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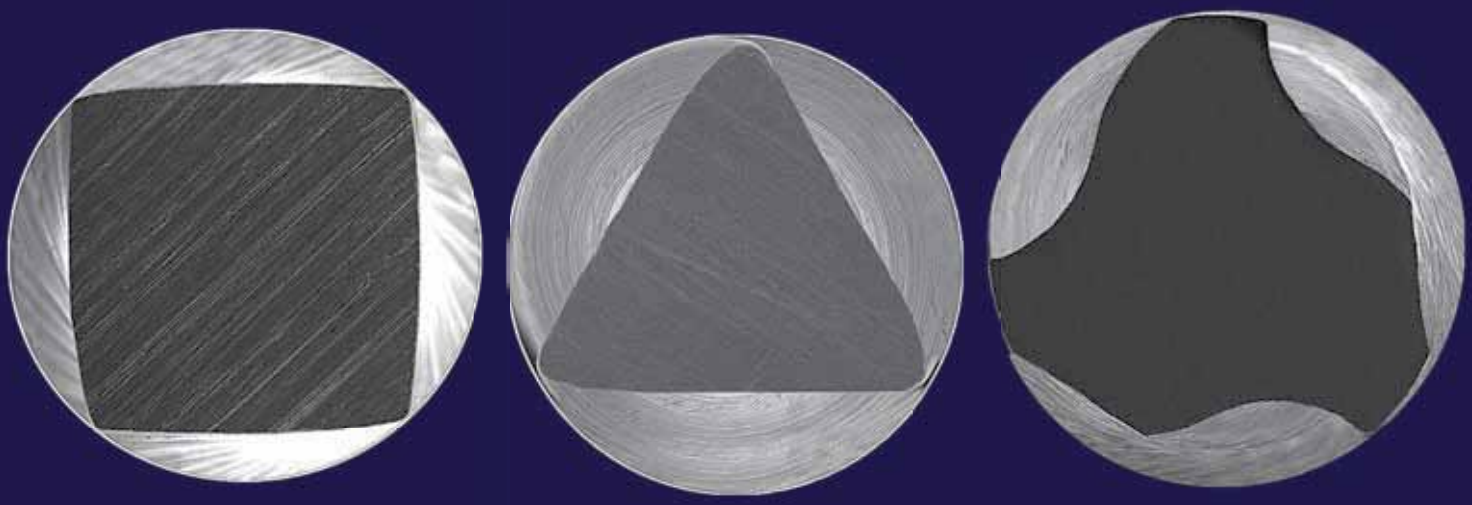

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Research challenges

Discovering new knowledge is an amazing fact. The perception is greater than watching a seed germinate after planting. In fact, the impression you get is as if you were preparing the seed itself. The acquisition of a new knowledge seeks to answer open and necessary questions for the progress which characterizes its importance in all areas of human life. Currently, many people fully commit their lives to this essential sector.

The "social and economic development of a country" is linked to science and present technology. Trained staff (researcher), an appropriate location (laboratory) and a condition for execution (available resources) are indispensable. The speed of economic and political return difficults the interests and investments in advances in research and training of new researchers. Brazil has witnessed a special moment, with well-deserved international prominence. It is observed that in several high-impact journals stands a growing number of studies by Brazilian researchers.

The interrelationship between teaching and research values the teacher-researcher, as well as the student, which characterizes the basic goal of knowledge. The association between education and research in dentistry facilitates the understanding of the scientific method, highlighting the need of the teacher-researcher understand it with a view to better implementation. It is worth recalling that the practice of science (educational-investigative, based on the construction and transmission of knowledge) is difficult to be explained and passed, imposing for the correct valorization and learning, the need to experience it. Be open to redirect it when it is needed becomes a constant.

A research challenge is to keep alive the reasons for seeking solutions to the problems created. Scale the consequences of the responses or trials, joys and frustrations, success or failure of the researcher is unpredictable. The balance and timing are crucial to the process. The motivation of the researcher can never end, as well as the value of the teacher, researcher, and father... The perfect interaction between the researcher and his students develops when both have maintained similar levels of reasons for the findings.

Learning teaching (self-education), research (understanding how to solve their own problems), and keep alive the motivation (energy that moves the man) are essential means to education, science and life.

Carlos Estrela
Editor-in-chief

Endo *in* Endo

Original articles

52. *In vitro* efficiency evaluation of an electronic apex locator in teeth with simulated root resorption

Emmanuel João Nogueira Leal da Silva
Isabela Reis Portella
Patricia Reis Rezende Brito
Karen Machado Magalhães
Tauby de Souza Coutinho-Filho

57. Incidence of flare-ups in endodontic treatments performed in necrotic teeth in a single and in multiple sessions

Flávia Villela Laurindo
Manoel Matos Neto
Alexandre Mascarenhas Villela
Matheus Melo Pithon

64. Filling of a C-shaped canal using the Epiphany System and McSpadden compactors

André Luiz da Costa Michelotto
Joel Alves da Silva Jr.
Marili Doro Andrade Deonizio

70. Apical surgery in complement to the endodontic treatment: Case report

Maria Antonieta Veloso Carvalho de Oliveira
Juliana Soares
Kellen Cristina Mendes Azevedo
João Carlos Gabrielli Biffi
Leandro Carvalho Quirino
Rodrigo Antônio Faria

75. The distance from the intraradicular post tip to the dental apex influences the degree of apical periodontitis

Etevaldo Matos Maia Filho
Suzanni do Amaral Rodrigues Veloso
Cláudia de Castro Rizzi
Fernanda Ferreira Lopes
Erick Miranda Souza

81. Modern endodontic microsurgery treatment improves the outcome of challenging cases: A series report

Warley Luciano Fonseca Tavares
Renata Carvalho Portes Lopes
Luiz Carlos Feitosa Henriques
Gustavo Batista de Menezes
Antônio Paulino Ribeiro Sobrinho

89. Accidental swallowing of a Protaper® file during root canal treatment

Simony Hidee Hamoy Kataoka
Flávio Moreira
Lisandro de Boutteville
Celso Luiz Caldeira
Oscar Faciola Pessoa

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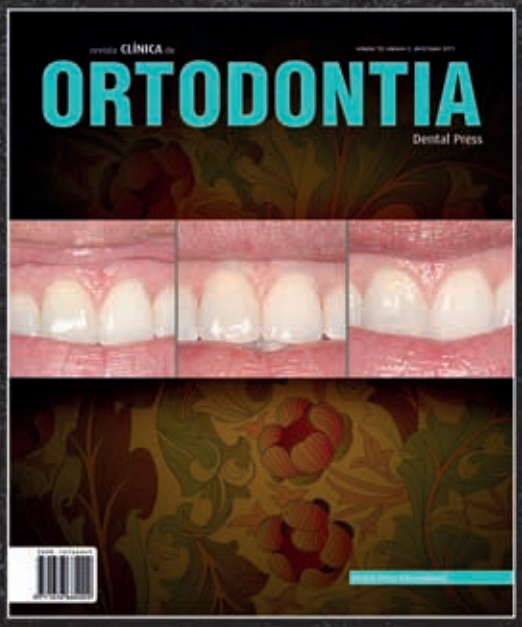

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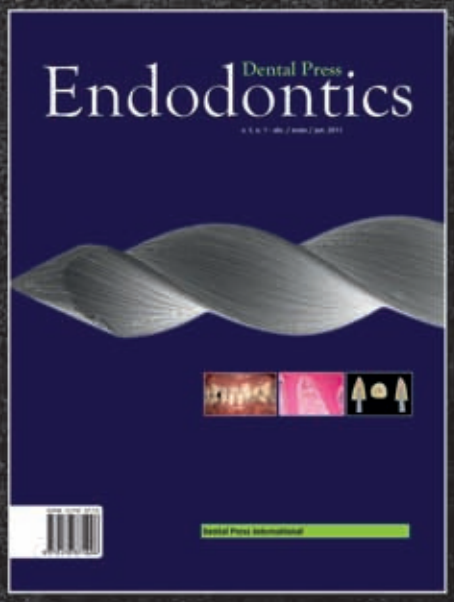

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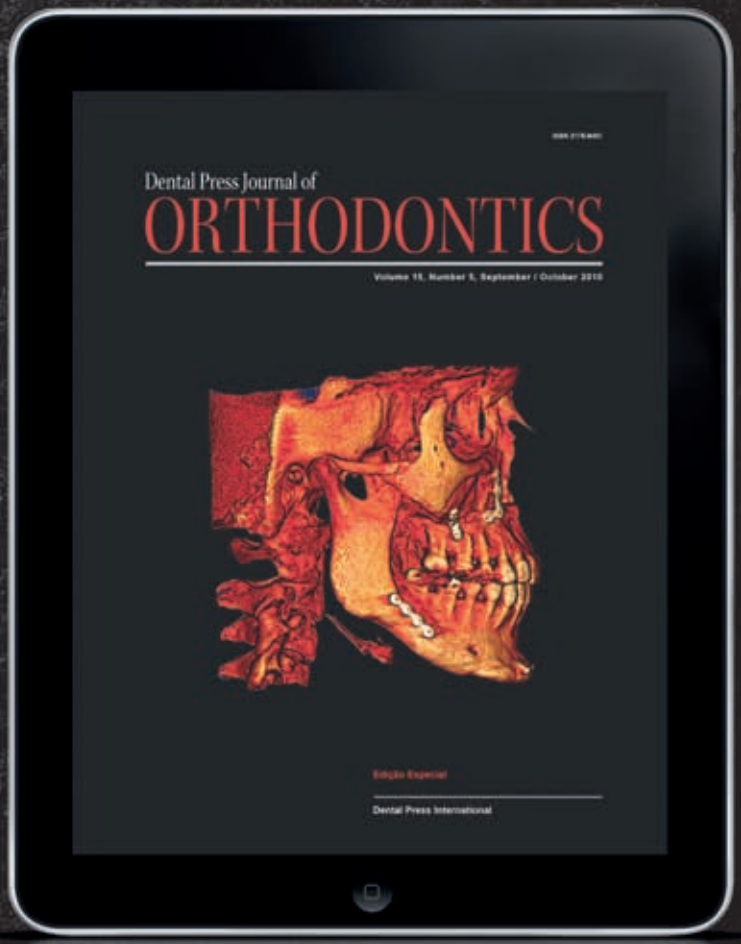

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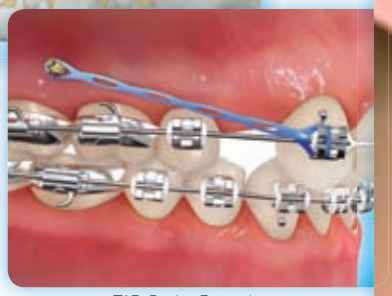

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Calcific metamorphosis and aseptic necrosis of the pulp:

Differential diagnosis of tooth discoloration

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Considerations and assumptions

Scientifically, the following questions have not been accurately answered yet:

1. What determines tooth color, its shades and hues and its variations even in the same person?
2. Does tooth color result from the distribution of a pigment at variable concentrations in tooth structure?
3. Is color a consequence of the level of mineralization of tooth tissues, their thickness or mineral density?
4. Is tooth color genetically determined and what is the genetic transmission pattern?
5. Do teeth have the same color primarily, which then undergoes changes due to intrinsic or extrinsic environmental factors to which the individual is exposed since the first moments of life?

Natural tooth color is yellowish, and its hue varies from tooth to tooth in the same patient and much more intensely between different patients. In addition to the yellow shades classified as normal, different hues have been seen and classified as truly abnormal or pathological changes in tooth color: Excessively yellowish, brownish, bluish, grayish and even blackish.[10]

"Tooth discoloration" is a diffuse change that results from increases of yellow and a change in its hue all over the tooth crown (Figs 1 and 2), or even in all the teeth of a single patient.[10] In several cases, the cause of tooth discoloration may be defined, but when it is not, the case is classified as idiopathic. Several people complain about the darker color of their teeth and, unhappy with that, ask for bleaching procedures, usually because the media advertises "white teeth" as healthy and beautiful, although their normal color is yellowish.

Two important terminology questions:

1st) The term bleaching: For several years this clinical procedure has been called "whitening" by most people, and its equivalent in Portuguese (*clareamento*), for example, has even been included in the latest editions of popular dictionaries. Therefore, the current use of the term "*clareamento*" (bleaching) may be justified by this linguistic incorporation.

2nd) The term "pigment", derived from Latin, means "color to paint" and names different types of

substances that impart a color to liquids, animal and vegetable tissues and even other substances. Pigments in the human body may have an endogenous or exogenous origin and may be deposited in excess inside cells or in intercellular spaces. The presence of pigments in cells and tissues may be normal, but their accumulation may be a morphological sign of aggression. The main pigments associated with human biology are:

» Endogenous pigments: Melanin, lipofuscin, bilirubin and hemosiderin;

» Exogenous pigments: Coal, silica, asbestos and silver.

