

Вітольд Поповіч[a,*] та Олександр Борисович Ткаченко[b]

АНОТАЦІЯ

При тривалому періапікальному ураженні іноді спостерігається деструкція як вестибулярної, так і оральної кортикальних пластинок і навіть наскрізне периапікальне ураження. Успіх лікування знижується, коли до наскрізного периапікального ураження додається апікомаргінальний дефект. Великі периапікальні ураження слід спочатку лікувати за допомогою ортоградної терапії кореневих каналів. Якщо ознаки та симптоми інфекції не зникають після лікування, слід розглянути можливість хірургічного втручання. У цьому випадку 22-річна жінка з раніше розпочатим лікуванням була направлена на ендодонтичну мікрохірургію зуба 22 (тобто верхнього лівого бокового різця). Після ендодонтичного лікування пацієнтку направили до орального хірурга для апікоектомії та заміщення кісткового дефекту. Синус тракт (тобто нориця) в ділянці верхівки зуба 22 з моменту хірургічного втручання залишився

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Акронім «КТР» у верхньому правому значку означає, що стаття містить опис методики керованої тканинної регенерації (КТР) при ендодонтичній мікрохірургії.

Підкреслення літер в імені та прізвищі авторів вказує на наголоси при їх вимові.

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активним. Виконано ендодонтичну мікрохірургію та керовану тканинну регенерацію. В статті представлено дані діагностики, а саме перед- та післяопераційні зображення конусно-променевої комп'ютерної томографії (через 2 та 4 роки), а також перед-, ітра- та післяопераційні клінічні зображення. Деталізовано всі перед- та інтраопераційні процедури і етапи. Зокрема, відокремлення з венозної крові збагаченого тромбоцитами фібрину (PRF, акронім англомовного терміну "platelet-rich fibrin"), ретроградне препарування з ультразвуковим наконечником і пристроєм із застосуванням стоматологічного операційного мікроскопу та використання колагенової мембрани для керованої тканинної регенерації (КТР) (синонім: направлена тканинна регенерація). Після дво- та чотирирічного спостереження рентгенологічне дослідження виявило загоєння, а клінічні ознаки та симптоми були відсутні. Відтоді пацієнт не повідомляв про жодні симптоми. В статті також аналізуються наукові джерела із застосування збагаченого тромбоцитами фібрину при кісткових дефектах щелеп та колагенових мембран. Також приділено увагу до формування клаптя при операціях такого типу. Виділено основні 6 фактори успіху в лікуванні таких складних випадків. Переосмислюючи попередньо виконану хірургічну маніпуляцію (апікоектомію) у даної пацієнтки, звернено увагу на основні 5 факторів, що могли сприяти невдачі.

КЛЮЧОВІ СЛОВА

Наскрізне періапікальне ураження, апікомаргінальний дефект, синус тракт, ендодонтична мікрохірургія, керована тканинна регенерація (КТР)

OPIS PRZYPADKU/TECHNIKA POLISH LANGUAGE

Postępowanie mikrochirurgiczne z wykorzystaniem sterowanej regeneracji tkanek (GTR) w przypadku rozległej, perforującej przezwyrostkowo zmiany okołowierzchołkowej z jednoczesnym całkowitym pionowym zniszczeniem blaszki zbitej: Studium przypadku z czteroletnią obserwacją

Witold Popowicz[a,*] i Oleksandr Tkachenko[b]

STRESZCZENIE

Długotrwałe zapalne zmiany okołowierzchołkowe mogą prowadzić do uszkodzenia blaszki zbitej po stronie przedsionkowej jak i podniebiennej, a nawet do przezwyrostkowej perforacji wyrostka. Współistnienie zmiany okołowierzchołkowej perforującej wyrostek z całkowitą pionową utratą blaszki pogarsza rokowanie leczenia. W przypadku rozległych zmian okołowierzchołkowych leczeniem z wyboru jest leczenie kanałowe. Dopiero w przypadku utrzymywania się objawów radiologicznych i/lub klinicznych stanu zapalnego, należy rozważyć leczenie chirurgiczne. W artykule zaprezentowano przypadek 22-letniej pacjentki u której wykonano najpierw standardowe leczenie kanałowe zęba 22 a następnie została skierowana do chirurga na zabieg resekcji wierzchołka i odbudowę ubytku kostnego materiałem ksenogennym. Po przeprowadzonym leczeniu chirurgicznym z uwagi na utrzymującą się aktywną przetokę ropną w okolicy wierzchołka zęba 22 pacjentkę

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Skrót „GTR" w ikonie w prawym górnym rogu oznacza, że artykuł zawiera opis techniki sterowanej regeneracji tkanek (guided tissue regeneration [GTR]) stosowanej w mikrochirurgii endodontycznej.

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skierowano na zabieg mikrochirurgii endodontycznej z zastosowaniem sterowanej regeneracji tkanek (z wypełnieniem ubytku kostnego osoczem bogatopłytkowym). W artykule zaprezentowano przebieg leczenia, począwszy od procedur diagnostycznych, poprzez pełną procedurę zabiegu mikrochirurgii endodontycznej oraz wyniki czteroletniej obserwacji. Przedstawiono przed- i pozabiegowe (po 2 i 4 latach) obrazy z CBCT a także przed-, śród- i pozabiegowe zdjęcia kliniczne. Szczegółowo opisano wszystkie procedury i etapy przed- i śródzabiegowe, w szczególności przygotowanie fibryny bogatopłytkowej (PRF) z krwi żylnej, preparację wsteczną za pomocą końcówki ultradźwiękowej z użyciem mikroskopu zabiegowego oraz zastosowanie błony zaporowej. Czteroletnia obserwacja kliniczna i radiologiczna wykazała ustąpienie objawów, wygojenie przetoki ropnej oraz odbudowę kości wyrostka zębodołowego szczęki. W artykule przeprowadzona została analiza naukowa stosowania PRF i błon kolagenowych w ubytkach kostnych szczęki i żuchwy. Zwrócono również uwagę na technikę preparacji płata podczas tego typu zabiegów. Wyróżniono sześć głównych czynników decydujących o powodzeniu w leczeniu tak złożonych przypadków. Analizując uprzednio wykonany zabieg chirurgiczny apicektomii u pacjentki, zwrócono uwagę na pięć głównych czynników, które mogły przyczynić się do niepowodzenia procedury.

SŁOWA KLUCZOWE

Przezwyrostkowa perforująca zmiana okołowierzchołkowa, apiko-marginalny ubytek kostny [MC1], przetoka, mikrochirurgia endodontyczna, sterowana regeneracja tkanek (GTR)

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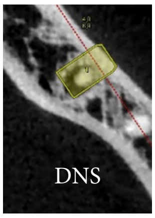

CASE REPORT/TECHNIQUE DYNAMIC NAVIGATION SYSTEM (DNS)

Endodontic Microsurgery of a Mandibular Molar Using a Dynamic Navigation System (DNS) and Cortical Window Technique: A Case Report

Gustavo A. Castillo[a,*], Silvia A. Restrepo-Méndez[b], Oscar E. Zuluaga[c], & Paola A. Escobar-Villegas[d]

ABSTRACT

Recent advancements in endodontic surgery have significantly improved outcomes through enhanced technology, including digital planning, cone-beam computed tomography (CBCT), and operating microscopes. The integration of dynamic navigation systems (DNSs) has particularly transformed endodontic microsurgery (EM) by providing real-time guidance and precision. This case report explores the application of DNS in a clinical case of EM involving a mandibular first molar with symptomatic apical periodontitis. A 36-year-old male patient presented with masticatory pain in the lower left quadrant. Radiographic and CBCT evaluations revealed an underfilled mesiolingual canal and a periapical lesion. The surgical procedure utilized DNS for precise osteotomy and apicectomy, guided by the Navident® system and incorporating the cortical window technique. Postoperative care included antibiotic therapy and follow-up appointments, demonstrating successful periapical healing at 21 months. DNS technology significantly enhances precision and conservativeness in EM, allowing for real-time guidance and minimizing iatrogenic risks. The cortical window technique, combined with DNS, facilitates effective root access while preserving bone structure. Despite its advantages, DNS is associated with high costs and a steep learning curve. Future research should focus on evaluating the long-term clinical outcomes of DNS, improving system usability, and exploring its applications in other endodontic

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The acronym "DNS" in the upper right icon means that the article contains a description of endodontic microsurgery with application of dynamic navigation system (DNS).

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procedures. This case report demonstrates the successful use of DNS in conjunction with the cortical window technique for EM, achieving favorable clinical outcomes and promoting accelerated healing. Further studies are needed to validate the broader clinical utility of DNS and to refine its integration into routine practice.

KEY WORDS

Apicoectomy, surgery, computer-assisted, case reports, microsurgery, osteotomy, cone-beam computed tomography

INTRODUCTION

The endodontic surgery field has evolved due to technological advancements in various equipment, diagnostic aids, techniques, and materials. More recently, the implementation of digital planning has favored the execution, predictability, and prognosis of the procedure [1]. The transition to computer aided 3D systems have represented a breakthrough, leading to higher success rates compared to conventional endodontic surgery [2].

Cone-beam computed tomography (CBCT) and magnification have become indispensable tools in endodontic microsurgery (EM). The digital workflow now incorporates navigation systems for both surgical and non-surgical endodontic procedures, primarily employing two techniques: static navigation and dynamic navigation [1-3]. Dynamic navigation, a computer-guided technology initially developed for precise and real-time planning in oral implantology, utilizes cameras and tracking devices attached to the handpiece and the patient. The system continuously compares the access path using software on the CBCT images, providing the clinician with information related to the milling path, which is visually displayed on a monitor [4].

Dynamic navigation systems (DNSs) have emerged as valuable tools in endodontics, finding application in various procedures, including the management of obliterated canals, post removal, and EM [2, 5-7]. A key advantage of DNS over static navigation is the elimination of the need for guide fabrication, enabling faster patient treatment [7]. Static guides, on the other hand, can pose challenges in accessing posterior regions, particularly when interocclusal space is limited [5]. Additionally, static guides can increase the risk of bone overheating due to inadequate irrigation, among other potential complications [2, 8].

The DNS uses instruments that help to perform more precise procedures at different surgical stages. For example, during osteotomy, it allows for a smaller access, which favors the repair process. This case report documented EM in a mandibular first molar using the Navident® DNS (ClaroNav, Toronto, Canada), applying the cortical window technique. Clinical and CBCT follow-up at 21 months showed a successful outcome in periapical healing.

CASE REPORT

Patient Presentation

A 36-year-old male with no significant medical history presented with chief complaint of pain on chewing in the lower left quadrant. Clinical examination revealed positive vertical percussion test on tooth #36 (i.e., lower left first molar), negative palpation, physiological mobility, and normal periodontal probing depths. No swelling or sinus tract was evident. CBCT analysis (Myray, Hyperion X9 tomograph, 75 microns, 6x4 window, Imola [BO], Italy) revealed an adequate coronal restoration, along with a previous endodontic treatment performed one year ago, where the mesiolingual canal was underfilled, while the mesiobuccal and distal canals were well obturated. A hypodense periapical area was identified in the mesial root (Fig 1), accompanied by a 4 mm diameter periapical lesion. The buccal cortical bone was intact, with a thickness of 5 mm to the root apex. Based on these findings, the tooth was diagnosed as previously treated with symptomatic apical periodontitis, classified according to the periapical index (PAI) CBCT PAI 3E [9].