Classification and causes of tooth pigmentation

The origin of pigments that discolor teeth may be:

(a) Intrinsic or endogenous: When they are produced by the organism itself, such as in the case of hemosiderin, iron and bilirubin.

(b) Extrinsic or exogenous: When originated in the environment, such as fluoride; in therapeutic agents, such as silver, bismuth or tetracycline; or, still, in other organisms, such as the pigments from chromogenic bacteria.

The incorporation of pigments in tooth discoloration may be:

(a) Internal: When incorporated into the structure of tooth tissues, such as when it results from endodontic treatment, systemic use of tetracycline during odontogenesis, and fluorosis.

(b) External: When the pigment undergoes apposition on the surface of mineralized dental tissues and is not part of their structure, such as in the case of tobacco tar, chromogenic bacterial pigments and food pigments in the bacterial plaque that adheres to tooth surfaces.

Some clinical conditions are directly associated with tooth discoloration:

1. Pulp haemorrhage associated with inappropriate crown opening in endodontic treatment favors tooth discoloration. Hemosiderin, a pigment derived from hemoglobin in red blood cells, has many iron ions. In pulp necrosis, pigments derived from hemosiderin are likely to play an important role in tooth discoloration.
2. The use of certain endodontic products, such as obturating pastes containing silver, bismuth and other metal ions, may also promote the discoloration of tooth structures and lead to serious esthetic problems.
3. When tetracycline, fluoride and other products that act as pigments are found in blood, they may incorporate into forming enamel and tooth matrix and affect the color of several teeth. Bilirubin and hemosiderin, when present in excessive amounts in blood, may also be incorporated into teeth, though rarely.
4. Calcific metamorphosis (Figs 1 and 2) and aseptic necrosis of the pulp (Figs 2 and 3): Very frequent and clinically important, they affect one or two teeth separately in the dental arch, especially incisors, due to their greater exposure to dental trauma.[18,21]

In an evaluation of 168 discolored and injured anterior teeth not treated endodontically, Oginni and Adekoya-Sofowora[16] found, respectively, 47.6% and 31.6% with total and partial calcific metamorphosis (Figs 1 and 2). The other 20.8% had pulp necrosis. The cases of calcific metamorphosis had a history of dental trauma due to concussion or subluxation, particularly in the first and second decades of life. In the cases of pulp necrosis, trauma occurred predominantly in the third decade of life and included fracture of the affected teeth.

Tooth discoloration: Unknown mechanism

We do not know precisely how and where pigments are incorporated into tooth structures. With which proteins or tissue compounds would they unite to the tooth structure? Would they discolor the enamel or the dentin at a higher degree?

If we do not know how pigmentation takes place, we also do not know how tooth whitening happens! Several articles and textbooks show diagrams of pigment transformation by bleaching substances to the point that they generate, eventually, water molecules.[4] As a hypothetical theoretical model, such diagrams are valuable, but in practice, we do not know how bleaching substances "destroy, inhibit, neutralize and modify" the pigments incorporated into teeth. Why does discoloration tend to recur, even if only partially, along time? Do pigments reconstitute or are new pigments incorporated?

Figure 1. A) Discoloration of the left maxillary central incisor due to calcific metamorphosis in an intact tooth, associated with dental trauma, especially concussion. In this situation, the differential diagnosis with aseptic necrosis of the pulp was defined according to radiographs (**B**), which showed poorly-defined pulp margins, typical of calcific metamorphosis of the pulp, when compared with the normal neighboring tooth (arrows).

We still do not have the answers to many of the questions about tooth discoloration, but several causes are known and, therefore, may be avoided by using advances in therapeutic approaches. Among the well-known, recognized causes of tooth discoloration are calcific metamorphosis and aseptic necrosis of the pulp.

Dental trauma in healthy teeth: what about the pulp?

Teeth that suffer trauma may either have a fracture or not. The neurovascular bundle in the apical foramen may be compromised at variable degrees, and their blood supply may be affected. Although the dental pulp may remain normal after trauma, there are many cases in which there is aseptic necrosis of the pulp (Figs 2 and 3).[16,19,20]

Of the extreme possibilities of keeping the pulp normal after dental trauma and aseptic necrosis of the pulp is pulp metaplasia, also known as calcific metamorphosis of the pulp (Figs 1, 2, 3 and 4).[2,16,19,20]

For the classic definition of aseptic necrosis and calcific metamorphosis of the pulp, we considered, in this description, injured teeth that did not have any type of fracture or periodontal changes that might lead to secondary contamination of the pulp and periapical region. That is, the teeth were injured but remained structurally sound and their mineralized tissues were intact (Figs 1, 2, 5 and 6).

1st - Preserving the normal pulp

When the pulp retains its normal vitality, unpredictable changes may be detected along time, such as early pulp ageing and internal root resorption. Early pulp ageing is characterized by a reduction in pulp volume associated with nodules resulting from isolated dystrophic calcifications. Dystrophic calcification is the mineralization of tissue that underwent changes or morphological and biochemical dystrophy, such as in hyaline areas of excessive pulp fibrosis or small areas of pulp necrosis due to the rupture of small vessels. Therefore, according to microscopic and radiographic findings, they promote the formation of pulp nodules.

2nd - Aseptic necrosis of the pulp:

Pulpal necrosis due to rupture or injury to the neurovascular bundle in the apical foramen promotes tissue protein denaturation characterized by loss of water; pulp cells remain in their framework,

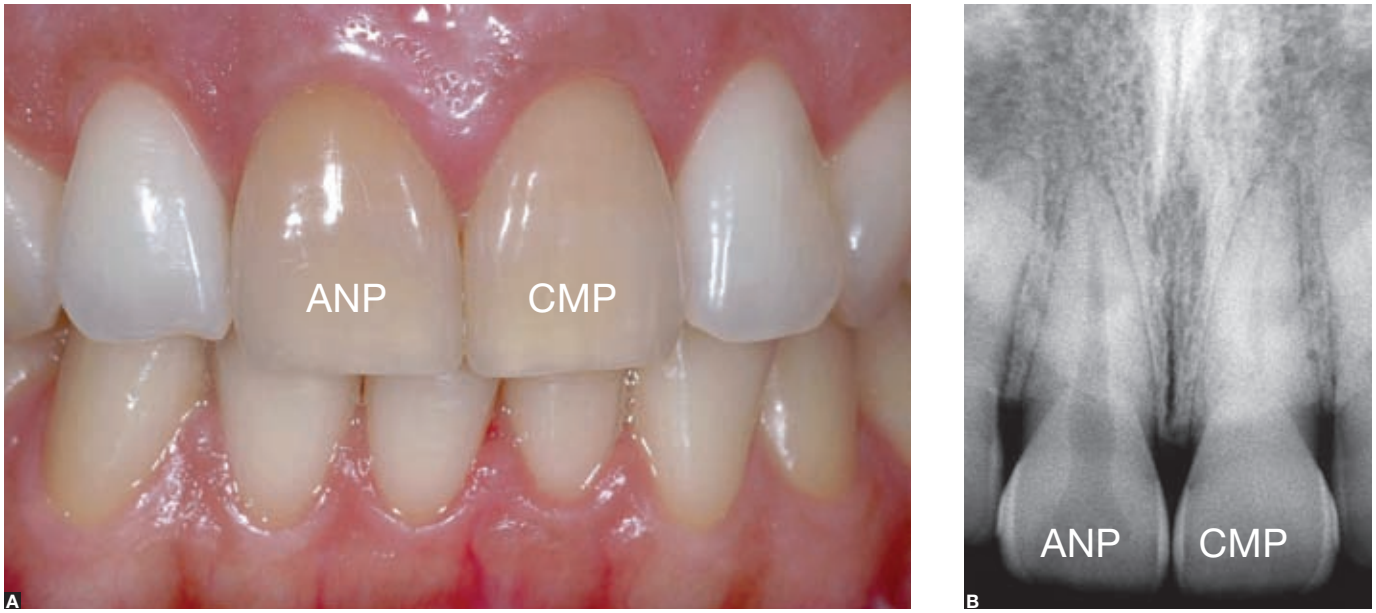

Figure 2. Discolorations of maxillary central incisors: Left incisor, due to calcific metamorphosis of the pulp (CMP) in intact tooth; and right incisor, due to aseptic necrosis of the pulp, both after dental trauma. Radiograph shows poorly-defined pulp canal margins, typical of calcific metamorphosis, when compared with aseptic necrosis of the pulp (ANP). Teeth had discoloration for years, but no symptoms; the two conditions were indistinguishable clinically.

though coagulated and lifeless. Pulp cells are poor in lysosomes, which are organelles full of proteolytic enzymes. Without proteolytic lysosomal enzymes, necrotized cells take too long to dissolve by hydrolysis. This type of necrosis is also called coagulation necrosis and may occur in several parts of the body, particularly in areas that are infarcted and poor in lysosomes.

In injured teeth in which the neurovascular bundle ruptures, but dental structure remains structurally intact without exposure of dentin or pulp to the oral environment and there is no periodontal damage, coagulation necrosis, also called aseptic necrosis of the pulp, is a sign of pulp infarction. Along time, the products derived from necrotized pulp tissue may incorporate into the dentin structure; protein decomposition usually generates dark components, and the tooth discolors into a dark yellowish hue of many shades (Fig 2). There are also pigments derived from hemosiderin, rich in iron and released into the pulp space due to the decomposition of red blood cells.

In aseptic necrosis of the pulp, radiographs show well-defined pulp margins in the chamber and in the root canal, and pulp spaces have normal dimensions and are homogeneously radiolucent. After all, cell death is so sudden that the pulp has no time to deposit new layers of reactional dentin.

In the periapical area of teeth with aseptic necrosis of the pulp, or coagulation necrosis, which is typical of dental trauma, chronic apical periodontitis or chronic periapical lesions suggestive of periapical granuloma may be found. They are long-lasting, discrete and practically asymptomatic lesions because the aggressive agents are products of tissue decomposition whose toxicity is low and there are no bacterial products. The main reason to seek dental care or the main complaint by the patient is the dark color of the crown.

3rd - Calcific metamorphosis of the pulp

In case of trauma, hard tissues may remain structurally sound and the pulp, healthy, or the damage may progress into aseptic necrosis of the pulp when the neurovascular bundle is severely and definitely affected.

However, the damage to the neurovascular bundle may be only partial or transient. Pulp cells may undergo transient hypoxia, temporary loss of nutrients, and reduce their metabolism to a minimum necessary for cell survival. This occurs mainly in

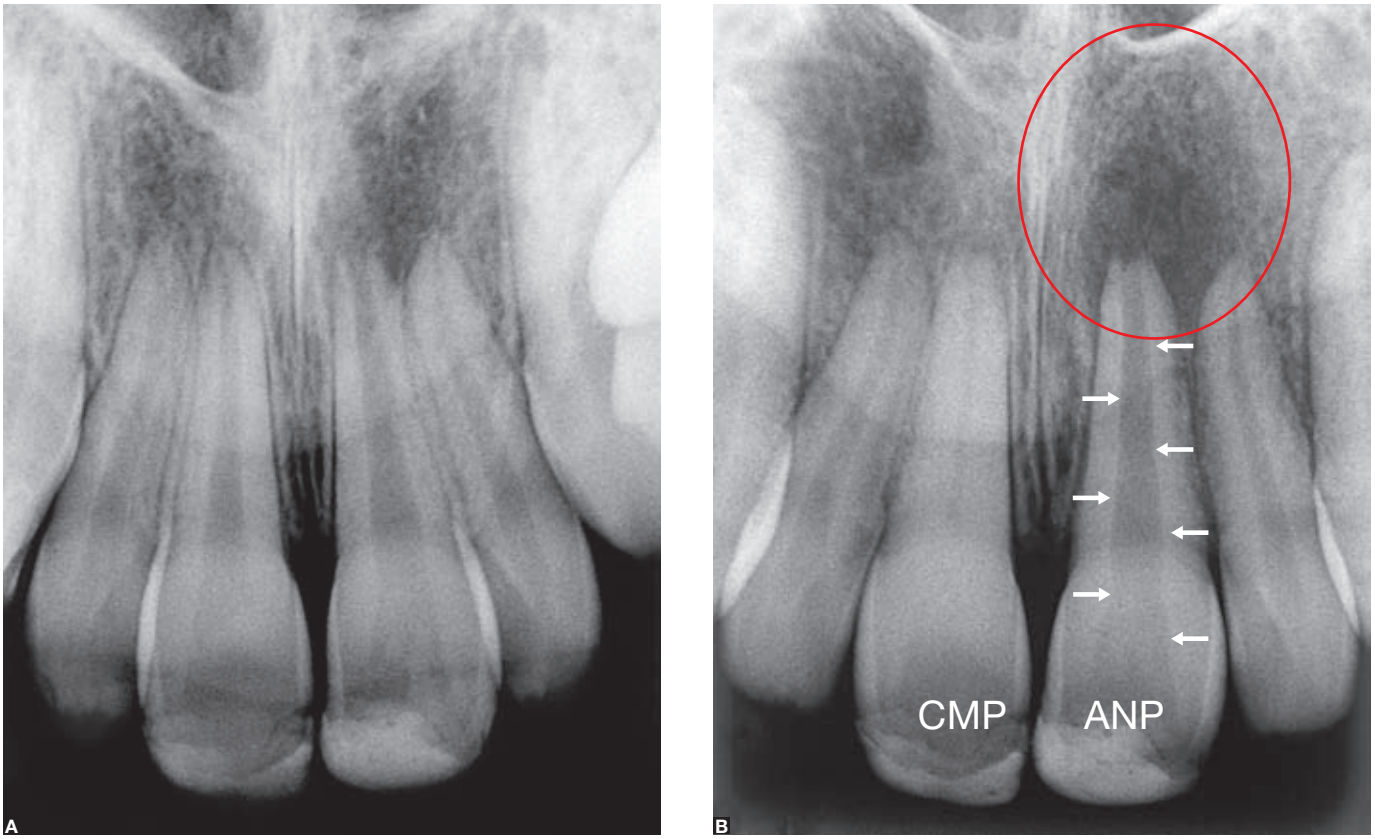

Figure 3. Central incisors had dental trauma according to patient's reports; no professional follow-up, as indicated by the crown lesion on radiograph obtained on an unknown date. The right central incisor progressed into calcific metamorphosis of the pulp (CMP) in some months, and radiograph shows practically no pulp margins and practically total obliteration of the chamber and root canal. Left central incisor had aseptic necrosis of the pulp (ANP), which progressed into chronic periapical lesion (circle), with preservation of well-defined pulp margins (arrows). The diagnosis was made using radiographs obtained for orthodontic planning as there were no symptoms (Source: Consolaro, Bernardini,[8] 2007).

cases of subluxation (in 45.8% of the cases) and concussion (in 31.6% of the cases).[16] Concussion may be defined as an aggression to supporting periodontal tissues with no abnormal mobility or tooth displacement, but with marked reaction to percussion. Subluxation is an aggression to supporting periodontal tissues with abnormal mobility, but without tooth displacement from the alveolus.[5,11]

One of the forms of cell adaptation to adverse situations is cell metaplasia. The mature cell undergoes transformations and changes its phenotype into another cell type, equally mature and of the same embryonic lineage. Metaplasia is an efficient form of cell adaptation. When an individual starts smoking, for example, the cells that cover the trachea and bronchi change from ciliated cylindrical cells that produce a large amount of mucus into stratified squamous cells, which may at times even produce surface keratin. In other words, metaplasia is metamorphosis of cell morphology and function.

In the pulp of teeth that underwent trauma and that remain structurally intact, but which have a partial lesion of the neurovascular bundle, pulp cells may undergo metaplasia to adapt to transient hypoxia and their metabolism reduction. Metaplasia produces fibroblasts, pericytes, undifferentiated cells or stem cells, pre-odontoblasts and even vascular cells that differentiate, modify or change into odontoblasts. This initiates a random and disorganized production of reactional dentin, incorporating cells and vessels into its structure, to the point of being identified as osteodentin or vasodentin, often also called tertiary dentin.[2,15] Osteodentin and vasodentin are primitive forms of dentin found in teeth of lower animals in the biological scale.

The random deposition of dysplastic, that is, malformed dentin is often very disorganized and little mineralized, and may be directed from the periphery to the center of the pulp (Fig 2), though this is not always the case (Figs 1, 2 and 3). Such random deposition of

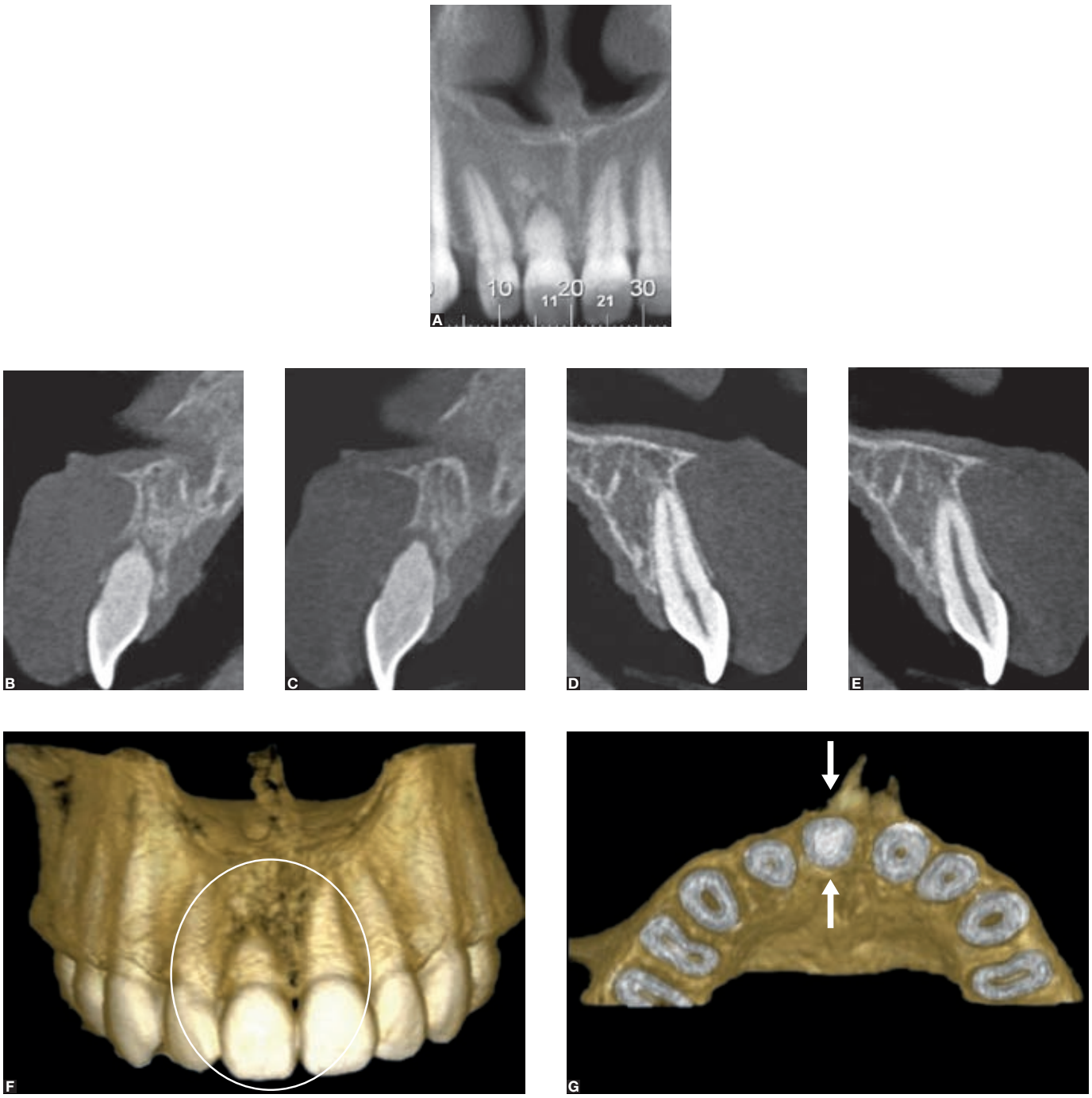

Figure 4. Dental trauma of incisor (11), which progressed into calcific metamorphosis of the pulp; CT scans show obliteration of pulp space and no definition of pulp margins (**B** and **C**) when compared with other central incisor (**D** and **E**). Three-dimensional reconstruction (**F**) shows that root is shorter (circle) and that there are separate apical fragments. Three-dimensional transverse views (**G**) show total obliteration of root canal by dysplastic dentin (arrows).

dysplastic dentin in injured teeth may be absolute and uncontrolled.[15] After three months to one year, radiographs may show the disappearance of normal pulp margins and the obliteration of pulp spaces in the chamber, the root canal, or both (Figs 1, 2 and 3). Obliteration may be completed when the pulp spaces completely disappear, from six months to one year after trauma.

Obliteration of pulp spaces by dysplastic dentin is a very frequent phenomenon simply known as pulp or canal obliteration, but seems to be better classified as calcific metamorphosis of the pulp, the name most often used in the literature about this topic, although it is also common to call it calcific metaplasia of the pulp.

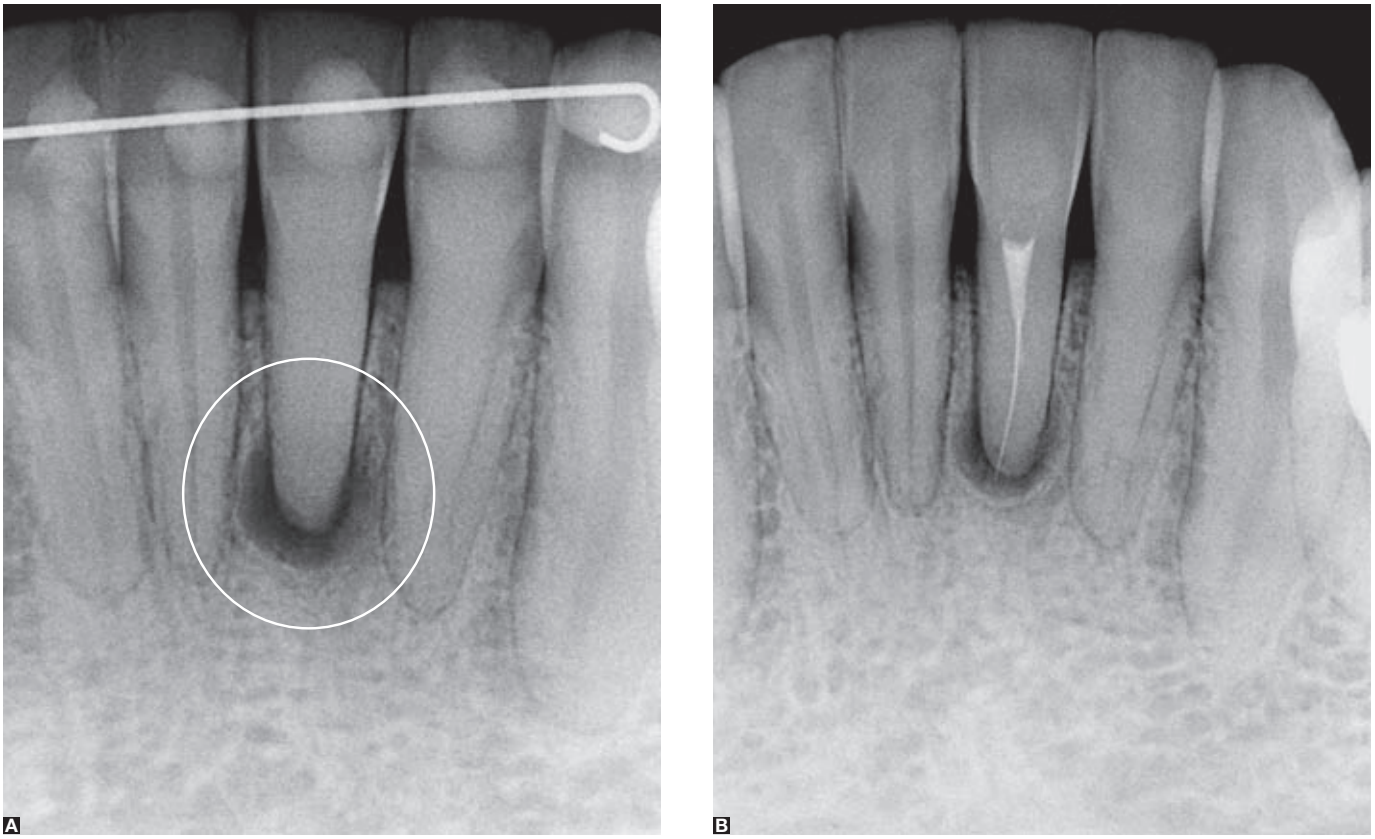

Figure 5. Calcific metamorphosis of the pulp obliterated the chamber and the root canal and prevented necessary endodontic treatment due to chronic periapical lesion (circle). Attempts to approach it through the canal to avoid endodontic surgery are risky because of the high probability of accidents, such as instrument fractures inside the root canal (**B**). However, even with a fractured instrument (**B**) and patient's refusal to undergo surgery, there was a reduction in lesion size.

In summary: calcific metamorphosis of the pulp is a response to trauma characterized by the deposition of hard tissues in the root canal space.[1] It occurs in about 3.8% to 24% of injured teeth.[16] Radiographs show the partial or total obliteration of the pulp chamber and root canal spaces (Figs 1 to 6).