Surgical Procedure

Preoperative Planning and Anesthesia

Pre-surgical Planning:

The surgical procedure commenced after obtaining informed consent and explaining treatment options. The Digital Imaging and Communications in Medicine (DICOM) data from the CBCT scan was imported into the Navident® software for meticulous surgical planning (Fig 2A). The planned angulation was set at 0-10 degrees relative to the tooth's longitudinal axis, as recommended by some studies [5].

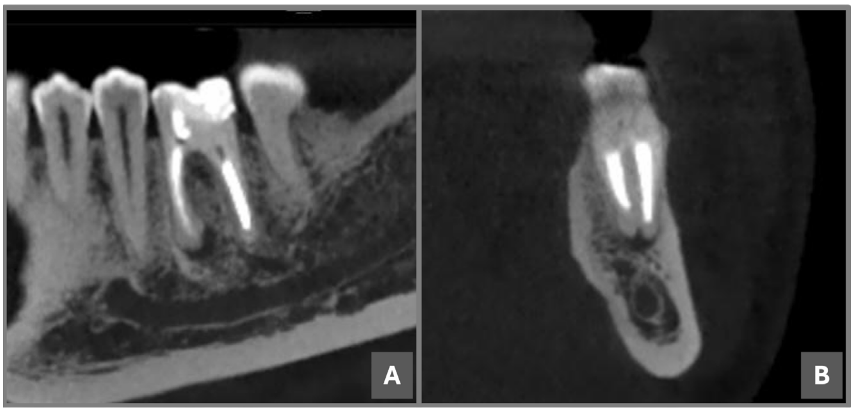

FIGURE 1. CBCT images of tooth #36 (i.e., lower left first molar). (**A**) Sagittal and (**B**) coronal view.

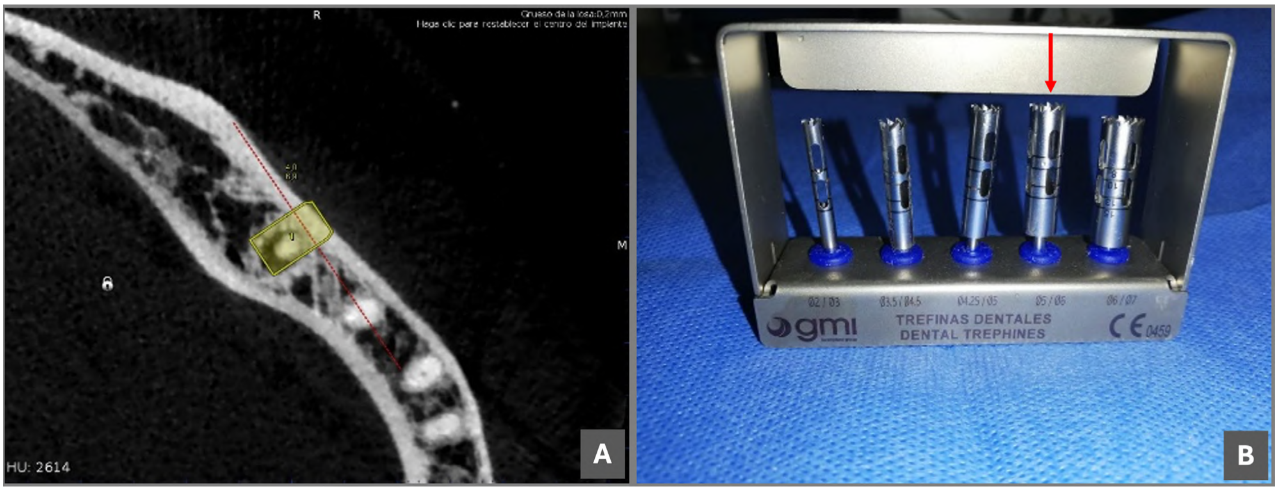

FIGURE 2. (**A**) Navident® software planning for trephine placement. (**B**) Trephine kit, the *red arrow* shows the trephine used.

Pre-operative Preparation:

Before surgery, a thorough 60-second rinse with 0.12% chlorhexidine solution (PerioGard®, Colgate-Palmolive, Anchieta, Brazil) was performed for oral disinfection. Local anesthesia was achieved using 2 cartridges (3,6 mL) of lidocaine 2% with epinephrine 1:80,000 (Newcaína, New Stetic, Guarne, Colombia). The anesthetic technique involved an inferior alveolar nerve block and buccal infiltration. This ensures adequate pain control throughout the surgery by blocking the nerve that supplies sensation to the lower jaw and infiltrating the surrounding tissue with an anesthetic.

Surgical Technique

A meticulous submarginal incision with a scalloped margin was placed, followed by a full-thickness flap (mucoperiosteal) elevation for optimal visualization and surgical field access. Mesial and distal releasing incisions were employed to facilitate exposure of the intact cortical bone and allow for adequate flap mobility.

Utilizing the DNS and a 5 mm diameter trephine bur (Global Medical Implants [GMI], Lleida, Spain) attached to a contra-angle handpiece (NSK Brasil, Sao Paulo, Brazil) (Fig 2B), an osteotomy was performed at a speed of 10.000 revolutions per minute (rpm) under continuous saline irrigation for cooling and debris removal (Fig 3A). The DNS precisely guided the trephine bur, ensuring creation of a well-defined bone window and simultaneous apicectomy at the pre-planned angulation of 0 degrees relative to the tooth's longitudinal axis. The bone fragment was carefully retrieved and placed in a sterile container with saline solution for potential grafting. The apical root segment, along with the associated periapical lesion, was meticulously removed with microsurgical instruments under high magnification.

The retropreparation cavity was subsequently stained with methylene blue (Disanfer, Bogotá, Colombia) to enhance visualization of the root canal orifice and facilitate precise cavity preparation (Fig 3B). Ultrasonic diamond tips (E30LD-S, NSK, Nakanishi, Japan) were employed in conjunction with the Biosonic S1 ultrasonic unit (Coltene Whaledent, Altstätten, Switzerland) for efficient and minimally invasive cavity shaping. Continuous saline irrigation was maintained throughout the procedure to ensure cooling and debris removal, followed by thorough drying with sterile paper points (New Stetic S.A., Guarne, Colombia).

Retrograde obturation of the prepared cavity was performed using BIO-C® Repair (Angelus, Londrina, Brazil) to create a hermetic seal and prevent bacterial leakage (Fig 3C). The carefully retrieved bone fragment was stabilized within the defect using 0.5 grams of xenograft bone with a particle size range of 300 to 600 microns (Biomod 3Biomat S.A.S, Bogotá, Colombia) to promote bone healing (Fig 3D). The mucoperiosteal flap was meticulously repositioned and sutured with 5-0 Dafilon sutures (B. Braun, Tuttlingen, Germany) for tension-free closure.

The entire surgical procedure was performed under the magnification of a surgical microscope OMS2350 (Zumax Medical, Suzhou, China) to ensure optimal visualization, precise handling of instruments, and meticulous attention to detail.

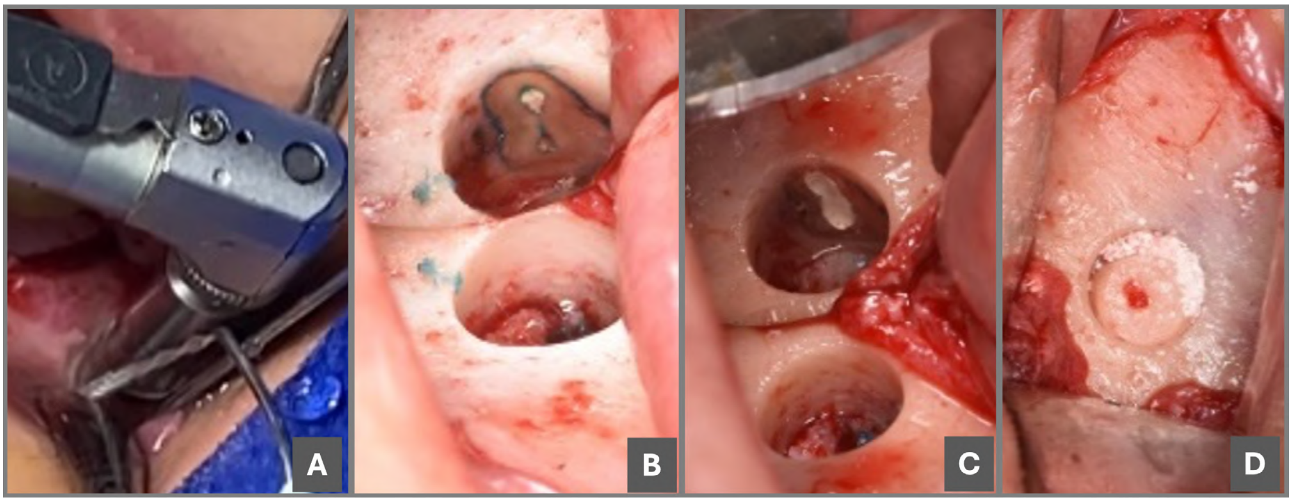

FIGURE 3. (**A**) Trephine positioning (**B**) Osteotomy and Navident-guided apicectomy with methylene blue staining. (**C**) Retrograde obturation with BIO-C® Repair. (**D**) "Cortical window" replacement and stabilization with Biomod bone graft.

Postoperative Care and Follow-up

To prevent potential infections and promote healing, the patient was prescribed a regimen of Amoxal 500 mg capsules (GlaxoSmithKline [GSK], London, England) one capsule every 8 hours for 5 days, Anexia 120 mg tablets (Tecnoquímicas S.A., Cali, Colombia) one tablet daily, and a 0.12% chlorhexidine mouthwash twice daily. Additionally, topical application of fitostimoline gel oral (Euroetika S.A.S, Bogotá, Colombia) was recommended to promote healing.

The sutures were carefully removed 7 days following the procedure. Follow-up appointments were scheduled at 6, 12, and 21 months to assess healing and ensure optimal outcomes. CBCT scans obtained at these follow-up visits revealed complete periapical healing (Fig 4), and the patient remained asymptomatic throughout the follow-up period.

DISCUSSION

In the presented case, guided EM emerged as the preferred treatment approach due to the low likelihood of successful retreatment via an orthograde technique. This decision aimed to circumvent the

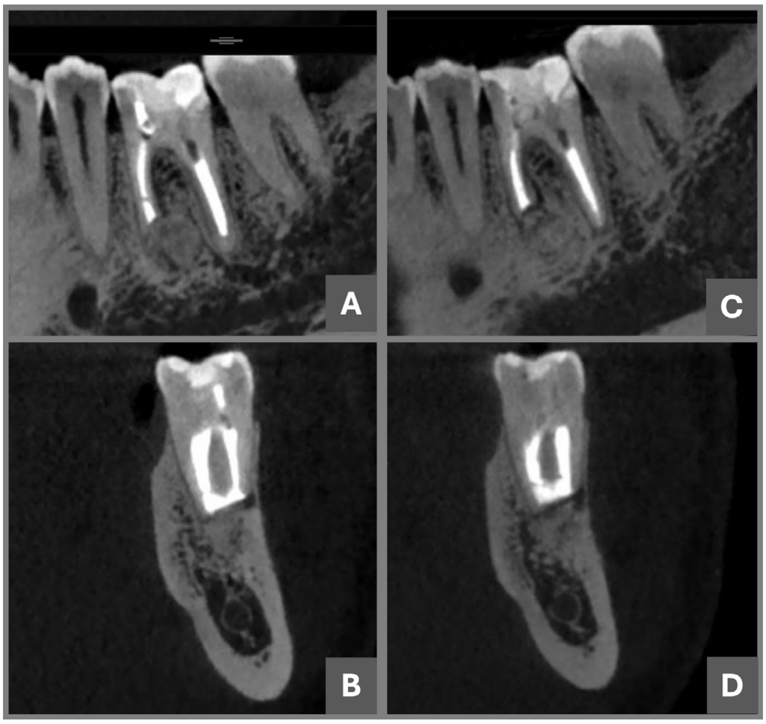

FIGURE 4. CBCT follow-up control of tooth #36. 12-month follow-up in (**A**) sagittal and (**B**) coronal views. 21-month follow-up in (**C**) sagittal and (**D**) coronal views.

potential risks associated with adverse events during non-surgical endodontic retreatment, particularly root perforation in the danger zone. By employing EM, conservative management of the furcation area was achieved, an area particularly susceptible to stripping-type perforations [10, 11].