Calcific metamorphosis of the pulp is not dystrophic calcification of the pulp,[6] but, rather, pulp metaplasia, or active deposition of dysplastic dentin. Dystrophic calcifications are the result of mineralization of previously injured tissues that necrotized or were somehow changed. Metaplasia is a form of tissue adaptation to a novel environmental condition.

Clinically, teeth with calcific metamorphosis of the pulp (Figs 1 and 2) gradually acquire a more yellowish color, subtle at first, but more perceptible and disturbing as time goes by, and eventually reaching severe crown discoloration (Fig 2). In most patients with calcific metamorphosis of the pulp, tooth discoloration is noticed much later, 5 to 10 years after dental trauma.[16] The greatest dentin thickness and the type of disorganized deposition of dysplastic dentin let a very dark and yellowish color appear through the enamel.

Teeth with calcific metamorphosis of the pulp may, along the years, progress into pulp necrosis in 1% to 16% of the cases; in 7.3% to 26.4% of those teeth, periapical rarefactions are induced in up to 4 years after trauma, especially when there is total obliteration of the pulp space.[2,16]

The initial diagnosis of calcific metamorphosis of the pulp may be made clinically according to the isolated discoloration of one or two intact teeth. The patient might not be able the recall the history of dental trauma, but it practically always occurred. Periapical radiographs showing poor canal margin definitions confirm canal obliteration and establish

the final diagnosis. However, it should be no surprise the fact that, in place of calcific metamorphosis of the pulp, the discolored tooth may have preserved pulp margins associated with chronic periapical lesion, a sign of aseptic necrosis due to severe trauma or neurovascular bundle rupture in the apical foramen. Not rarely, the discolored tooth with such changes has small lateral areas of inactive root resorption, a sign of previous trauma (Fig 5).

Clinically and radiographically, calcific metamorphosis of the pulp points to a history of dental trauma[25] and injured teeth that, when moved orthodontically, have greater chances of developing more severe root resorption.[5,8]

Often, root resorption may be severe if an orthodontist places an appliance and moves a tooth with undiagnosed calcific metamorphosis.[8] At the same time or after the end of orthodontic treatment, crown discoloration makes the patient seek a dentist specialized in esthetics, and an inaccurate opinion may unfortunately be made: Orthodontic treatment induced pulp necrosis and, consequently, crown discoloration!

In fact, the diagnosis should be calcific metamorphosis or aseptic necrosis of the pulp due to previous dental trauma. Orthodontic movement does not induce aseptic necrosis or calcific metamorphosis of the pulp.[7,9,12,14,26] In the same way, occlusal trauma does not induce aseptic necrosis or calcific metamorphosis of the pulp.

Basis for clinical and therapeutic decisions

In the clinical cases of aseptic necrosis and calcific metamorphosis of the pulp, the clinical decisions to be directly and immediately made involve the endodontist.[2,3,13,17,23] The endodontic approach should be, along time, inevitable, either for canal treatment or for endodontic surgery.

Among the clinical decisions to be made, the following conditions should be taken into consideration:

1st - The patient reports recent dental trauma

If the patient reports dental trauma that affected a certain tooth, usually one of the incisors in the last days, weeks or months, the pulp should be evaluated using periapical radiographs and vitality tests. If there are no radiographic signs of calcific metamorphosis or chronic periapical lesions and the vitality test is positive, the patient should be followed up with radiographs after 6, 9 and 12 months, time points at which calcific metamorphosis may appear. The same occurs with periapical lesions and crown discoloration in cases of aseptic necrosis of the pulp (Figs 2 and 3).

2nd - Patient reports discrete recent discoloration

When complaining about discrete crown discoloration in one or two isolate teeth, with no symptoms or relevant history, the patient may report previous dental trauma, even when apparently not significant. Tests may detect total loss of pulp vitality or positive responses only in the most severe and long tests with dry ice, for example.

Periapical radiographs of these teeth may lead to two diagnoses: Aseptic necrosis (Figs 2 and 3) or calcific metamorphosis of the pulp (Figs 1, 2 and 3).

If the diagnosis is aseptic necrosis of the pulp, conventional endodontic treatment should be prescribed, followed by specific external bleaching of the affected tooth or internal bleaching, if this is the option recommended by the endodontist. The advantage of external bleaching in these cases is the lack of risk of external cervical resorption and less weakening of tooth structures.

If the diagnosis is calcific metamorphosis of the pulp, with radiographic signs, even if subtle, of partially obliterated pulp chamber or canal, the most adequate option is, first, endodontic treatment to avoid the complete closing of the root canal. Canal obliteration complicates any future approach, because 16% of the cases may progress into necrosis in 3 to 21 years.[24] This approach would prevent severe and isolated discoloration of the tooth affected, which is esthetically recommended. After endodontic treatment, external bleaching should be performed specifically for the affected tooth.

3rd - Patient reports intense and long-lasting discoloration

The patient has an isolated tooth with discoloration, but no symptoms or any other sign. The patient has a very old history of dental trauma or does not associate discoloration with any previous event. Periapical radiographs may suggest two different diagnoses: Aseptic necrosis, probably with chronic periapical lesion, or calcific metamorphosis of the pulp.

If the diagnosis is aseptic necrosis of the pulp, probably with chronic periapical lesion, conventional

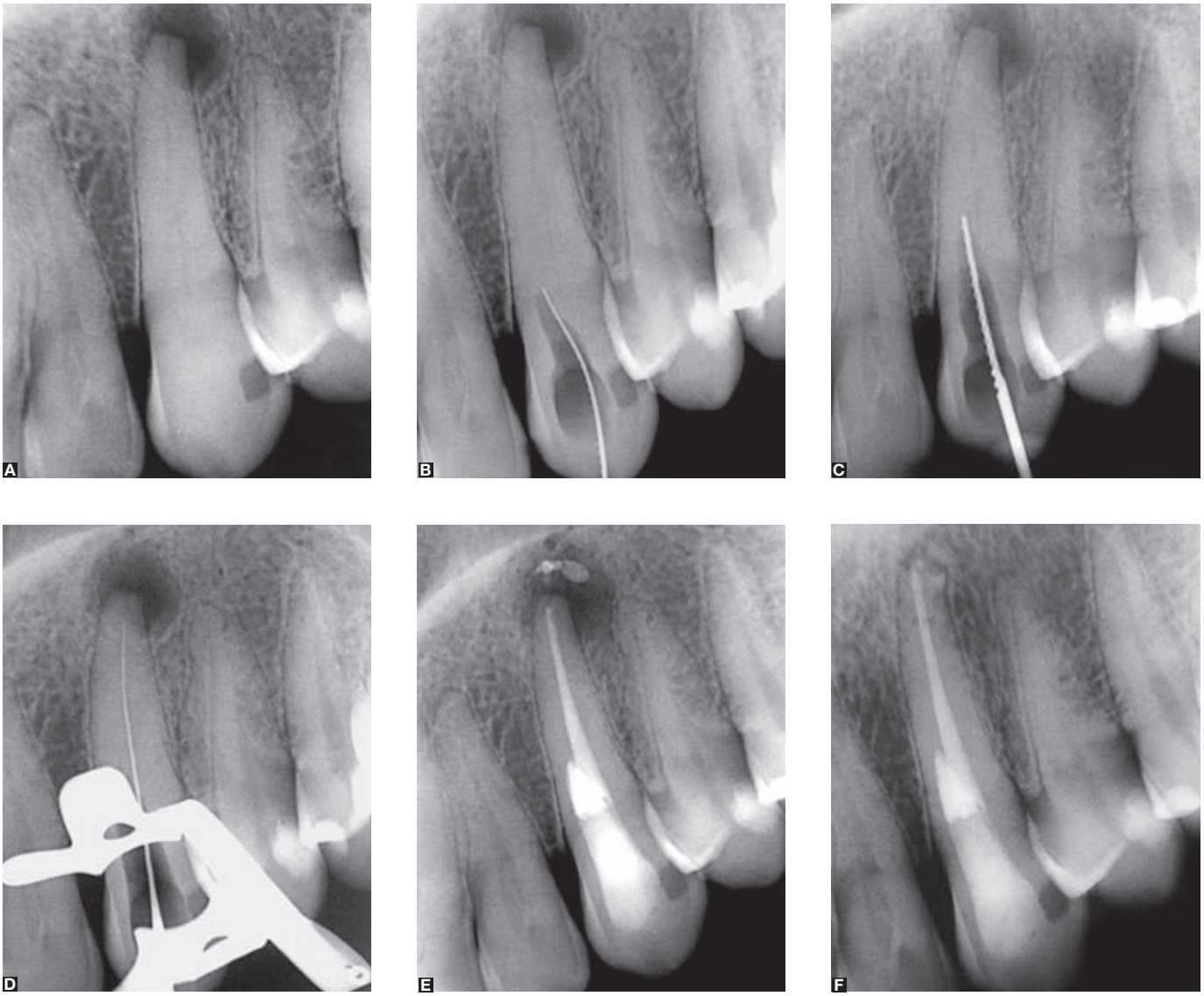

Figure 6. The appearing of the chronic periapical lesion occurred as it happens in approximately 25% of the cases of Calcific Metamorphosis of the Pulp (**A**). The endodontic treatment of teeth with Calcific Metamorphosis of the Pulp compose a risky maneuver due to the high probability of lateral trepanning of the root. In this clinical case almost occurred a trepanning of the maxillary canine (**B** and **C**), what was avoided with the aid of more experienced professionals, allowing to reach the apical foramen and fill the canal (**D** and **E**). After three years of control the regression of the associated chronic periapical lesion can be noticed (**F**).

endodontic treatment should be prescribed (Figs 2 and 3) followed by specific external bleaching of the affected tooth or internal bleaching if this is the most adequate option according to the endodontist's evaluation.

If the diagnosis is calcific metamorphosis of the pulp, there may be total obliteration of the pulp chamber and canal with or without periapical lesion. In this case, the best option is endodontic surgery and root-end obturation (Figs 5 and 6)[2,22,23] or specific external bleaching for the affected tooth.

Several patients refuse to undergo endodontic surgery (Figs 5 and 6) at first, and request only bleaching of the affected tooth. Bleaching, in these cases, has temporary results, and discoloration returns in one to three years, when other bleaching procedures may be conducted. Another option may be the manufacture of veneers or crowns, a more stable and long-lasting solution. In such cases, the patient should be followed up yearly for radiographic control of chronic periapical lesions.

Final considerations

Isolated discoloration of teeth with structurally intact mineralized tissues strongly suggests the diagnosis of calcific metamorphosis or aseptic necrosis of the pulp. Any clinical procedure for these teeth, either a simple bleaching procedure or the placement of crowns or veneers, should be preceded by careful clinical and radiographic evaluations.

If not previously evaluated, any esthetic solution may be temporary and harmful for the patient, because the teeth may have aseptic necrosis or calcific metamorphosis of the pulp, which progress into chronic periapical lesions. Root resorptions, substantial loss of bone, and systemic repercussions due to these long-lasting chronic periapical lesions may be associated with this progressive condition.

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Influence of the sodium hypochlorite on the healing process of the dog's teeth treated in single-visit

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ABSTRACT

Introduction: Elimination of bacteria from root canals is essential in the endodontic treatment of necrotic pulp teeth once bacteria not only cause, but also maintain, periapical lesions. **Objective:** The aim of this study was to analyze, *in vivo*, the influence of the irrigating solutions (1.0% NaOCl, 2.5% NaOCl, 0.9% sterile saline) in single-visit treatment of dogs' teeth with chronic periapical lesion. **Methods:** Forty root canals from three Beagle dogs were left exposed to the oral cavity to allow contamination and formation of the chronic periapical lesion. After that, the root canals were biomechanically prepared. During the instrumentation, three irrigating solutions were used: G1- 2.5% NaOCl; G2- 1.0% NaOCl; G3- 0.9% sterile saline. Control Group (G4) had no treatment and no coronal sealing. The root canals were filled with gutta-percha points and Sealapex. The crown openings were sealed with IRM® and amalgam. After six months, the animals were sacrificed and blocks of tissue histologically processed to be stained with hematoxylin and eosin, or Brown and Brenn. **Results:** There was no histological difference between the utilization of 1.0% or 2.5% sodium hypochlorite ($p>0.05$), but between them and sterile saline ($p<0.05$). **Conclusion:** It was concluded that the use of irrigating solutions with antibacterial potential (1% or 2.5% sodium hypochlorite) provided more favorable conditions for the healing process.

Keywords: Root canal treatment. Irrigating solution. Sodium hypochlorite. Biocompatibility. Healing process.

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Introduction

The essential role of microorganisms to develop and maintain the pulp and periapical diseases have been demonstrated in animal and human studies.[1,2,3]

Dental pulp and periapical tissues are commonly affected by a variety of microorganisms and their products. Even after microbial death, cellular components, such as lipopolysaccharide (LPS), persist for prolonged periods and can cause reactions resulting in chronic inflammation.[4]

Elimination of bacteria from root canals is an ideal in the endodontic treatment of teeth with a non-vital pulp and a chronic periapical lesion once bacteria not only cause, but also maintain periapical lesions.[5,6] Endodontic therapy requires the use of irrigating solutions to reduce microorganisms, remove debris and neutralize organic compounds, but due to the risk of leakage through the apical foramen, irrigants must be biocompatible and non-irritant to the periapical tissues.[7,8]

Sodium hypochlorite (NaOCl) is the most commonly used irrigating solution because of its antibacterial action, dentinal bleaching and organic dissolution ability.[9,10,11] On the other hand, the high superficial tension of this chemical irrigant avoids its penetration into the irregularities of the canal system. Besides, its use increases the dentin hydraulic conductivity.[7,11-14] In high concentrations, it has a potent antimicrobial action due to the release of a large number of secondary chlorates, leading to tissue dissolution.[15,16,17] On the other hand, no difference was showed in the antibacterial activity of 1%, 2.5%, and 5% NaOCl in an *in vitro* study.[18]

Thus, the purpose of the present study was to evaluate *in vivo* the influence of the irrigating solutions (1.0% NaOCl, 2.5% NaOCl and 0.9% sterile saline) in single-visit treatment of dogs' teeth with chronic periapical lesion.

Material and methods

Forty root canals from 3 male Beagle dogs, aged one year were used in this study. Procedures were conducted according to the guidelines approved by the Research Committee of São Paulo State University, Brazil.

The animals were intramuscularly pre-anaesthetized with 2 ml of a mixture of xylazine (Rompum; Bayer do Brasil S/A, São Paulo, SP, Brazil) and ketamine hydrochloride (Ketalar; Park Davis-Aché Laboratórios Farmacêuticos S/A, São Paulo, SP, Brazil), in a 1:1 ratio, and anesthetized with sodium Nembutal (30 mg/kg body weight, Thionembutal, Abbott Ltda., Rio de Janeiro, RJ, Brazil).

Previously to the interventions, radiographs were taken to observe the normality of the structures. Coronal access were prepared with a #1090 cylindrical diamond bur (KG Sorensen, Barueri, SP, Brazil) and pulp extirpation with a size #15 K-file (Maillefer Instruments, Ballaigues, Switzerland), both performed under rubber dam isolation and antisepsis with 3% iodated alcohol solution (Asteriodine-Aster, Sorocaba, SP, Brazil). Pulp extirpation was performed with K files at the apical barrier. The root canals were left exposed to the oral cavity for 6 months to allow the formation of the chronic periapical lesion, which was radiographically confirmed.

After that, the root canals were explored with a #15 K-file. The root canals were biomechanical prepared up to a #40 K-file at the apical cementary barrier. During the biomechanical preparation, after each instrument change, one of three irrigating solutions was used: 2.5% NaOCl, 1.0% NaOCl or 0.9% sterile saline. The experimental groups were divided in four groups: G1- 2.5% NaOCl; G2- 1.0% NaOCl; G3- 0.9% sterile saline and G4- Control. The roots of the control group had the pulps removed and the root canal remained exposed to the oral cavity until the sacrifice of the animals.

After biomechanical preparation, a #30 K-file was once again used to remove dentin chips left in the apical foramen during instrumentation. After preparation, the root canals were irrigated, aspirated and dried, and 17% EDTA was placed and agitated for 3 min with a lentulo spiral. Irrigating solution was finally used for irrigation and the root canals were dried with sterile absorbent paper points (Tanari Industrial Ltda., Manaus, AM, Brazil).

The root canals of the Groups 1, 2 and 3 were filled with a gutta-percha points and Sealapex (Sybron Kerr, Romulus, Michigan, USA) using active lateral condensation technique, followed by radiographic confirmation. The crown openings were sealed with IRM® (Dentsply Ltda.) and amalgam (SS White Ltda.). The control group were not filled and remained exposed to the oral cavity until the sacrifice of the animals.

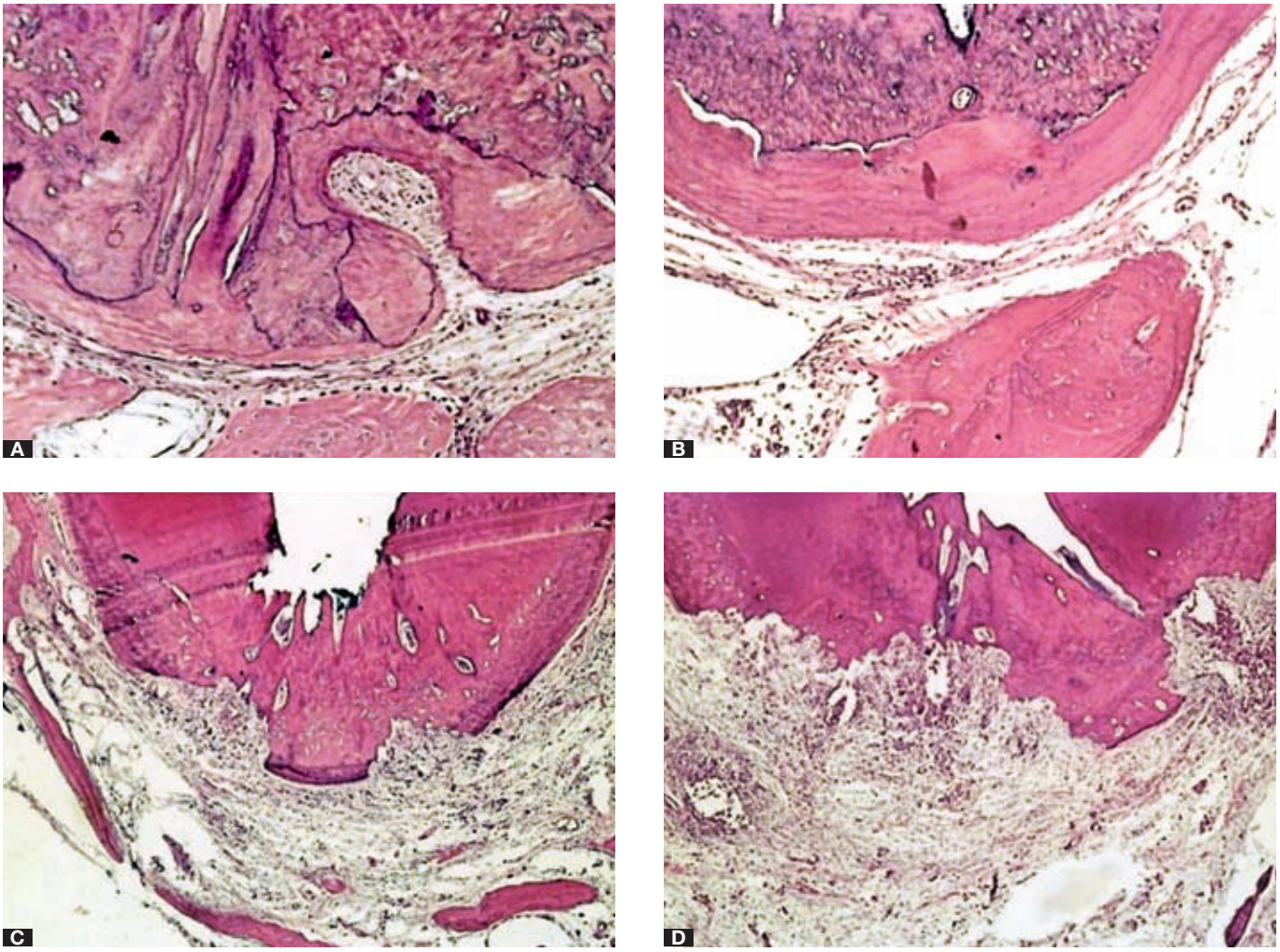

Figure 1. A) 2.5% sodium hypochlorite: Closure of apical ramifications with new cementum and periodontal ligament with few chronic inflammatory cells (H.E., 100x). **B**) 1.0% sodium hypochlorite: New cementum recovering the apex and the sealing of the apical ramifications, but the periodontal ligament shows few chronic inflammatory cells (H.E., 100x). **C**) Saline: Absence of new cementum, presence of resorption areas and severe inflammatory infiltrate (H.E., 40x). **D**) Control: Presence of chronic periapical lesion and resorption areas.

The animals were sacrificed with anesthetic overdose after 6 months and the maxilla and mandible were removed, fixed in 10% buffered formalin solution for 48 hours and demineralized in formic acid and sodium citrate solution. Blocks including the teeth and surrounding tissues were produced, and the specimens were embedded in paraffin wax, serially sectioned at 6 µm intervals, stained with hematoxylin and eosin (H.E.) and Brown and Brenn techniques. They were examined under light microscopy by a skilled examiner blinded to the groups.

The histomorphological parameters were examined and scored 1 to 4, 1 being the best result and 4 the worst, according to previous established criteria.[19] Data were submitted to statistical analysis by Kruskal Wallis tests at 5% significance level.

Results

Group 1 - 2.5% NaOCl solution

Connective tissue with cementum recovering the dentinal walls was observed in five cases. The connective tissue showed the presence of acute inflammatory infiltrated in 2 cases. In 2 specimens there was absence of acute inflammatory infiltrated while in the remaining it was observed a chronic inflammatory infiltrated of variable intensity. Complete biological sealing (complete sealing of the apical foramens with new cementum) was noted in only 2 cases and was completely absent in 2 specimens. The newly formed cementum covered all of the resorption areas except in 1 specimen. The periodontal ligament was completely organized in only 2 specimens. Brown and Brenn staining detected micro-organisms in 4 specimens.

Group 2 – 1.0% NaOCl solution

Connective tissue with cementum recovering the dentinal walls was observed in five cases. The connective tissue showed the presence of chronic inflammatory infiltrated of variable intensity in 6 cases. The new cementum was formed with a mean thickness of 84 µm which covered all of the resorption areas except in 1 specimen. The periodontal ligament presented completely organized in 4 specimens. Brown and Brenn staining detected microorganisms in 3 specimens.

Group 3 – 0.9% sterile saline

It was observed in 4 specimens that almost half of the delta canals presented invagination in the connective tissue infiltrated by inflammatory cells. In the remaining specimens, a connective tissue without inflammatory infiltrated and the presence of deposition of new cementum was observed. In 2 cases in which new cementum was not observed an active bone resorption was noted. The periodontium was completely organized in 2 specimens. Brown and Brenn staining detected microorganisms in 8 specimens.

Group 4 – Control group

The control group was characterized by the presence of chronic periapical lesion which involved the whole area between the apex of the tooth and the surrounding bony tissue with the presence of active resorption areas in the apical cement. Brown and Brenn staining detected microorganisms in 8 specimens.

Comparison among the groups

Statistical analysis showed that the best histological results were observed in Groups 1 and 2, which received 2.5% NaOCl and 1.0% NaOCl as irrigating solution respectively with no significant difference ($p>0.05$). However, between them and Group 3, which received saline as irrigating solution, and Group 4 (Control) there was a significant difference ($p<0.05$).

Table 1. Distribution of specimens in the groups according to the scores of the histomorphological parameters.