DNS stands as a novel technology that significantly enhances precision during microsurgical endodontic procedures. It serves as a real-time guide for instrument orientation, fostering the protection of adjacent anatomical structures [6]. DNS enables a conservative approach during osteotomy, particularly in cases where cortical bone fenestration is absent or when the cortical thickness hinders access to the root apex. This conservative approach positively impacts bone healing time, as evidenced by the successful outcome in the presented case. However, DNS has drawbacks, including its high acquisition cost and the substantial space requirement due to the equipment's size [12]. Additionally, it presents a steeper learning curve than traditional techniques or static guides, demanding operator calibration, manual dexterity, and exceptional hand-eye coordination [4].

Currently, several systems facilitate a more conservative and precise osteotomy phase during EM. One such system is the piezoelectric system, equipped with diverse tips that offer protection against nerve structure damage and minimize bleeding, enhancing visibility during the procedure [13-15]. Another option is the use of trephines, available in various diameters and lengths. Trephines allow for the preservation of the intact bone block that is removed, enabling its subsequent repositioning and, if necessary, fixation before flap replacement [12, 16].

Research suggests that computer-assisted static navigation techniques planned with trephines offer a cylindrical geometry that helps prevent unwanted deviations during osteotomy. This can result in greater accuracy in locating the root apex [17]. This technique, known as the "cortical window," facilitates faster healing, considering autologous bone's osteogenic, osteoinductive, and osteoconductive potential [14, 15]. Given the advantages mentioned above and others reported in the literature, the cortical window technique guided by DNS using a trephine was employed in the presented case. The primary objective was to preserve the bone structure, maintain the integrity of the vestibular cortical bone, facilitate access to the root to be treated, and enable successful apicectomy [12, 14, 18].

CONCLUSION

This case report demonstrates the successful application of dynamic navigation system (DNS) combined with the cortical window technique using a trephine for endodontic microsurgery (EM) of a mandibular molar with a periapical lesion and intact buccal cortical bone. This minimally invasive approach facilitated precise osteotomy, root apex access, and retrograde filling, leading to successful periapical healing at the 21-month follow-up as confirmed by cone-beam computed tomography (CBCT).

Key Advantages of the Technique:

- **Enhanced Precision:** DNS provides real-time guidance, minimizing the risk of iatrogenic complications during osteotomy and protecting vital structures.
- **Conservative Approach:** The cortical window technique allows for a smaller access cavity, preserving bone structure and promoting faster healing.
- **Autologous Bone Grafting:** Repositioning the retrieved bone fragment promotes osteoconduction and facilitates bone regeneration in the defect area.

Future Directions:

While DNS offers significant benefits, further research is needed to evaluate its long-term cost-effectiveness compared to traditional techniques. Additionally, advancements in technology and user interface design can potentially reduce the learning curve associated with DNS.

Overall Significance:

This case report highlights the potential of DNS-guided EM with the cortical window technique as a predictable and minimally invasive treatment option for managing complex endodontic cases with limited surgical access. This approach offers a promising future for improving surgical outcomes and patient care in EM.

AUTHOR CONTRIBUTIONS

Conceptualization, G.A.C. and O.E.Z.; methodology, G.A.C., O.E.Z., and P.A.E-V.; software, G.A.C.; validation, G.A.C.; formal analysis, G.A.C.; investigation, G.A.C.; resources, G.A.C., O.E.Z., S.A.R-M., and P.A.E-V.; data curation, G.A.C., O.E.Z., S.A.R-M., and P.A.E-V.; writing—original draft preparation, G.A.C., O.E.Z., and P.A.E-V.; writing—review and editing, G.A.C., O.E.Z., S.A.R-M., and P.A.E-V.; visualization, G.A.C., O.E.Z., and P.A.E-V.; supervision, G.A.C., O.E.Z., and P.A.E-V.; project administration, G.A.C., O.E.Z., and P.A.E-V. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

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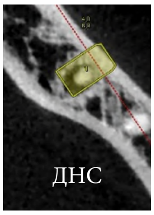

ЗВІТ ПРО ВИПАДОК/МЕТОДИКА

UKRAINIAN LANGUAGE

Ендодонтична мікрохірургія моляра нижньої щелепи із використанням динамічної навігаційної системи (ДНС) і методики «кортикального вікна»: опис випадку

Густаво Кастільо[a,*], Сільвія Рестрепо-Мендес[b], Оскар Зулуага[c] та Паола Ескобар-Віллегас[d]

АНОТАЦІЯ

Останні досягнення в ендодонтичній хірургії значно покращили результати завдяки вдосконаленій технології, включаючи цифрове планування, конусно-променеву комп'ютерну томографію (КПКТ) та операційні мікроскопи. Інтеграція динамічних навігаційних систем (ДНС) особливо змінила ендодонтичну мікрохірургію (ЕМ), забезпечуючи вказівки в реальному часі та точність. У цьому звіті досліджується застосування ДНС у клінічному випадку ЕМ, що включає перший моляр нижньої щелепи з симптоматичним апікальним періодонтитом. Пацієнт чоловічої статі 36 років звернувся зі скаргами на біль при жуванні у лівому нижньому квадранті. Рентгенографія та КПКТ виявили недостатньо заповнений мезіолінгвальний кореневий канал і періапікальне ураження. Під час хірургічної процедури використовувалася ДНС для точної остеотомії та апікоектомії за допомогою системи Navident® і включала методику «кортикального вікна». Післяопераційний догляд включав антибіотикотерапію та

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Акронім «ДНС» у верхньому правому значку означає, що стаття містить опис ендодонтичної мікрохірургії із застосуванням динамічної навігаційної системи (ДНС).

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контрольні огляди, що продемонструвало успішне періапікальне загоєння через 21 місяць. Технологія ДНС значно підвищує точність і консервативність ЕМ, дозволяючи надавати вказівки в реальному часі та мінімізуючи ятрогенні ризики. Методика «кортикального вікна» в поєднанні з ДНС полегшує ефективний доступ до кореня, зберігаючи структуру кістки. Незважаючи на свої переваги, ДНС пов'язаний з високими витратами та крутою кривою навчання. Майбутні дослідження мають бути зосереджені на оцінці довгострокових клінічних результатів ДНС, покращенні зручності використання системи та дослідженні її застосування в інших ендодонтичних процедурах. Цей випадок демонструє успішне використання ДНС у поєднанні з методикою «кортикального вікна» для ЕМ, що забезпечує сприятливі клінічні результати та сприяє прискоренню загоєння. Потрібні подальші дослідження, щоб підтвердити ширшу клінічну доцільність ДНС і вдосконалити її інтеграцію в повсякденну практику.

КЛЮЧОВІ СЛОВА

Апікоектомія, хірургія, комп'ютерна підтримка, описи випадків, мікрохірургія, остеотомія, конусно-променева комп'ютерна томографія

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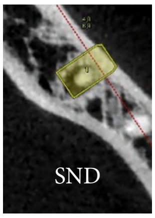

CASO CLÍNICO/TÉCNICA SPANISH LANGUAGE

Microcirugía endodóncica de un molar mandibular mediante un sistema de navegación dinámica (SND) y técnica de ventana cortical: reporte de caso

Gustavo A. Castillo[a,*], Silvia A. Restrepo-Méndez[b], Oscar E. Zuluaga[c] y Paola A. Escobar-Villegas[d]

RESUMEN

Los recientes avances en la cirugía endodóncica han mejorado significativamente los resultados a través de una tecnología mejorada, que incluye la planificación digital, la tomografía computarizada de haz cónico (TCHC) y los microscopios quirúrgicos. La integración de los sistemas de navegación dinámica (SND) ha transformado particularmente la microcirugía endodóncica (ME) al proporcionar guía y precisión en tiempo real. Este informe de caso explora la aplicación de DNS en un caso clínico de ME que involucraba un primer molar mandibular con periodontitis apical sintomática. Un paciente masculino de 36 años presentó dolor masticatorio en el cuadrante inferior izquierdo. Las evaluaciones radiográficas y TCHC revelaron un conducto mesiolingual insuficientemente obturado y una lesión periapical. El procedimiento quirúrgico utilizó SND para una osteotomía y apicectomía precisas, guiadas por el sistema Navident® e incorporando la técnica de ventana cortical. El cuidado posoperatorio incluyó terapia con antibióticos y citas de seguimiento, demostrando una curación periapical exitosa a los 21 meses. La tecnología SND mejora significativamente la precisión y el carácter conservador en la ME, lo que permite una guía en tiempo real y minimiza los riesgos iatrogénicos. La técnica

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El acrónimo “SND” en el icono superior derecho significa que el artículo contiene una descripción de la microcirugía endodóntica con aplicación del sistema de navegación dinámica (SND).

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de ventana cortical, combinada con SND, facilita el acceso eficaz a la raíz al tiempo que preserva la estructura ósea. A pesar de sus ventajas, SND está asociada a altos costos y una curva de aprendizaje pronunciada. Las investigaciones futuras deben centrarse en evaluar los resultados clínicos a largo plazo de SND, mejorar la usabilidad del sistema y explorar sus aplicaciones en otros procedimientos endodóncicos. Este informe de caso demuestra el uso exitoso de SND junto con la técnica de ventana cortical para ME, logrando resultados clínicos favorables y promoviendo una curación acelerada. Se necesitan más estudios para validar la utilidad clínica más amplia de SND y refinar su integración en la práctica de rutina.

PALABRAS CLAVE

Apicectomía, cirugía, asistida por computadora, informes de casos, microcirugía, osteotomía, tomografía computarizada de haz cónico

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CASE REPORT/TECHNIQUE GUIDE | LASER

Guided Periradicular Surgery with Er,Cr:YSGG Laser Osteotomy: A Case Report

Julian Torres Celeita,[a] Johanna Hernández la Rotta,[b,*] Amdie Chirinos Salazar,[c] Jorge Fandiño Rodríguez,[d] Laura López Rincón,[e] Mauren Orduz Solorzano,[f] Diana Parra Galvis,[g] & Oscar Jiménez Peña[h]

ABSTRACT

Purpose: The aim of the study is to observe the bone healing process of a guided periradicular surgery, performed in the endodontics postgraduate course of the Saint Thomas University, in which an osteotomy was performed for a bone window with erbium, chromium: yttrium, scandium, gallium, garnet (Erbium,Chromium:YSGG) laser (can also be written as Er,Cr:YSGG laser), and the healing process was evaluated by cone-beam computed tomography (CBCT) during the first four months after surgery.

Materials and Methods: After completing the clinical history and studying the CBCT scans, a patient was selected with a diagnosis of symptomatic apical periodontitis, periapical lesion less than 5 mm with intact vestibular cortex that required periradicular surgery due to the presence of an adapted fixed prosthesis and the proximity of the mental foramen to the apex of the tooth to be treated. The treatment plan was established, the surgical guide was designed and the osteotomy was performed with Erbium,Chromium:YSGG laser. The size of the periradicular lesion and the bone density of the surgical area were measured at three points in time: pre-

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The word 'Guide' at the upper right icon means that article contains a description of the periradicular surgery applying surgical guide and Er,Cr:YSGG laser.