Histomorphological parameters	Scores	Groups			
		G1 (n=10)	G2 (n=10)	G3 (n=10)	G4 (n=10)
Thickness of newly formed cementum	1 - more than 60 µm	6	9	7	0
	2 - from 20 to 59 µm	4	1	1	0
	3 - from 1 to 19 µm	0	0	0	0
	4 - absence	0	0	2	10
Extension of newly formed cementum	1 - repair of all of the resorption areas or recovering of the pre-existent cementum	9	9	8	0
	2 - 1/2 to 2/3 repair of the resorption areas	1	0	0	0
	3 - 1/3 or less repair of the resorption areas	0	1	0	0
	4 - absence of cementum repairing resorption areas	0	0	2	10
Closure of the apical delta by cementum	1 - complete	2	5	2	0
	2 - complete in most of the ramifications	4	4	2	0
	3 - complete in few ramifications	2	0	4	0
	4 - absence	2	1	2	10
Cementum resorption	1 - absence or resorption areas completely repaired	9	9	8	0
	2 - resorption areas partially repaired	1	0	0	0
	3 - non-repaired resorption areas	0	0	0	0
	4 - active resorption areas	0	1	2	10
Bone resorption	1 - absence	10	10	6	0
	2 - inactive areas	0	0	3	0
	3 - few active areas	0	0	2	0
	4 - many active areas	0	0	0	10

Acute inflammatory infiltrate (intensity)	1 - absent or few cells	8	8	5	0
	2 - small: less than 50 inflammatory cells	0	2	4	0
	3 - moderate: between 50 and 250 inflammatory cells	1	0	1	10
	4 - severe: more than 250 inflammatory cells	1	0	0	0
Acute inflammatory infiltrate (extension)	1 - absent or few cells	8	8	5	-
	2 - small: less than 50 inflammatory cells	2	2	4	-
	3 - moderate: between 50 and 250 inflammatory cells	0	0	1	10
	4 - severe: more than 250 inflammatory cells	0	0	0	0
Chronic inflammatory infiltrate (intensity)	1 - absent or few cells	2	4	2	0
	2 - small: less than 50 inflammatory cells	3	3	1	0
	3 - moderate: between 50 and 250 inflammatory cells	1	1	5	0
	4 - severe: more than 250 inflammatory cells	4	2	2	10
Chronic inflammatory infiltrate (extension)	1 - absent or few cells	2	4	2	0
	2 - small: less than 50 inflammatory cells	6	3	2	0
	3 - moderate: between 50 and 250 inflammatory cells	1	3	4	0
	4 - severe: more than 250 inflammatory cells	1	0	2	10
Apical periodontal ligament space	1 - up to 200 µm	3	3	1	0
	2 - from 201 to 300 µm	3	5	3	0
	3 - from 301 to 400 µm	4	1	1	0
	4 - above 401 µm	0	1	5	10
Organization of periodontal ligament	1 - inserted from the cementum to the bone in the entire apical portion	2	4	2	0
	2 - inserted partially from the cementum to the bone of the apical portion	6	5	5	0
	3 - parallel to the surface of the tooth	0	0	1	0
	4 - without organization	2	1	2	10
Limit of filling	1 - 2 mm before the apical opening	0	1	0	-
	2 - at the level of the apical opening	8	7	8	-
	3 - beyond the apical opening	1	1	1	-
	4 - overfilling	1	1	1	-
Presence of debris	1 - absence	8	8	6	-
	2 - discreet presence	1	2	4	-
	3 - moderate presence	1	0	0	-
	4 - intense presence	0	0	0	-
Presence of giant cells	1 - absence	9	9	7	10
	2 - discreet - 1 to 3 cells	0	1	2	0
	3 - moderate - 4 to 6 cells	0	0	1	0
	4 - severe - 7 or more cells	1	0	0	0
Presence of microorganisms	1 - absent	6	7	2	0
	4 - present	4	3	8	10
Group x Group*		a	a	b	c

* Different letters indicate statistically significance at 5% (Kruskal-Wallis test).

G1: 2.5% NaOCl; G2: 1.0% NaOCl; G3: Saline; G4: Control.

Discussion

Sodium hypochlorite, in high concentrations, has a potent antimicrobial action due to the release of a large number of secondary chlorates, leading to greater tissue dissolution, thus being recommended for treatment of teeth with periapical lesions.[17] According to the present histopathological study, similar results were obtained with both concentration of NaOCl solutions (2.5% and 1%), which may be due to the fact that NaOCl solutions have more direct performance just on the bacteria contained in the main canal, but without action in the root canal

system as a whole, specially in the ramifications of the apical delta and inside the dentinal tubes. Some studies have demonstrated the reinfection of the main canal some days after obtaining high index of negative bacteriological tests with the instrumentation.[20,21]

On the other hand, although NaOCl has limited action in the root canal system as a whole, its performance promoted better results when compared with the 0.9% sterile saline solution. This result can be justified by the absence of microorganisms in most of the specimens where NaOCl solutions were used.

Several *in vitro* studies have been performed to check the antibacterial activity of NaOCl and showed that 4% NaOCl is effective against Enterococcus faecalis;[22] 4% NaOCl and 2.5% NaOCl were significantly greater than other tested agents;[23] there was no difference in the antibacterial activity of 1%, 2.5%, and 5% NaOCl.[18] These results corroborate with the present study that show no significant difference among the 1% and 2.5% NaOCl.

Although the present study has demonstrated the importance of the use of irrigants with antibacterial activity in the treatment of teeth with the presence of bacteria in the root canal, an ideal solution should act not only directly on the bacteria but also on the bacterial endotoxin. It has been demonstrated that endotoxin is present in higher concentration in infected teeth, mainly when there is chronic periapical reaction.[24] Although the NaOCl solutions can inhibit the action of some endotoxin, it is admitted that the NaOCl is not effective against all of them.[25] Therefore, the initial disinfection should be maintained or enlarged with the root canal dressing and the filling material.

The presence of the smear layer formed after the biomechanical preparation can also explain the similarity of results among those studies that evaluated different concentrations of NaOCl, wich is ineffective to remove it.[26-29]

NaOCl is also able to bleach the dentin and to dissolve organic material. These properties can increase the permeability[30,31] and decrease the superficial tension facilitating the diffusion of the ions of the filling material in the apical ramifications of the root canal,[32] which could lead to the best results in the groups where it was used.

Besides the irrigating solutions, the final result of the present study was conditioned to the use of filling material. Sealapex was used due to its biological properties and ability to stimulate deposition of mineralized tissue in the apical foramen.[33] Apical and periapical repair of dogs' teeth with chronic periapical lesion has been shown to occur with the use of Sealapex.[34,35]

In the present study, when a single-visit treatment of teeth with chronic periapical lesion was performed, it was demonstrated that the use of irrigating solutions with antibacterial potential provided more favorable conditions for the development of the healing process.

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Filling displacement after apicectomy with different instruments: A scanning electron microscopic study

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ABSTRACT

Objective: To evaluate the displacement of the filling in root canals after apical root resection using various instruments. **Methods:** Sixty extracted human canines had their crowns removed at the cement-enamel junction, were instrumented and filled 1 mm short of the apex and randomly assigned to six groups, according to the instruments used for apical root resection 3 mm from the apex. The displacement of the filling during the resection procedure was evaluated under a scanning electron microscope by measuring the gap formed between the root canal wall and the material. **Results:** Statistical analysis between groups was performed (Tukey-Kramer's test), revealing that gaps between the filling material and dentinal walls were smaller in the group where Zekrya surgical burs were used, compared to the other tested instruments ($p<0.05$). **Conclusions:** Apical root resection using Zekrya surgical burs promotes less displacement of the filling when compared to the other tested instruments.

Keywords: Apicectomy. Apical surgery. Filling displacement. Filling space. Filling. Root resection.

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Introduction

The main goals of an endodontic treatment is cleaning, disinfecting and shaping the root canal.[1] However, these primary objectives are not always achieved, even with the use of biologically compatible techniques and materials. Together with this condition, it is frequent the presence of ledges, perforations, fractured instruments, posts or cores that may not be removed, calcifications or even anatomic alterations that lead the clinician to solve such problems by periapical surgery. Apicectomy with or without retrograde filling is one of the most indicated surgical procedures when conventional endodontic procedures fail.[2,3,4]

During the apicectomy, 2 to 3 mm of the apical portion of the root must be removed, by means of mechanical and manual instruments, ultrasonics or laser.[2,3,5-8] Apparently, the regularity of the apical surface after apicectomy is related to the repair process.[9,10] The deposition of newly formed cement over the resected surface is preceded by a dentin remodelling, and repair is favoured by a smooth and regular dentinal surface. Another important aspect is to determine if the instruments used for root resection will displace the root filling, thus creating voids that may lead the surgical procedure to failure. This situation may occur mainly with the classical indication of using tapered fissure burs, such as the 700 series.

The aim of this study was to evaluate quantitatively under the scanning electron microscope the gaps between the filling material and dentin walls created by different instruments used for root resection.

Material and methods

For the present experiment, sixty extracted human canines stored in 10% formalin solution and with no apparent defects in the roots were selected. The crowns were removed at the cement-enamel junction, the root canals were explored with a #10 K-file to the apical foramen and the working length was established as 1 mm short of this measurement. The canals were instrumented using the step-back technique, with a #60 master apical file. Irrigation was performed with 1 ml of 2.5% sodium hypochlorite between each file, and after shaping the canals they received 5 ml of 17% EDTA and a final irrigation with 5 ml of 2.5% sodium hypochlorite. The canals were dried with paper points and filled with gutta-percha and Grossman's sealer (Endofill®, Dentsply, Petrópolis, Brazil) using Tagger's hybrid filling technique. Proximal and buccolingual x-rays were obtained from the specimens to evaluate the quality of the filling, and if any voids were present, the sample was replaced.

The excess of filling was removed from the cervical portion of the root 1 mm apically from the cement-enamel junction, and Cimpat® (Septodont, Saint Maur des Fosses, France) was placed to seal this space. Specimens were kept in 0.9% saline solution at 37°C for one week for complete set of the filling material.

The specimens were randomly assigned to six groups, according to the instruments used for root resection. Group I had the roots resected with a tapered carbide fissure bur (#700, S. S. White, Rio de Janeiro, RJ, Brazil), attached to a low-speed engine. Group II was prepared with a #2082 diamond bur (KG Sorensen, Barueri, SP, Brazil) on a high-speed handpiece, while Group III had the root resection performed with a Zekrya bur (Maillefer, Ballaigues, Switzerland) on a high-speed handpiece. Groups IV, V and VI had the roots resected with #700 burs and the surfaces were refined either with a Shofu point (Shofu Inc., Kyoto, Japan), a #31-32 periodontal file (Neumar, São Paulo, SP, Brazil) or a 12-blade high-speed bur (S. S. White, Rio de Janeiro, RJ, Brazil), respectively. All roots were resected 3 mm from the apex at a 90° angle, with constant irrigation by saline solution. The position of the burs during the beginning and ending of the resection was recorded for each root by marks on their surfaces, which were observed during the specimen evaluation.

After one week stored in saline solution, specimens were prepared for observation under a scanning electron microscope (JEOL ISM T220A, Tokyo, Japan) at 75X magnification. The displacement of the filling during the resection procedure was evaluated by measuring the gap formed between the root canal wall and the material, recorded in micrometers. Statistical analysis between groups was performed using the Tukey-Kramer's test.

Results

Photomicrographs of the most representative specimens of each group are shown on Figures 1 to 6.

The statistical analysis revealed that roots resected

with Zekrya burs (Group III) presented less displacement of the filling when compared to Groups I and V ($p<0.05$). Groups I, II, IV and V presented statistically similar results ($p>0.05$). Figure 7 presents graphically the results obtained for the measurements of the displacement of the filling after root resection.

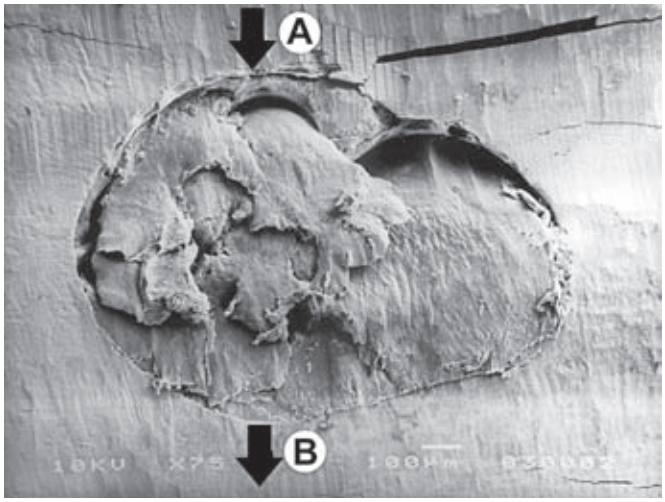

Figure 1. Photomicrograph (75X magnification) of the apical surface after resection with a #700 bur (Group I). **A**) Entry surface of the bur during the resection; **B**) exit surface of the bur after the resection.

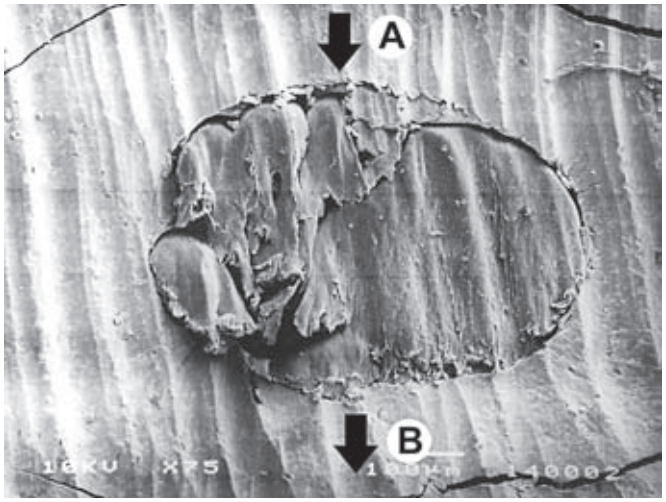

Figure 2. Photomicrograph (75X magnification) of the apical surface after resection with a #2082 diamond bur (Group II). **A**) Entry surface of the bur during the resection; **B**) exit surface of the bur after the resection.