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surgical (T0), post-surgical at 24 hours (T1), and at 4 months (T2).

Results: Bone density measured in Hounsfield units (HU) on CBCT in the axial section showed preoperative values in the vestibular apex of 1478 and 1435 HU, at 24 hours after surgery -95 and -210 HU, and in the control at 4 months of 992 and 860 HU. In the coronal slice in the mid vestibular area at the apex level, a preoperative value (T0) of 1335 HU was reported, at 24 hours (T1) -18 HU and at 4 months 1269 HU. At one year of evolution, greater bone density was evidenced comparing between month 4 and month 12.

Conclusions: By performing a surgical procedure with guided technique and Erbium,Chromium:YSGG laser for the osteotomy, the adverse effects of the surgical procedures are reduced, achieving results with greater accuracy and better prognosis.

KEY WORDS

Er,Cr:YSGG laser, guided periradicular surgery, dental laser, Hounsfield units

INTRODUCTION

Periradicular surgery is one of the options considered to resolve non-surgical endodontic treatment failure and recurrent apical periodontitis when the prognosis of non-surgical retreatment is questionable [1].

We know that the success rate of endodontic microsurgery has increased from 44.2 to 91.1% attributed to technological advances, which allow better visibility during surgery thanks to magnification and direct illumination and the biocompatibility of the materials used [2]. In addition, the use of conventional radiographs provides a two-dimensional view that hinders the precise localization of the lesion; therefore, cone-beam computed tomography (CBCT) is recommended as a complementary tool due to its advantages of showing the exact location of the lesion and its relationship with other anatomical structures, thus allowing precise treatment and post-treatment planning [3-5].

Rubinstein and Kim (2006), suggest that the size of the osteotomy is crucial in the healing process, and advise that the osteotomy should be as small as possible, but wide enough to allow access to the necessary instruments, removal of the periapical lesion and apical resection [5, 6]. It should be noted that the management of freehand periradicular surgery represents greater difficulty when locating the root apex, in addition to the experience of the operator, the technique and the instruments used which are determinant in the amount of alveolar bone removal; This is why guided surgery has been an excellent alternative, which guarantees a more conservative procedure reducing the risk of damage to adjacent anatomical structures, optimizes the time of the procedure, avoids complications and contributes to a better post-surgical prognosis, in addition to improving the healing of the bone defect and reducing postoperative symptoms [7, 8].

Over the years, different techniques have been used to perform osteotomy such as drills, trephine drills, piezoelectric and laser systems [9, 10]. It is also known that the use of rotating parts with drills has been the most used technique; however, it is associated with the generation of heat during the procedure and detritus that increases the inflammatory response with a poor healing process [10-12]. Piezoelectric osteotomy has been used since 2005, with the purpose of minimizing the risks of tissue damage caused by the conventional technique, this is based on ultrasonic microvibrations that through a tip has the ability to cavitate the bone, with the disadvantage of generating too much vibration causing discomfort to the patient [4, 10]. Finally, we have Erbium lasers with wave lengths ranging from 2780 nm to 2940 nm. These lasers have been used in periradicular surgery for approximately two decades [7]. Properly, when used with the proper parameters, a significant decrease in adverse effects has been observed, this is due to the lack of contact with the structures, the reduction of the vibration and reduced heat generation. Thus, as a result, the inflammatory response improves and bacterial filtration after apicoectomy is reduced [13]. Then, its mechanism of action is given by the interaction of Erbium laser with chromophores such as water and hydroxyapatite, through absorption, giving the effect of ablation of mineralized tissues [9, 13]. Thus, thanks to technological advances in bone surgery procedures, a promising alternative to drills, microsaws, trephines and piezosurgery is bone osteotomy by laser [14].

Studies on the use of the Erbium laser in periradicular surgery are limited, which leaves gaps on its different uses and benefits, so studies in this field help to support and give confidence to specialists about the implementation of alternatives in osteotomy during periradicular surgery. Therefore, the objective of this case report is to describe the bone healing process of a guided periradicular surgery with Er,Cr:YSGG laser osteotomy, evaluated by means of CBCT during the first four months after the surgical intervention. The abbreviation Er,Cr:YSGG stands for erbium, chromium: yttrium, scandium, gallium, garnet.

MATERIALS AND METHODS

A descriptive, case report study was performed, approved by the Ethics Committee of the Saint Thomas University (ethical concept 01952023-3129032032 recorded in minute No. 31 of March 29, 2023, in Bucaramanga). The patients who attended the Endodontics Postgraduate Clinic of the Saint Thomas University, Bogotá extension, during the year 2023 were then evaluated. The clinical history and digital periapical radiography were duly completed. In addition, CBCT scans were requested, and one patient was selected who met the inclusion criteria: Patient between 25 and 50 years of age, ASA 1 and 2 (according to the American Society of Anesthesiologists [ASA] Classification), diagnosis of asymptomatic or symptomatic apical periodontitis, pulp calcification, with periapical lesion less than 5 mm, intact vestibular cortex and requirement of periradicular surgery. Finally, patients whose teeth had periodontal disease, maladapted restoration, perforation, interradicular retainer with extension to the apical third, fracture of the apical root third or indication for endodontic retreatment were excluded.

CASE REPORT

The 30-year-old female patient, who came to the clinic of the Dental Federation for consultation with a history of endodontic and prosthetic treatment performed 4 years ago. The patient reported persistent pain during chewing. Clinical examination revealed a fixed prosthesis from tooth #29 (i.e., tooth #45 according to FDI World Dental Federation notation) to tooth #31 (i.e., tooth #47), with pontic #30 adapted. Tooth #29 (i.e., lower right second premolar) presented mild to moderate pain on percussion, without gingival bleeding or periodontal pockets. There were no signs of inflammation or fistulous tract. Radiographically, tooth #29 showed a radiopaque coronal area consistent with an adapted coronal restoration, a radiopaque area within the canal consistent with an intraradicular post and endodontic filling material, a radiolucent area compatible with an enlarged periodontal ligament space, and the mental foramen in relation to the apex of tooth #29 (Figs 1 and 2).

It was decided to perform guided periradicular surgery due to the proximity of the mental foramen to the apex of the tooth #29 (Figs 3 and 4). The patient was informed about the objective of the surgery, the surgical protocol, recovery period, possible complications, accepted and signed the informed consent form containing all the details of the study. Subsequently, an intraoral scan was performed to create the surgical guide. The Digital Imaging and Communications in Medicine (DICOM) files were processed in Blue Sky Plan software (Blue Sky Bio, LLC, Libertyville, IL, United States). The guide was designed (Fig 5A) taking into account the location of the mental foramen, with a surgical window of 4.95 mm high and 6.74 mm wide and then it was printed using a laser printer, and thus we had the essential tool to perform the surgery (Fig 5B).

The variables to be evaluated in this study were bone density, which was measured on CBCT in Hounsfield units (HU), at 3 different times: (T0) pre-surgery, (T1) post-surgery at 24 hours, and (T2) at 4 months.

Surgical Protocol

The patient performed mouthwash with 0.12% chlorhexidine, disinfected extraorally with antiseptic and the fields were placed.

Local anesthesia was administered in the surgical area by means of a truncal block with 4% articaine with 1:100,000 epinephrine and submucosal injections with 2% lidocaine with 1:80,000 epinephrine. The flap design was modified triangular, with intrasulcular access at internal bevel, starting in the distal area of tooth #27 and extending to distal of the pontic of tooth #30. The incision was made with a 15C scalpel blade, and the flap was lifted to full thickness. Finally, the fit of the surgical guide was verified (Fig 6A).

FIGURE 1. Initial periapical radiography.

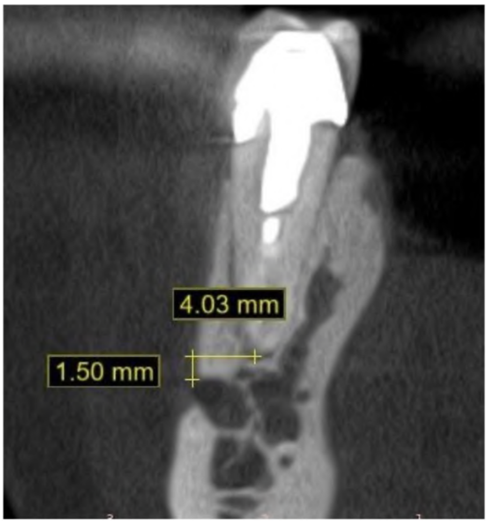

FIGURE 2. CBCT coronal section. Bone cortical thickness to the apex of the tooth #29. Mental foramen and apex of the tooth #29 relationship.

FIGURE 3. CBCT coronal section. Mental foramen to tooth #29 apex relationship.

FIGURE 4. CBCT: Path of the inferior alveolar nerve (*yellow*) to the exit of its terminal branch (mental nerve) through the mental foramen.

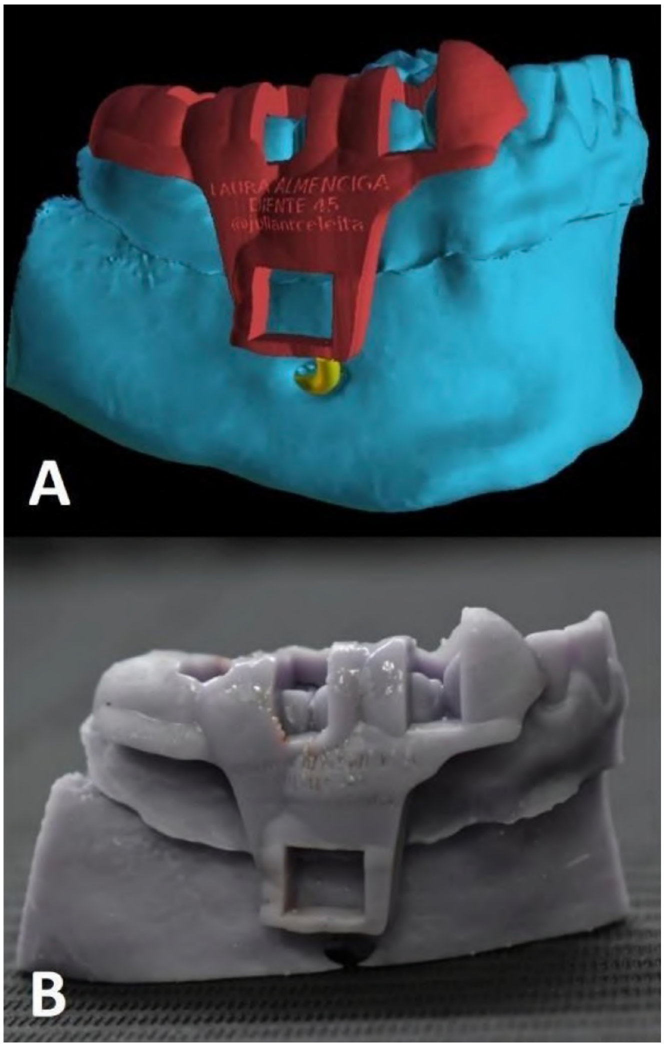

FIGURE 5. Surgical guide with focus on the periapical area of the root of tooth #29 (i.e., lower right second premolar [tooth #45]). **A**, Design of the surgical guide. **B**, Printed guide.

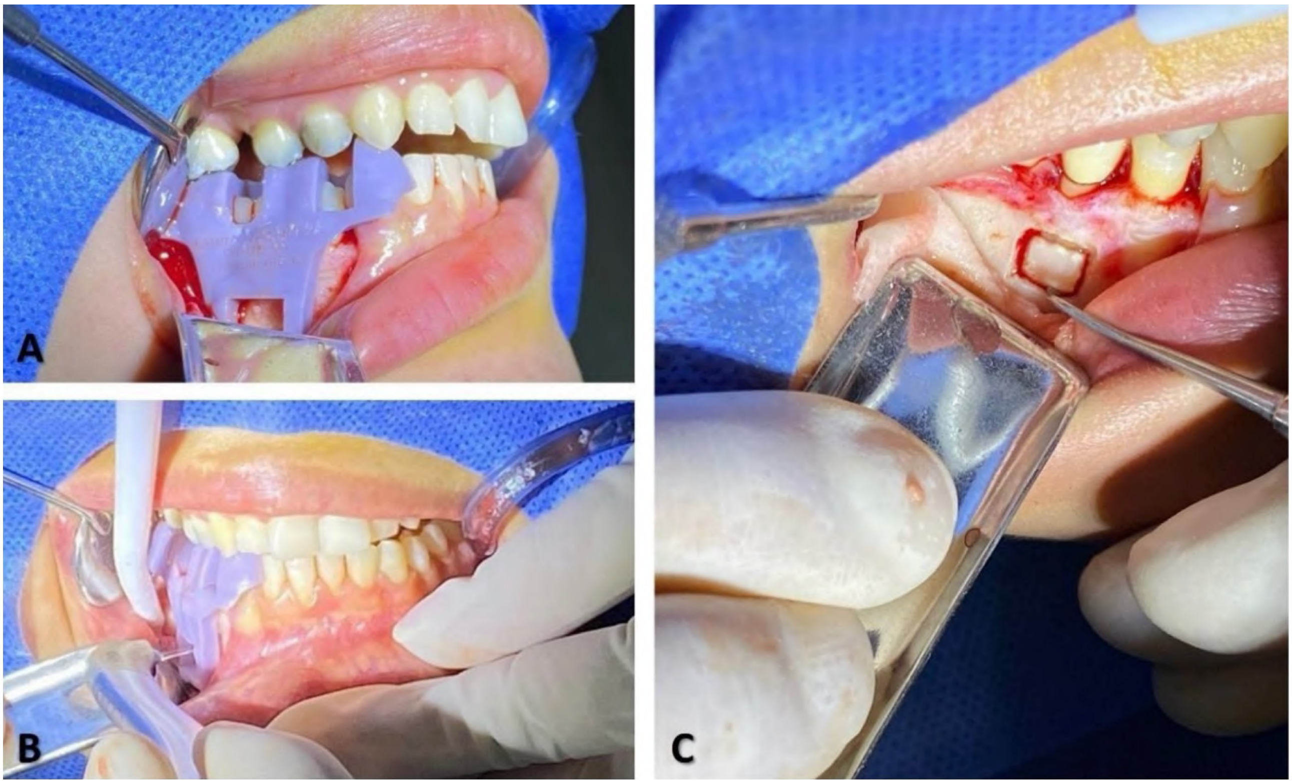

FIGURE 6. A, Surgical guidance test. **B**, Erbium laser osteotomy. **C**, Bone window.

Erbium,Chromium:YSGG Laser Protocol

Laser protective goggles were used on the operator and the patient. The water flow in the Erbium laser (Fig 7) was checked before starting the surgical procedure.

Limited by the window of the surgical guide (6.74mm and 4.95mm), the osteotomy was performed with the 2780 nm Erbium,Chromium:YSGG laser (Waterlase MD; Biolase, Inc., Foothill Ranch, California, United States) with one fiber, MG6 tip, 6 mm length, 3.5 W power, 20 Hz frequency, 55% air, 45% water, H mode, the laser tip is contacted with the bone cortex making firm and continuous movements (Fig 6B,C). The time used to perform the bone window was counted, which was 11'37"73, the bone fragment was removed with the help of a Buser style periosteal elevator and preserved in saline solution.

Periradicular Surgery

The root apex was checked with methylene blue to rule out possible fractures or fissures and the apical 3mm were resected by cutting with a Zekrya bur (Fig 8A). The lesion was removed with Lucas curette and hemostasis was performed with sterile gauze impregnated with cold saline. Apical retro-preparation of 3 mm was performed with E11D ultrasonic diamond tip and and retro-obturated with Biodentine® bioceramic material (Septodont Ltd., Saint-Maur-des-Fossés, France). Type I collagen sponge was used, the bone cortex was repositioned, the 15 x 20 mm pericardium membrane (bonefill lamina, Bionnovation Biomedical Bauru, São Paulo, Brazil) was positioned, the flap was repositioned and sutured with 6-0 monofilament suture, Polygalactin 910 (Fig 8B-D). Finally, the surgical field was compressed with moist sterile gauze for 3 to 5 minutes for hemostasis.

The following medications were formulated: (1) 500-mg Amoxicillin capsule #21 (1 every 8 hours), (2) 8-mg Dexamethasone ampoule (single dose), and (3) 500-mg Naproxen tablet #9 (1 every 8 hours).

Postoperative Management

CBCT was taken 24 hours after the surgical procedure (T1).

FIGURE 7. Erbium,Chromium:YSGG laser handpiece.

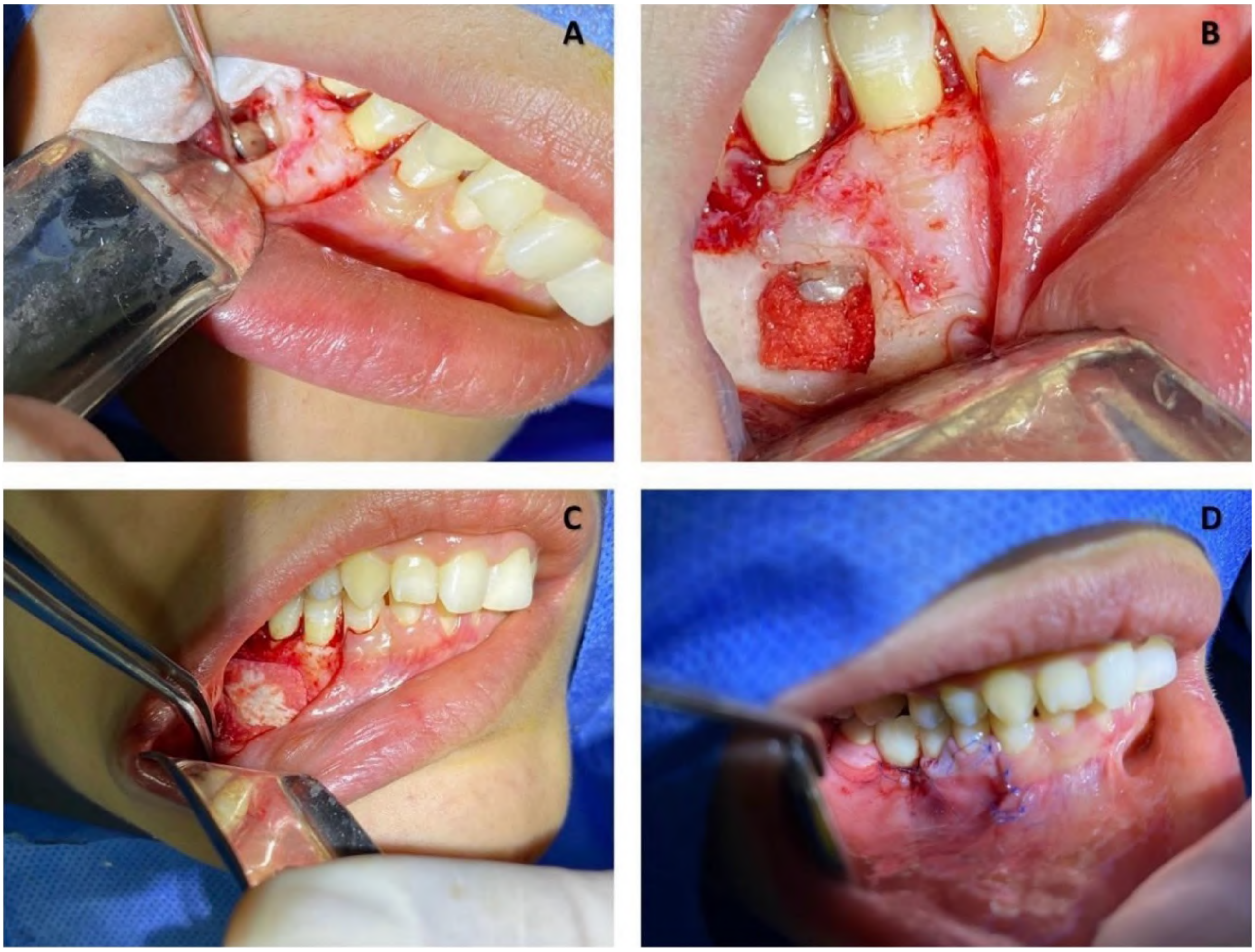

FIGURE 8. Periradicular surgery of the tooth #29 (i.e., lower right second premolar). **A**, Apical resection. **B**, Retrofilling and collagen sponge. **C**, Collagen membrane position. **D**, Flap repositioning and suturing.

Eight days after surgery, the suture was removed, and good healing was observed (Fig 9). Figure 10 shows the condition of soft tissues 1 month after the surgery.

At 4 months CBCT (T2) was taken. By means of the Blue Sky Plan software on the CBCT, the bone density of the bone in the surgical area was measured in Hounsfield units (HU).

Bone Density

Bone density values were measured by the same trained operator.

Preoperative and postoperative measurements were taken in different slices (axial, coronal and sagittal) and the results are shown in Tables 1, 2 and 3.

The preoperative bone density in the vestibular axial slice at the apex (T0) was between 1435 and 1478 HU and at 4 months (T2) between 860 and 992 HU. While the initial bone density at 3 mm from the apex in vestibular (T0) was between 1452 and 1661 HU, and at 4 months (T2) was between 882 and 1392 HU. The lowest bone density values in vestibular are reported 24 hours after surgery with negative values between -210 and -95 HU at the apex and at 3 mm from the apex between -199 and -63 HU (Fig 11).

In the different areas (distal, medial and mesial) of the coronal section the preoperative bone density (T0) in vestibular was between 1335 and 1651 HU, at 24 hours after surgery (T1) the values in vestibular were between -166 and 270 HU and in the control at 4 months between 591 and 1269 HU (Fig 12).

In the sagittal section before surgery (T0) the HU values were between 165 and 1281 HU (average 511 HU), later (T1) between 130 and 793 HU (average 501 HU), and at 4 months (T2) between 427 and 1094 HU (average 853 HU) (Fig 13).

The patient did not report transient paresthesia at any time postoperatively and the follow-up CBCT at 4 months shows satisfactory periapical bone healing, considering that this is the short-term control available.

12-Month Follow-Up

At one year of evolution, greater bone density was evidenced comparing between month 4 and month 12 (Fig 14).