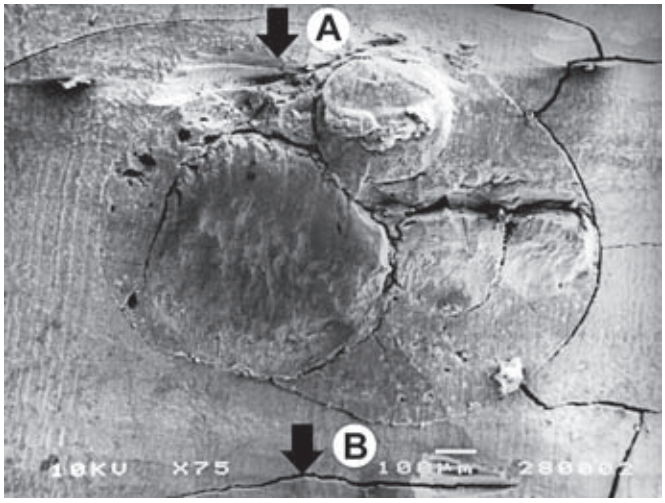

Figure 3. Photomicrograph (75X magnification) of the apical surface after resection with a Zekrya bur (Group III). **A**) Entry surface of the bur during the resection; **B**) exit surface of the bur after the resection.

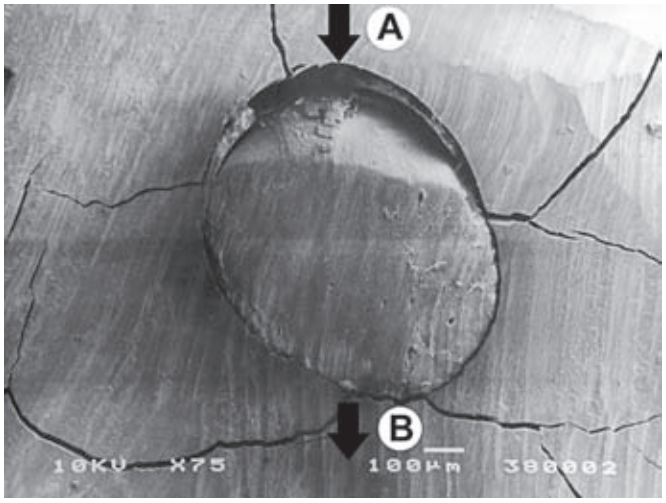

Figure 4. Photomicrograph (75X magnification) of the apical surface after resection with a #700 bur refined with a Shofu point (Group IV). **A**) Entry surface of the bur during the resection; **B**) exit surface of the bur after the resection.

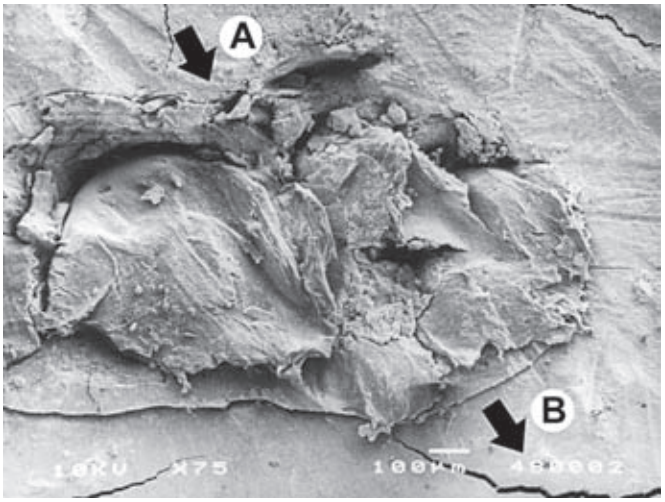

Figure 5. Photomicrograph (75X magnification) of the apical surface after resection with a #700 bur refined with a #31-32 periodontal file (Group V). **A**) Entry surface of the bur during the resection; **B**) exit surface of the bur after the resection.

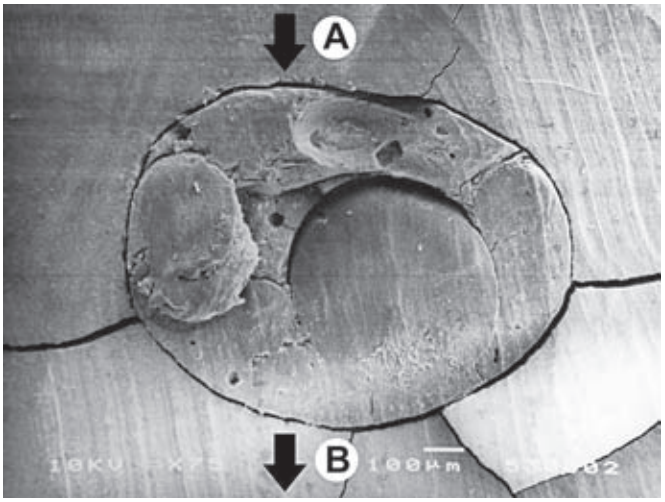

Figure 6. Photomicrograph (75X magnification) of the apical surface after resection with a #700 bur refined with a 12-blade, high-speed bur (Group VI). **A**) Entry surface of the bur during the resection; **B**) exit surface of the bur after the resection.

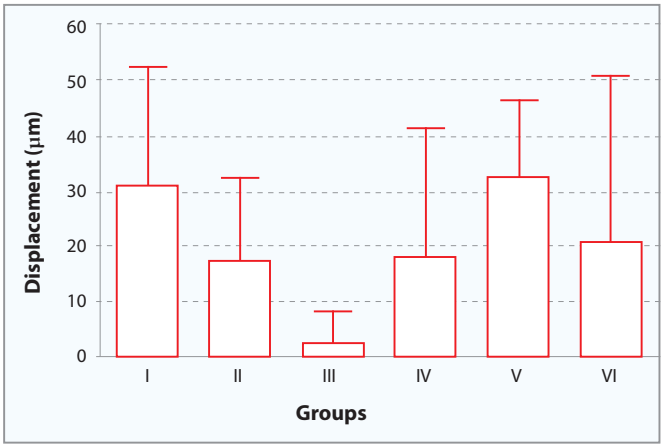

Figure 7. Graph showing the mean values and standard deviation of the gaps due to displacement of filling after apical root resection with different instruments.

Discussion

According to previous studies, a higher resection angle during apicectomies avoids unnecessary exposition of dentinal tubules, which could allow the infiltration of periapical fluids and the passage of microorganisms to and from uncovered dentin.[9,11,12]

In the present study, apical resection was performed at a 90° angle, which was also recommended by other authors.[5,11,13,14,15] Gilheany et al[16] reported that there was a significant increase in leakage as the resection angle increased.

A resection located 3 mm from the apex, used in the present study, is accordingly to previous authors.[17-21]

There are few studies on the effects of the bur on the resected dentinal surface and the eventual consequences on the filling, which are both poorly addressed by research.[3]

The #700 bur is one of the most indicated instruments for apical root resection,[3,18,19,20,22] and the use of this bur attached to a low-speed handpiece enhances visualization and control during the resection in a proximal direction.[17] The association of a #700 bur with other instruments was suggested by previous authors, and also tested in the present experiment.[6,23]

Diamond burs are advocated by other authors as the instrument of choice during apical root resection.[3,13,24] The Zekrya surgical bur is indicated by the manufacturer for root hemisection and amputation; it was included in the present experiment for being recommended by some authors.[7]

The resected specimens were observed under the scanning electron microscope, which was also used by previous authors with good results.[7,15,18] The microscopy artefacts, represented by cracks surrounding the canal in most of the samples, were also evidenced by other authors.[13]

During root resection, the action of the instrument on the filling may compromise apical seal, which may

lead to an unsuccessful outcome of the surgical procedure.[19,27] Despite most authors support the necessity of retrograde filling after apicectomy, some find higher success rates in cases where this filling was not performed.[26]

Interface infiltration between the retrofilling material and dentinal walls is the main cause of failure in endodontic surgery.[27] However, despite most authors relate interface infiltration with retrofilling materials, root canals treated with the conventional technique also present successful outcomes.[13] This seems to correspond to the findings of previous studies, where teeth with canals filled with gutta-percha and sealer submitted to apicectomy revealed absence of infiltration.[22]

The present study revealed that root resection using #700 burs in low-speed handpieces causes more displacement of the filling at the side where resection began, producing a gap which is more pronounced in this area and creating a "combed" pattern in the gutta-percha. Apical resection with Zekrya burs caused less displacement of the filling (2.67±8.43 μm) when compared to Groups I and V (31.20±20.86 μm and 32.53±13.73 μm), being similar to Groups II and IV (17.46±14.81 μm and 18.26±22.93 μm, respectively). A similar finding is reported by Nedderman et al,[15] who found that a non-fissure bur promotes the least displacement of the filling. The use of such burs in high-speed handpieces apparently favours the maintenance of the filling in place, maybe due to the efficiency in cutting both dental tissue and the filling material.

Conclusions

The results of the present study demonstrated that apical root resection using Zekrya surgical burs promotes the least displacement of the filling when compared to the other tested instruments.

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Antibacterial action of intracanal medicaments on infected dentin of deciduous and permanent teeth

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ABSTRACT

Objective: The purpose of this study was to evaluate the antimicrobial effectiveness of intracanal medicaments on infected dentin of deciduous and permanent teeth. **Methods:** Dentin blocks were inoculated with *Enterococcus faecalis* every 72 h for 60 days; then they were irrigated, dried and completely filled with one of the following mixtures: 1) Calcium hydroxide powder, propolis and propylene glycol; 2) calcium hydroxide powder and propylene glycol; 3) calcium hydroxide powder and sterilized water; 4) propolis and propylene glycol; 5) propolis and sterilized water. After 30 days, the samples were washed with sterilized water, immersed in Letheen Broth and incubated for 48 hours at 37 °C. **Results and Conclusion:** The hypothesis that the association of calcium hydroxide with propolis would be more effective than the medicaments themselves was not confirmed, as the results indicated that all the mixtures tested were not able to inhibit *E. faecalis* biofilm, either in dentin blocks of deciduous or permanent teeth.

Keywords: Calcium hydroxide. Propolis. Biofilms. *Enterococcus faecalis*.

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Introduction

It is well known that endodontic infections have a polymicrobial nature either in deciduous[1] or permanent teeth,[2] being *Enterococcus faecalis* one important microorganism to be controlled. *E. faecalis* was observed by polymerase chain reaction in 22% and 32% of necrotic deciduous and permanent root canals, respectively,[3] and it is more prevalent in secondary than in primary endodontic infections.[4] *E. faecalis* is a nonspore-forming, fermentative, facultative anaerobic, and gram-positive coccus that can colonize the dentinal walls from the root canals, adhering to the mineral part as well as to the collagen through different virulence factors.[4,5]

Several substances have been tested in attempt to eliminate *E. faecalis* from root canals, aiming an optimal outcome in non-vital pulp therapy. Although calcium hydroxide has been widely used in endodontics due to its various biological properties,[6] it cannot eliminate *E. faecalis* when used as a solely agent in infected dentin models.[7] A recent systematic review concluded that calcium hydroxide is little effective against bacteria from human root canal.[8] Antimicrobials such erythromycin and oxytetracycline, beside calcium hydroxide, were effective in erradicating two-day-old *E. faecalis* biofilm, whereas ampicillin, co-trimoxazole, and vancomycin followed by gentamicin were ineffective.[9]

Propolis might be a satisfactory adjunct substance for pulp therapies in deciduous and permanent teeth. Propolis is a resinous substance collected by bees that has been extensively used for centuries as a natural chemical agent against infectious diseases.[10] Particularly in endodontics, propolis has been suggested for root canal desinfection, so reducing and controlling pulp and periapical inflammatory reactions, inducing the healing process and controlling post-treatment pain and discomfort.[11] As an endodontic antimicrobial agent, a 10% ethanol extract of propolis is quite effective against *Prevotella nigrescens*, presents intermediate action against *Fusobacterium nucleatum*, but shows high minimum inhibitory and bactericidal concentrations against *Actinomyces israelii* and *E. faecalis*, using the broth macrodilution method.[12] Similarly *E. faecalis* was the most resistant Gram-positive bacterium in regards to 20% ethanol extract of propolis,[13] but propolis solutions have demonstrated good activity against *E. faecalis* in single-rooted canal after short-term application in two experiments using infected model from human permanent teeth.[14,15]

Even though it was reported that experimental pastes containing calcium hydroxide and 11% propolis extract were effective against polymicrobial cultures collected from necrotic root canals in deciduous molars by means of the agar-well diffusion method,[16] little is known about the antimicrobial properties of this mixture. This study aimed to assess the effectiveness of the association 'calcium hydroxide and propolis' against *E. faecalis* in an infected dentin model, to test the hypothesis that this combination might be a satisfactory intracanal medication for endodontic infections in deciduous and permanent teeth.