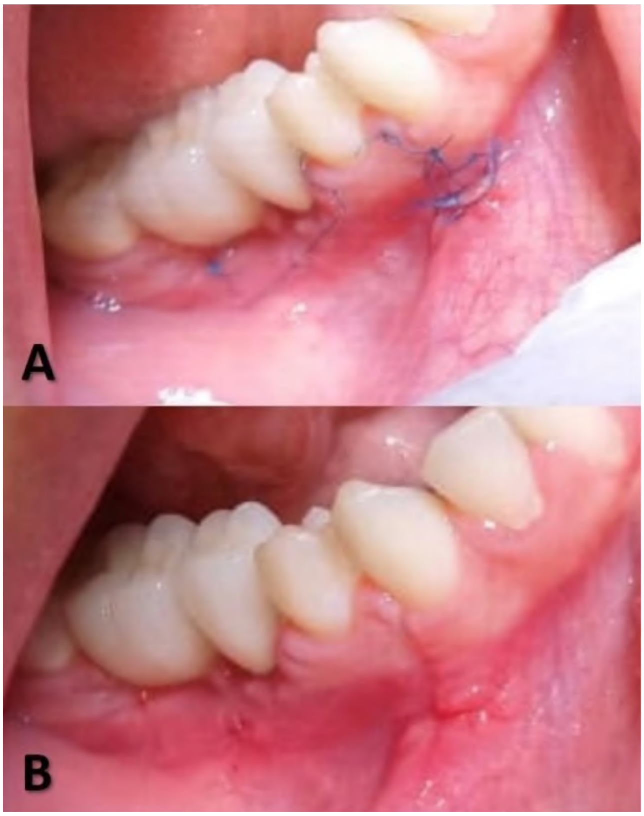

FIGURE 9. Postoperative period. **A**, Sutures at day 8. **B**, Immediate view after removal of the sutures.

FIGURE 10. Condition of soft tissues 1 month after the surgery.

TABLE 1. CBCT: Measurements in HU in Axial Aection.

AXIAL SECTION - BONE DENSITY (HU)								
Time Period	Apex				3mm from apex			
	Vestibular		Lingual		Vestibular		Lingual	
T0 Pre-operative	1478	1435	555	85	1661	1452	727	912
T1 24 Hours	-95	-210	251	76	-63	-199	368	389
T2 4 month	992	860	968	1139	882	1392	1028	1131

TABLE 2. CBCT: Coronal Section Measurements in HU.

CORONAL SECTION - BONE DENSITY (UH)												
Time Period	Distal Zone				Middle Zone				Mesial Zone			
	Vestibular		Lingual		Vestibular		Lingual		Vestibular		Lingual	
T0 pre-operative	1630	1651	1435	787	1480	1335	1599	664	1615	1346	1392	1281
T1 24 Hours	-117	-104	16	440	270	-18	-174	3	-166	-16	83	172
T2 4 month	770	1204	861	622	778	1269	477	861	591	1258	946	575

TABLE 3. Sagittal Section Measurements in HU.

SAGITTAL SECTION - BONE DENSITY (HU)			
Time Period		Distal	Mesial
T0 Pre-operative	Coronal Apical	127 165	1281 471
T1 24 Hours	Coronal Apical	296 130	787 793
T2 4 month	Coronal Apical	808 427	1094 1084

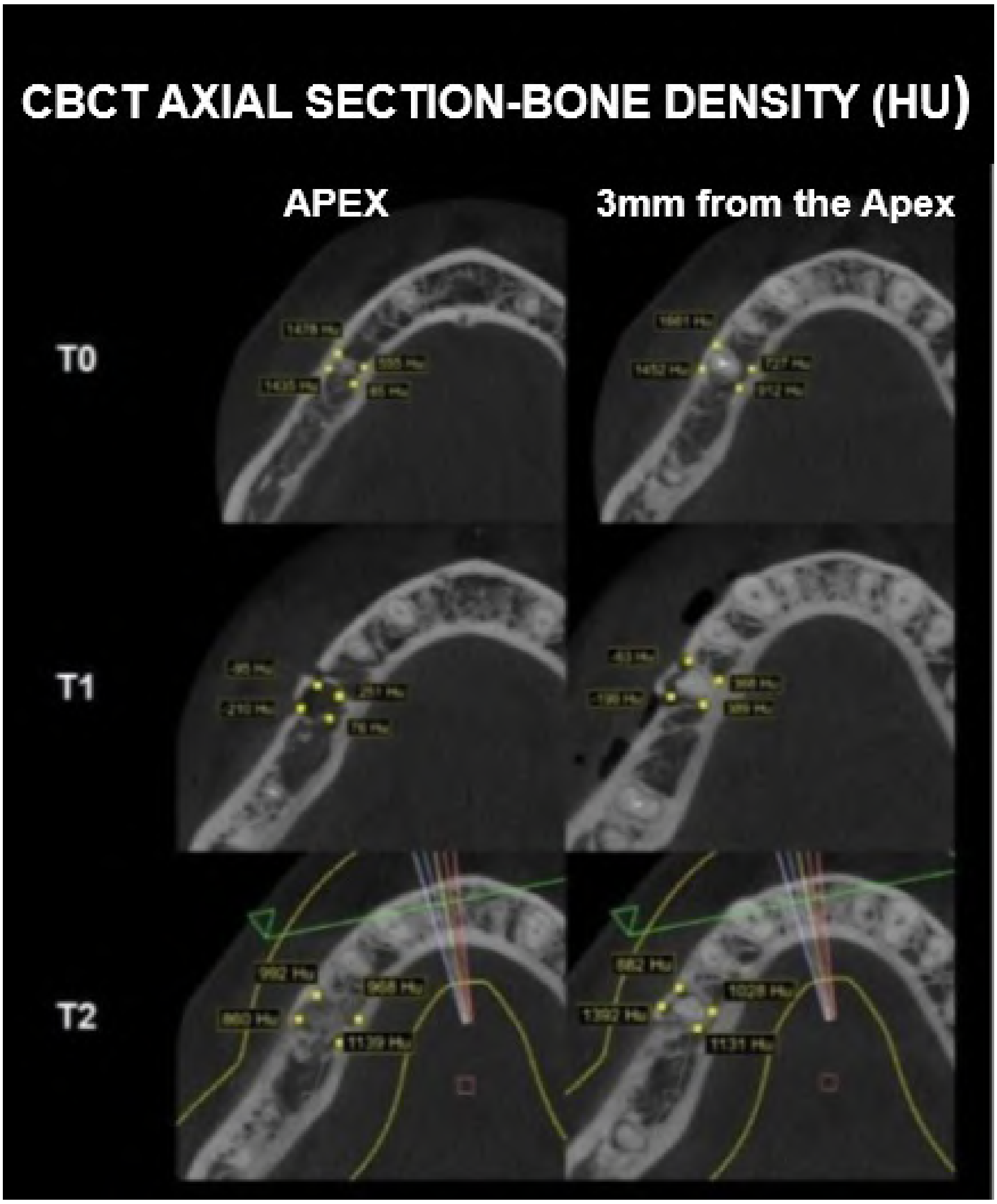

FIGURE 11. CBCT: Bone density measured in axial section.

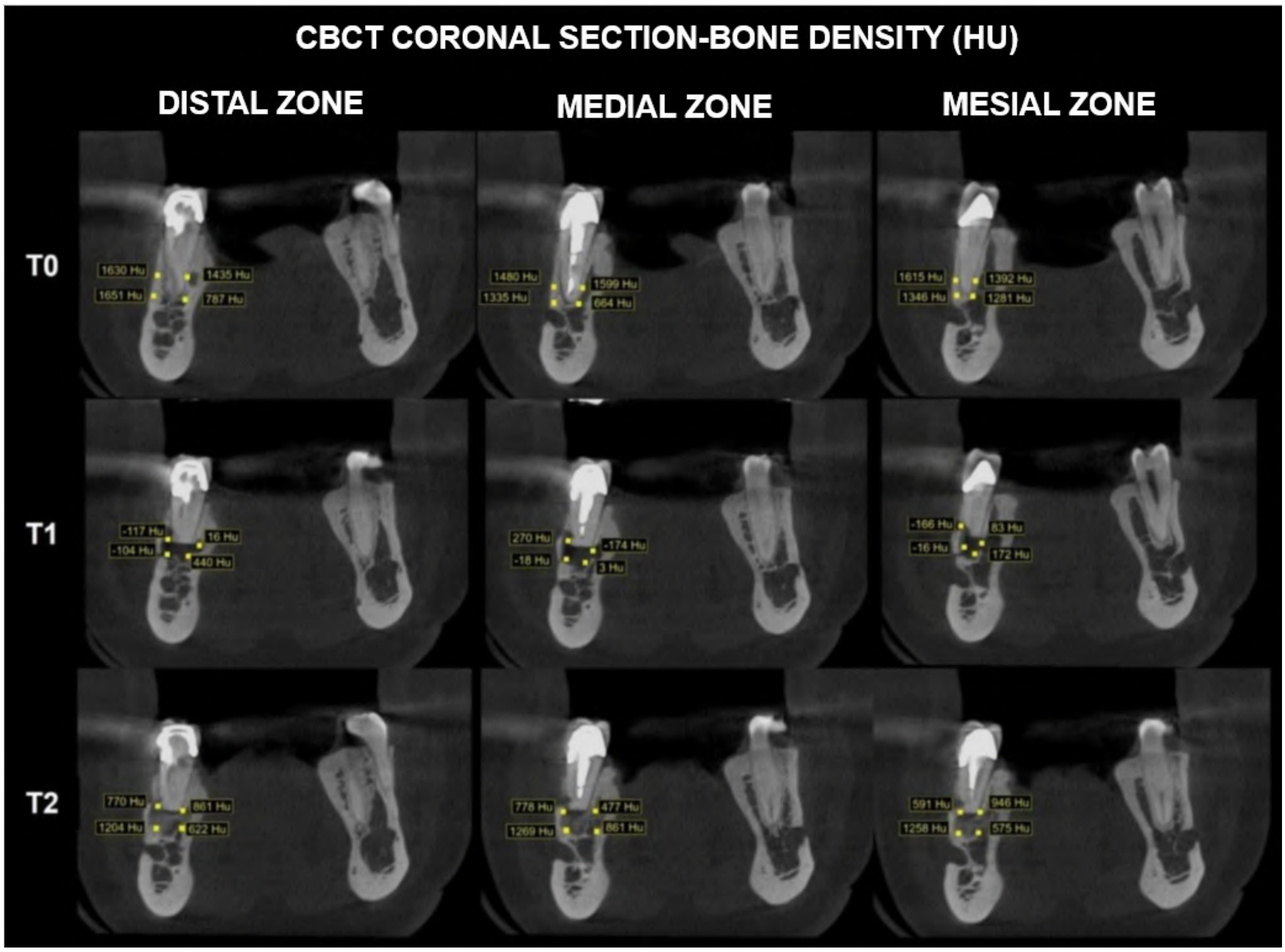

FIGURE 12. Bone density measured in HU taken in three coronal slices.

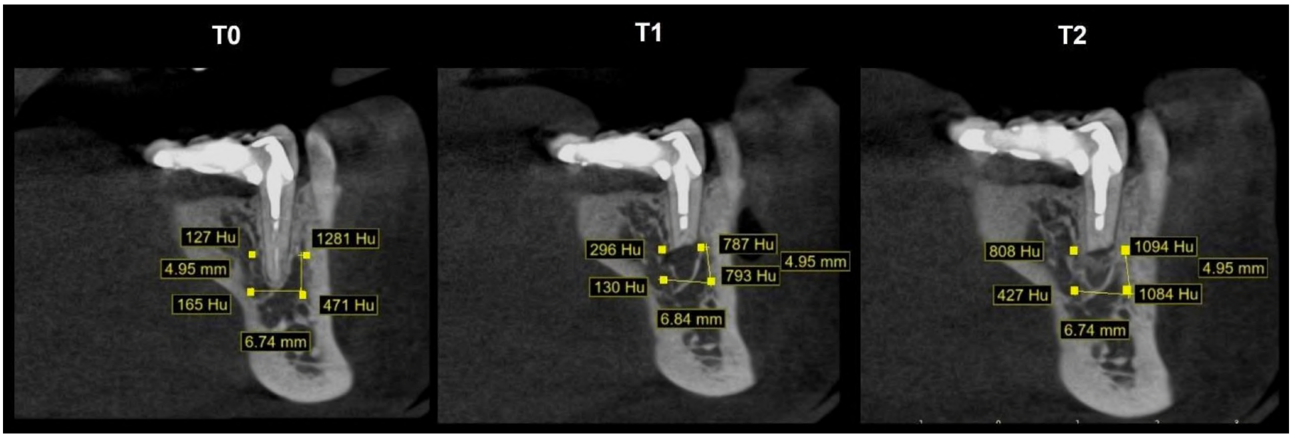

FIGURE 13. CBCT: Bone density measured in sagittal section in HU.

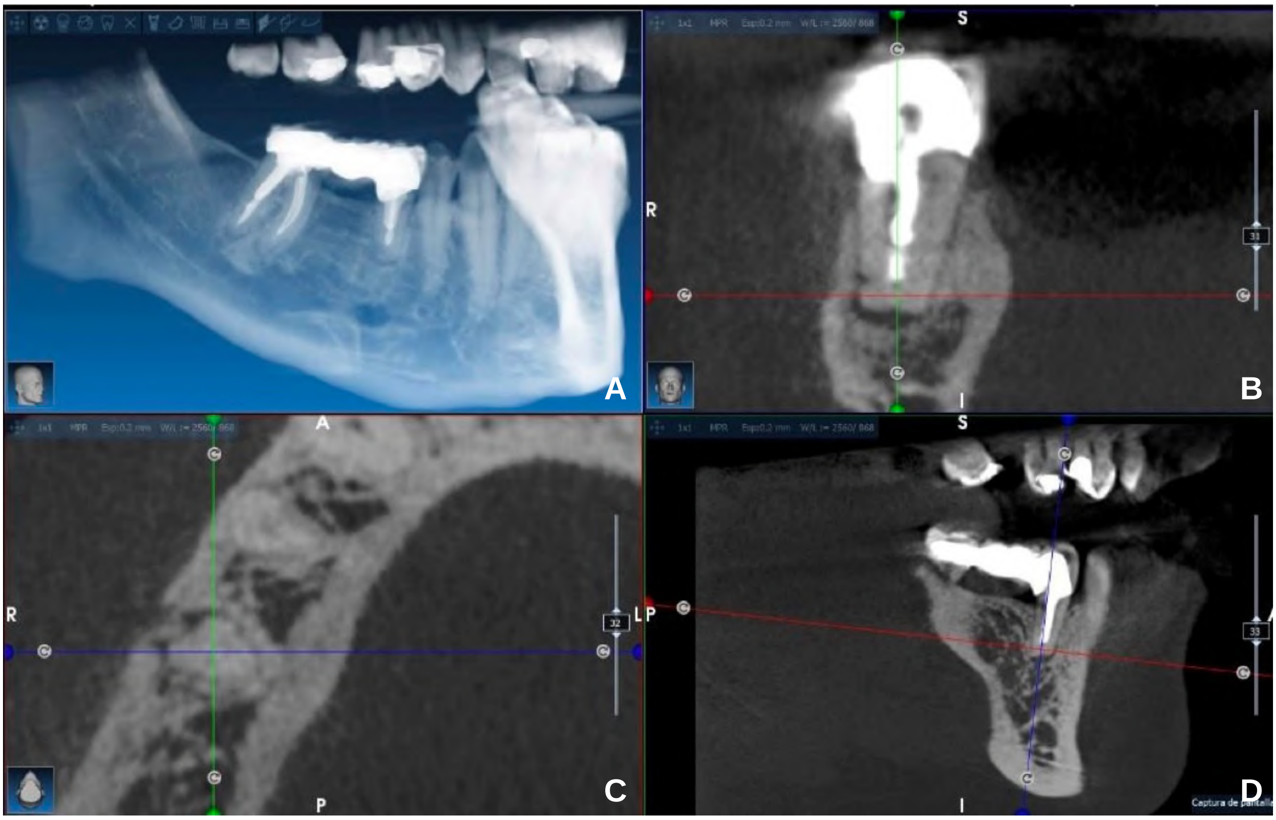

FIGURE 14. CBCT at 12-month follow-up. **A**, Three-dimensional view. **B**, Coronal section. **C**, Axial section. **D**, Sagittal section.

DISCUSSION

Endodontic surgery is defined as the treatment performed on the root apices of an infected tooth that was not resolved with conventional endodontics. In lower posterior teeth this surgery can be more difficult due to limited access, the thickness of the vestibular bone cortex, root morphology and the proximity of the apex to the dental canal and mental foramen [2].

Although there are morphological generalities, each patient presents anatomical variations that may increase the risks during periradicular surgery, therefore, the professional should identify them during the preoperative phase to plan the patient's treatment.

The mental foramen is an important anatomical structure to be taken into account during surgery, being necessary to consider its shape, location, extension of the anterior loop and presence of accessory mental foramina before any surgery to avoid injuring the nerve.

According to a study by Shalash et al. (2020) in a sample of 120 patients, the anterior loop was present in 55% of the cases, while studies report an incidence of accessory mental foramen between 3% and 10.67% which, although smaller, is usually located near the root apex of the second premolars [15]. Therefore, protection of these anatomical structures is important to avoid nerve injury during apical surgery [16].

Regarding the mental foramen in a study by Wang et al. (2017) the results indicated that the majority of the lower posterior teeth can be safely treated by endodontic microsurgery, because the mean distance for most roots with the mental foramen was greater than 5.9 mm, however, that horizontal distance was less than 2 mm in 19.9% of second premolars [16]; Although the debate persists, different studies concluded that in most patients the mental foramen is closer to the second premolar apex [16-20].

The clinical aspect of this study was the proximity of the mental foramen to the root apex of the tooth to be treated, since the distance measured in the tomography was 1.5 mm (Fig 3); therefore, identifying its exact position with respect to the root apex was important for surgical planning and thus reducing or avoiding damage to the neurovascular bundle that could leave temporary or permanent sequelae in the patient.

Phillips et al. (1992) in their study on mandibles observed that the radiographic position of the mental foramen was located 3.8 mm mesial to its real location of the tooth apex in 71% of the periapical radiographs examined [21], therefore, measurements on periapical radiographs are not reliable for a surgical approach. In the present clinical case, the use of CBCT was decided for greater planning accuracy.

Pinsky et al. (2007) showed an error of more than 3 mm in 22% of the osteotomies performed freehand and no error with the use of surgical guidance, thus the use of CBCT, surgical guidance together with periradicular microsurgery, are the choice in highly complex cases, and for this reason they were used in the planning and execution of the surgery in the case report of this study [22].

Osteotomy is a surgical procedure in which the bony cortex is removed to establish access to the root apices [16]. Rubinstein and Kim (2002), advise that the osteotomy should be minimal in size, but at the same time and enough extensive to allow adequate visualization and access to the instruments required to treat the tissues [6, 10]. Among the disadvantages of performing freehand osteotomy is damage to anatomically important structures and increased size of the bony defect, which is associated with unsuccessful, uncertain or delayed healing, and increased risk of postoperative complications [23, 24]. In this study, trauma was minimized by using surgical guidance to perform the bony window over the apex, taking into account that the vestibular cortical bony plate was intact. The osseous window measured 6.74 mm and 4.95 mm.

In addition, it was taken into account at the time of the osteotomy that fractures can occur due to the contact pressure exerted by the cutting instrument and the vibration generated by mechanical instruments [8], being important to highlight that the friction generated with the conventional method can cause pain, thermal damage to the surrounding tissue, chip deposition and bacterial contamination [25]. Some authors have demonstrated positive effects on bone healing derived from the use of piezoelectric compared to conventional mechanical methods [25-27]. However, studies such as that of Pandurić et al. (2012) performed on pig ribs and that of Pandarathodiyil et al. (2020) highlight that Erbium laser osteotomy, has no direct contact with the structures, offers a regular cut, operative field free of impurities, absence of carbonization, short time for its execution and elimination of the smear layer that allow the blood cells to adhere more easily on the intervened surface resulting in a better healing process [28, 29]. Studies in animal models have shown that the irradiation generated with the Er,Cr:YSGG laser stimulates the secretion of platelet-derived growth factor, reinforcing the premise of improved healing at the intervened site [30]. Thanks to the incorporation of high energy lasers for bone surgery procedures in the last decades, it is possible to highlight the properties of the Erbium laser in these treatments. Also, studies speak of the advantages of using the Erbium laser in periradicular surgery compared to conventional surgical procedures, such as the tendency to less bleeding, less tissue trauma of surrounding tissues, absence of vibrations and less heat production in hard tissues [13]; mentioned benefits, it was chosen to perform the osteotomy of the periradicular surgery of this case report with the Er,Cr:YSGG laser, being evident during the procedure the low presence of bleeding, uniform cutting of the bone tissue and the minimum generation of bone spicules or fragments, its easy handling, absence of necrosis and carbonization zone due to the constant irrigation of the Erbium laser that avoids overheating of the bone.

The use of the Erbium laser has been reported since 1960 and has been investigated and used in a wide variety of wavelengths depending on the requirement, whether for coagulation, vaporization and ablation of hard and soft tissues [26]. The Er,Cr:YSGG is of infrared energy distribution with a wavelength of 2780 nm, non-ionizing, pulsed emission, and its active medium consists of Erbium (Er), Chromium (Cr), Yttrium (Y), Scandium (S), the Gallium (G), and Garnet (G), and is provided with an aerosol of water and air, which in combination with the light beam, cools the area of incidence, which minimizes the thermal effects and enhances its mechanism of action, for a variety of intraoral applications [31, 32].

On the other hand, the interaction between the Erbium laser and chromophores present in the tissue, such as water and hydroxyapatite, occurs through a thermomechanical ablation mechanism. This phenomenon is commonly known as “water molecule explosion", where surface water in the tissue matrix undergoes a rapid increase in temperature, resulting in increased molecular vibration and consequently an increase in surface pressure [33].

In a study carried out in rabbits by De Santis et al. (2018) selected five instruments for osteotomy used in dentistry (burr, Piezosurgery I, Piezosurgery II, erbium-doped yttrium aluminium garnet laser [Er:YAG laser], and Er,Cr:YSGG laser) with which they evaluated the cutting characteristics in vivo and in vitro; the results showed that the width of the cut represents an increased risk of rupture depending on the caliber and vibrations of the instrument during osteotomy, the burr obtained the highest values, followed by Piezosurgery I, Piezosurgery II, and Er:YAG laser, and the lowest risk was evidenced with the use of the Er,Cr:YSGG laser [34]. The number of repetitions was also evaluated giving as results higher number of interventions recorded in both piezoelectric devices to perform the same osteotomy. Finally, the data regarding osteotomy time showed some significant differences between the devices.

The drill needs twice less time than Piezosurgery I and Er,Cr:YSGG laser and three times less time than Piezosurgery II and Er:YAG laser to execute the same procedure [34]. The Er,Cr;YSGG laser osteotomy performed in this case report took 11 minutes and 37 seconds, which is considered an optimal time for this procedure if one seeks to generate the least tissue damage. However, this time is influenced by several factors, including the size of the bony window, the thickness of the osseous cortex, the complexity of accessing the site to be intervened, and the additional caution due to the proximity of the mental foramen.

De Santis et al. also analyzed the surface morphology of the cut and examined them with optical microscopy, and observed that the drill is less precise, generates irregular edges and tears the periosteal tissue, while the piezoelectric I and II allow straighter cuts, and both lasers generate slightly wavy cut edges, due to the absence of direct contact of the device and the physiological fluctuations of the operator's hand [34]. Thus, they conclude that the drill produces a large amount of small debris that obstructs the medullary spaces, the Piezosurgery II generates abundant detritus due to the type of vibration, and, on the contrary, this eventuality is almost completely absent with the laser and Piezosurgery I, these devices generate a lower amount of detritus, substantially preserving the medullary spaces [34]. The study points out that, although the piezoelectric and Erbium laser demonstrate advantages, their high acquisition cost and the need for specific training continue to limit their use among professionals, in addition to highlighting that the Erbium laser has advantages in case of risky interventions near to anatomical landmarks [34]. For this study, the Er,Cr;YSGG Laser was chosen, but, the choice of the instrument to perform the osteotomy is going to depend on the experience of the operator and the characteristics of the intervention. For this reason, before the patient was operated on, a pilot test was performed on pig mandibles to perform osteotomies with the Er,Cr:YSGG laser.

In their study, De Oliveira et al. (2016), highlight that one of the limitations of the use of the Er,Cr:YSGG laser for bone tissue ablation are the time required to remove the desired tissue compared to drills mounted on high-speed handpieces [35]; However, the alteration in the pulsed mode of lasers proved to be an alternative to accelerate the ablation of bone tissue and, thus, solve this limitation, furthermore they refer that it is likely that the irregularities observed after Laser irradiation in their study are beneficial for healing because they facilitate the adhesion of the fibrin network, which represents the first event of hard tissue healing [35].

Thus, it should be evaluated whether the time taken to achieve osteotomy really represents.

A disadvantage versus the described benefits of Er,Cr:YSGG laser in performing osteotomy. HU scanning is used to distinguish tissue types, such as cysts from granulomas, e.g., air = -1000 HU, water = 0 HU, muscle = +40 HU, and bone >+400 HU [36]. Some studies suggest that scatter and artifacts have undesirable impacts on the reliability of HU values in CBCT images and this is why HU values are applied over CT. However, there are also several studies reporting that HU values could be used to assess bone density in CBCT images with certain advantages over multi-slice computed tomography (MSCT), such as high resolution, potentially lower radiation doses and reduced costs [37], so it remains the best available method to monitor bone mineral density changes, provided that the same CBCT machine and scanning configuration are used [38]. In the methodology used for this study, the same tomographic equipment was used with the same image acquisition setup, patient head posture and fields of view (FOV) during image acquisition to minimize problems associated with the technique.

The HU depends on the composition and nature of the tissue being imaged, thus denser tissue (higher absorption of the X-ray beam) has positive values, while less dense tissue (lower absorption) has negative values, where distilled water is arbitrarily defined as zero HU and air as -1000 HU. Upper limits can reach up to 1000 HU for bone, 2000 HU for dense bone such as the cochlea, over 3000 HU for metals and muscle 40 HU [36, 39]. Continuing advances in computed tomography (CT) as a diagnostic tool have resulted in different CT designs. In turn, different CT designs may alter HU. For example, CBCT, used primarily in dentistry, cannot show true HU similarly to conventional CT, but does show a strong correlation [39]. In this case report, in the axial section, preoperative values (T0) in vestibular at the apex of 1478 and 1435 HU were recorded, which after periradicular surgery (T1) were -95 and -210 HU, and in the 4-month control (T2) positive values of 992 and 860 HU were again recorded, Similarly, in the coronal section in the mid vestibular area at the apex level, a preoperative value (T0) of 1335 HU was reported, which 24 hours after periradicular surgery (T1) was -18 HU and at 4 months 1269 HU. The negative values correspond to the space due to the apical resection of the root and the positive values after 4 months show a real healing process in the area of the apical resection.

A study by Goyushov et al. (2023) measured periapical bone density in lower teeth with CBCT. The mean value of HU in the periapices of premolars was 470.58 HU [37]. In the present case report the HU values taken in the sagittal cut before surgery (T0) had an average of 511 HU, at 24 hours (T1) average of 501 HU, and in the control at 4 months (T2) an average of 853 HU, these values were measured taking into account the size of the surgical guide that was used to make the bone window, HU values at the three moments do not show negative values, and the average HU before and 24 hours after surgery is similar indicating that the osteotomy was kept within the limits of the surgical guide preserving the bone tissue and taking care not to lacerate the mental nerve.

The use of HU to measure tissue density has aided radiologists in image interpretation and disease diagnosis, and is used in different specialties of medicine, for example in the diagnosis of fatty liver, predictor of growth in meningiomas, differential diagnosis of odontogenic cysts, determine bone density, estimate bone quality prior to spinal instrumentation, predict pedicle screw loosening and in degenerative lumbar scoliosis, among many other uses [39], such as assessing bone quality prior to implant surgery, particularly immediate implantation, it has been shown that primary implant stability improves with higher peri-implant bone density (higher HU values) [37]. The use of these tools is useful to establish whether new technologies really favor and accelerate the bone healing process.

CONCLUSIONS AND RECOMMENDATIONS

From the clinical case report it is highlighted that the patient did not manifest neural alteration, and the postoperative symptomatology was very positive. Even, in the control performed at 4 months the patient did not present pain on percussion or chewing. The clinical and tomographic healing process up to 4 months has been positive. It is recommended to perform controls at 8 months, 1, 2, and 5 years.

In the same line, it was observed that by performing a surgical procedure with a guided technique and with Erbium laser for the osteotomy, the adverse effects of the surgical procedures are reduced, achieving results with greater accuracy and better prognosis.

On the other hand, guided periradicular surgery is an excellent alternative in cases without fenestration that helps to minimize the extension of the osteotomy, facilitates the location of the pathologic process area and protects nerve structures. Likewise, the Er,Cr:YSGG laser is useful for professionals in oral surgical procedures because it favors better healing by generating fewer adverse effects, due to the fact that it ablates the tissue through absorption by chromophores. Moreover, more studies using the Er,Cr:YSGG laser in osteotomy during periradicular surgery with a larger sample size and comparing it with other techniques are required to determine if the advantages offered by the laser in the healing process are statistically significant.

Finally, to know how to measure bone density as a Hounsfield units can be useful as a diagnostic tool and provide information that allows the modification of surgical techniques.

CONFLICT OF INTEREST

The authors declare that they don't have any conflicts of interest.

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ЗВІТ ПРО ВИПАДОК/МЕТОДИКА UKRAINIAN LANGUAGE

Керована перірадикулярна хірургія із остеотомією лазером Er,Cr:YSGG: опис випадку

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АНОТАЦІЯ

Мета. Метою дослідження є спостереження за процесом загоєння кістки під час керованої навколокореневої хірургії, виконаної на курсах післядипломної освіти з ендодонтії Університету святого Томаса, під час якої була виконана остеотомія кісткового вікна за допомогою ербієвого, хромового: ітрієвого, скандієвого, галієвого, гранатового (Erbium,Chromium:YSGG) лазера (також називається Er,Cr:YSGG лазером), а процес загоєння оцінювався за допомогою конусно-променевої комп'ютерної томографії (КПКТ) протягом перших чотирьох місяців після операції.

Матеріали і методи. Після збору анамнезу та вивчення даних комп'ютерної томографії було відібра-

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Слово «шаблон» у верхньому правому значку означає, що стаття містить опис перирадикулярної хірургії із застосуванням хірургічного шаблона та лазера Er,Cr:YSGG.

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но пацієнта з діагнозом: симптоматичний апікальний періодонтит, періапікальне ураження менше 5 мм з інтактною вестибулярною кортикальною кісткою, що потребує перірадикулярного хірургічного втручання у зв’язку з наявністю адаптованого незнімного протеза та близькість підборідного отвору до верхівки зуба, який підлягає лікуванню. Було складено план лікування, розроблено хірургічний шаблон та виконано остеотомію за допомогою Er,Cr:YSGG лазера. Розмір перірадикулярного ураження та щільність кісткової тканини хірургічної зони вимірювали в три моменти часу: передопераційний (T0), післяопераційний через 24 години (T1) та через 4 місяці (T2).

Результати. Щільність кісткової тканини, виміряна в одиницях Хаунсфілда (Hounsfield units (HU)) на КПКТ в аксіальному розрізі, показала передопераційні значення у вестибулярній верхівці 1478 і 1435 HU, через 24 години після операції -95 і -210 HU, а в контрольній групі через 4 місяці 992 і 860 HU. У коронарному зрізі в середній вестибулярній області на рівні верхівки передопераційне значення (T0) становило 1335 HU, через 24 години (T1) -18 HU і через 4 місяці 1269 HU. За один рік спостереження була виявлена більша щільність кісткової тканини порівняно з 4-м і 12-м місяцями.

Висновки. Виконуючи хірургічне втручання із керованою технікою та Er,Cr:YSGG лазером для остеотомії, побічні ефекти хірургічних процедур зменшуються, досягаючи результатів з більшою точністю та кращим прогнозом.

КЛЮЧОВІ СЛОВА

Лазер Er,Cr:YSGG, керована перірадикулярна хірургія, стоматологічний лазер, одиниці Хаунсфілда

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CASO CLÍNICO/TÉCNICA SPANISH LANGUAGE

Cirugía perirradicular guiada con osteotomía láser Er Cr:IEGG: informe de un caso

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RESUMEN

Objetivo: El objetivo del estudio es observar el proceso de cicatrización ósea de una cirugía perirradicular guiada, realizada en el posgrado de endodoncia de la Universidad Santo Tomás, en la que se realizó osteotomía para ventana ósea con láser de Erbio, Cromo: Itrio, Escandio, Galio, Granate (Erbio,Cromo:IEGG) (también se puede escribir como Er Cr:IEGG láser) y se evaluó el proceso de cicatrización mediante tomografía computarizada de haz cónico (TCHC) durante los primeros cuatro meses posteriores a la cirugía.

Materiales y métodos: Luego de completar la historia clínica y estudiar las imágenes de TCHC, se seleccionó un paciente con diagnóstico de periodontitis apical sintomática, lesión periapical menor de 5mm con cortical

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La palabra 'Guía' en el ícono superior derecho significa que el artículo contiene una descripción de la cirugía perirradicular aplicando guía quirúrgica y láser Er Cr:IEGG.

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vestibular íntegra que requirió cirugía perirradicular debido a la presencia de prótesis fija adaptada y la proximidad del foramen mentoniano al ápice del diente a tratar. Se estableció el plan de tratamiento, se diseñó la guía quirúrgica y se realizó la osteotomía con láser Erbio,Cromo:IEGG. Se midió el tamaño de la lesión perirradicular y la densidad ósea del área quirúrgica en tres momentos: prequirúrgico (T0), postquirúrgico a las 24 horas (T1) y a los 4 meses (T2).

Resultados: La densidad ósea medida en unidades Hounsfield (UH) en TCHC en el corte axial mostró valores preoperatorios en el ápice vestibular de 1478 y 1435 UH, a las 24 horas postoperatorias -95 y -210 UH, y en el control a los 4 meses de 992 y 860 UH. En el corte coronal en la zona vestibular media a nivel del ápice se reportó un valor preoperatorio (T0) de 1335 UH, a las 24 horas (T1) -18 UH y a los 4 meses 1269 UH. Al año de evolución se evidenció mayor densidad ósea comparando entre el mes 4 y el mes 12.

Conclusiones: Al realizar un procedimiento quirúrgico con técnica guiada y láser Erbio,Cromo:IEGG para la osteotomía se disminuyen los efectos adversos de los procedimientos quirúrgicos, logrando resultados con mayor precisión y mejor pronóstico.

PALABRAS CLAVE

Láser Erbio,Cromo:IEGG, cirugía perirradicular guiada, láser dental, unidades Hounsfield