Materials and methods

Test microorganism

A bacterial strain obtained from the American Type Culture Collection (*Enterococcus faecalis*, ATCC 29212) was inoculated into 7 ml of Brain Heart Infusion (BHI; Difco, USA) and incubated at 37 ºC for 24 hours. The experimental suspension was prepared on the surface of Brain Heart Infusion agar; bacterial cells were resuspended in saline to be adjusted to tube 1 of the MacFarland scale (3×10^8 cells/ml).

Teeth preparation

A total of 42 root samples were prepared from deciduous and permanent extracted maxillary first molars. The deciduous teeth had at least two thirds of root length and absence of perforation in the root wall or furcation area; and the permanent had complete rhyzogenesis, without resorptions. This study was approved by Research Ethics Committee at the Federal University of Goiás, Brazil (protocol number 62/2006). Teeth were obtained from dentists and from a teeth bank, after the donors (adults and children's legal guardian) had consented for the use of their teeth in this research.

Experimental procedures

All teeth were decoronated at the cement-enamel junction. Then blocks of 4 mm and 5 mm height for deciduous and permanent teeth, respectively, were removed from the cervical palatal root with a diamond disk #7020 (KG Sorensen, São Paulo, Brazil) at low speed and under water cooling. The blocks had their cementum layer removed by a cylindrical diamond bur #3101 (KG Sorensen) in a high-speed handpiece and under water cooling.

Each dentin block was individually shaped, using K-files #15 to #30 for deciduous teeth and, K-files #15 to #40 (Maillefer®, Switzerland) for permanent teeth; then they were enlarged with Gates-Glidden drills #2 (deciduous)

and #3 (permanent). Dentin blocks were continuously irrigated with 1% sodium hypochlorite (Miyako®, Guarulhos, SP, Brazil) during the mechanical preparation.

Samples were separated into 7 groups for deciduous and 7 for permanent teeth, each one containing three root dentin blocks in accordance with the medicaments associations specified in the first two columns of Table 1. Dentin blocks were dried and filled with 17% EDTA (pH 7.2) for 3 min; after cleaning and shaping they were sterilized by autoclaving (30 min at 120 °C).

The design of the dentin infection was based on previous studies.[17,18] All blocks (except the negative control) were initially inoculated with *E. faecalis* strains. This procedure was repeated every 72 h during 60 days, always using 24 h cultures adjusted to tube 1 of the MacFarland turbidity standard. Blocks were maintained in a humid environment at 37 °C.

After 60 days, positive control was used to check bacterial viability throughout the experiment. Subsequently, the other blocks were irrigated with 5 ml of saline solution, dried with two sterile gauze and four sterilized absorbent paper points, and completely filled with the intracanal medicament. After this, they were immediately placed in Petri dishes containing 1 g of the medicament (sufficient to cover the blocks) and maintained during 30 days. Subsequently, the samples were individually washed with 10 ml of sterilized water, transported and immersed in a respective tube with 7 ml of Letheen Broth (Difco, USA), homogenized and incubated for 48 hours at 37 °C. Microbial growth was analyzed by turbidity of the culture medium. Afterward, an inoculum of 0.1 ml obtained from Letheen Broth was transferred to 7 ml of BHI under identical incubation conditions. All assays were carried out in duplicate. Each block was scored as either positive or negative for viable *E. faecalis* under the growth conditions.

Results

The associations of propolis with calcium hydroxide, as well as other associations of propolis or calcium hydroxide with other vehicles were not able to inhibit *E. faecalis* growth on dentin blocks extracted from deciduous or permanent teeth (Table 1). Bacteria were viable in the positive control group, while the negative control group was free of microorganisms.

Table 1. Atimicrobial activity of studied medications on *E. faecalis* biofilm.

Group	Association of medicaments	Dentin blocks[a]	
		Deciduous teeth	Permanent teeth
1	0.4 g calcium hydroxide powder[b] 0.1 g pure, dry extract of propolis[c] 0.2 ml propylene glycol[d]	+++	+++
2	0.5 g calcium hydroxide powder[b] 0.2 ml propylene glycol[d]	+++	+++
3	0.5 g calcium hydroxide powder[b] 0.2 ml sterilized water	+++	+++
4	0.5 g pure, dry extract of propolis[c] 0.2 ml propylene glycol[d]	+++	+++
5	0.5 g pure, dry extract of propolis[c] 0.2 ml sterilized water	+++	+++
	Positive control group	+++	+++
	Negative control group	- - -	- - -

[a] Symbol represents bacterial growth in repeated experiments: (+++) indicates positive growth result i.e. presence of *E. faecalis* and medication inneficacy for each dentin block; (- - -) represents negative result (absence of growth or medication efficacy) for each dentin block. [b] Biodinâmica, Ibiporã, PR, Brazil. [c] Pool of Brazilian propolis (patent pending, Apis Flora, Ribeirão Preto, SP, Brazil). [d] Henrifarma, São Paulo, SP, Brazil.

Discussion

This study in infected human dentin demonstrated no antimicrobial effectiveness of the association 'propolis and calcium hydroxide' against *E. faecalis* biofilm. Within the conditions of this study the same result occurred to calcium hydroxide with propylene glycol or with sterilized water and to propolis with propylene glycol or with sterilized water. The positive cultures of *E. faecalis* following the application of all medicaments suggest their inability to disinfect the human root canal, confirming that the reduction of cell viability inside biofilms is extremely difficult. The complex internal anatomy of root canals offers opportunity of microorganisms surviving in the inaccessible and remote areas promoting a good environment for growth, multiplication, and interaction in pulp infections,[19,20] despite it refers to deciduous or permanent teeth.

The method of dentin blocks used in this study attempted to reproduce a clinical situation even though the microorganisms were obtained *ex vivo* from pure culture collection. Dentin was contaminated with *E. faecalis* for 60 days, allowing bacteria penetration into the dentinal tubules to form a biofilm. Clinically, the level of bacterial invasion into the root dentinal tubules is also related to the incubation period: The extended exposure of the root canal to the oral environment results in significant amplified microbial invasion of the root canal system.[21]

Other studies have assessed the antimicrobial activity of intracanal medicaments using infected dentin blocks removed from different sources: human teeth *in vivo*[14,15,18] and *ex vivo,*[17,22] and dog's teeth *in vivo*.[23,24] However, none of them had investigated dentin samples from deciduous teeth. Considering the lower permeability of deciduous molars,[25] one could expect that bacteria would be able to invade easier and deeply the dentin tubules of permanent teeth becoming more aggressive and difficult to eliminate, but this was not the case in the present study. Probably the contamination period was enough to allow the infection of deciduous molars' dentin.

It should be emphasized that the results could be different if we had investigated the same medicaments on planktonic cells as it happened with another antimicrobial agent: Ozone had an antibacterial effect on planktonic *E. faecalis* and on those suspended in fluid, but little effect was observed when this microorganism was embedded in biofilms.[18] Moreover, both propolis and calcium hydroxide as antibacterial agents were effective against *E. faecalis* only in macrodilution method.[12] Multiple resistance mechanisms such as the production of an exopolysaccharide protective matrix and the modulation of the gene expression pattern are related to an increased bacterial resistance in biofilms: Biofilm bacteria can become up to 1,000 times stronger against an antimicrobial than their planktonic counterparts.[26]

In this study, the association of medicaments aimed to produce an intracanal medication able to eliminate *E. faecalis*. However, the antimicrobial agents were applied after the microorganism inoculation without any previous irrigation. Considering that irrigants are important to optimize intracanal disinfection others results may be waited if we had used an effective irrigant solution.[27] Chemicals that alter the physicochemical properties of dentin can influence the nature of adherence, adhesion force, and subsequent *E. faecalis* biofilm formation on dentin.[28]

It is difficult to contrast the results of different studies on propolis antimicrobial activity against *E. faecalis* due to differences in propolis formulations as well as in microbiologic methods. The results of the present study are in disagreement with other two investigations that concluded that propolis is effective against *E. faecalis* biofilms.[14,15] Both of them used shorter contamination periods, e.g. 7 days[14] and 21 days.[15] In addition, one tested a 10% ethanolic extract of bursa propolis[14] and the other, a 30% solution of Jordanian propolis.[15] The contamination period of *E. faecalis* in dentin was discussed earlier in this section. As the composition of propolis varies according to the region where propolis is collected,[10] one could speculate that Brazilian propolis would not be so effective. However, previous studies using other microbiologic methods have reported that *E. faecalis* was susceptible to Brazilian propolis.[12]

Nevertheless, the findings in the present study are in agreement with those investigations that reported that calcium hydroxide medications are not able to eradicate *E. faecalis* biofilm[27]. This ineffectiveness is due to the poor diffusion of hydroxyl ions into infected dentin and the buffering capacity of dentin, reducing its alcalinization potential.[29] Moreover, the dentinal collagen can confer resistance to the bacterium against calcium hydroxide.[30]

To sum up, calcium hydroxide and propolis were not able to eliminate 60 day *E. faecalis* biofilm *in vitro*. Considering that *in vitro* assessments do not exactly

reproduce clinical outcomes, further studies using different methods should answer the questions that have arisen. Nevertheless, calcium hydroxide plays an important role in endodontics as long as vital pulp therapies are concerned. Propolis should be further tested under other experimental conditions though. One cannot ignore the broad properties of propolis and its potential application in endodontics as a pulpotomy agent in deep carious lesions, as intracanal medications in primary endodontic infections of permanent teeth, and as filling agent in deciduous teeth pulpectomies.

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Analysis of concentration and storage method of sodium hypochlorite solutions in dental offices

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ABSTRACT

Objective: Evaluate the concentration and storage method of sodium hypochlorite solution in dental offices from Santa Cruz do Sul/RS, Brazil. **Methods:** Fifty samples of the solution were collected, where, by titration, we analyzed the concentration of active chlorine. Besides the collection, a questionnaire was conducted in order to verify the type of packaging and cover that the sodium hypochlorite solution was in, as well as the storage location. **Results:** Thirty-eight of the 50 samples tested had concentrations below the indicated, 3 had active chlorine content above of the information from the professional and only 9 had the indicated concentration. As regards the packaging and the type of cover that hypochlorite solutions were stored, 40 of the 50 samples were stored in milky plastic containers, 6 in amber plastic containers, 3 in transparent plastic containers and 1 in glass bottle. Regarding the type of cover, 46 of the collected solutions were found stored in containers with screw cover, and only 4 in packages of pressure cover. Moreover, 43 of the 50 solutions collected were stored in cabinets, 6 in refrigerated environments and 1 was found on the counter next to a stove. **Conclusion:** The majority of the sodium hypochlorite solutions collected and analyzed showed a lower percentage of active chlorine than the informed by the professional, were stored in milky plastic containers with screw cover and kept at room temperature in cabinets.

Keywords: Sodium hypochlorite. Titration. Concentration. Storage.

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Introduction

The success of endodontic treatment is reached being careful, observing techniques and biological principles in all phases of implementation. Therefore, it is necessary to sanitize the root canal using an irrigating solution with proper concentration able to remove debris and microorganisms within the canal, facilitating its shaping.

Several substances have been used during root canal preparation, performing chemical and physical actions concurrently with the mechanical action of endodontic instruments.[1] It is highly desirable that the agents selected as endodontic irrigants possess some fundamental properties such as antimicrobial activity, dissolve organic tissue, assist in debridement and absence of cytotoxicity to periapical tissues.[2,3]

Among the chemical substances used there is the sodium hypochlorite, a chlorinated classified as the main auxiliary chemical substance used in currently endodontics.[4] This compound has a number of properties and advantages, among which it is included the ability to dissolve organic matter,[5] and the broad antibacterial spectrum that enables the effective elimination of microorganisms from the root canal[6] and the dentinal tubules.[7] The concentration and temperature interfere with the antimicrobial action and tissue dissolution capacity of sodium hypochlorite, where the higher concentration and temperature, the greater the antimicrobial activity and faster tissue dissolving.[8,9]

Among its disadvantages, sodium hypochlorite is unstable to storage and it is inactivated by organic matter[1], highly cytotoxic when extravasated within the periradicular tissues,[10] reduces the fracture resistance of teeth and the bond strength of restorative materials to dentin.[11]

Thus, the aim of this study was to evaluate the concentration and the storage method of sodium hypochlorite solution used in dental offices from Santa Cruz do Sul - RS.

Methodology

Fifty dental offices located in Santa Cruz do Sul – RS - Brazil were selected. Prior to the sample collection, professionals received and signed the Informed Consent Statement.

In each dental office it was sampled a quantity of 50 ml of sodium hypochlorite used in the endodontic therapy by the dentist at the collection site. This solution was stored in a clear plastic with screw cap. The offices were identified by numbers 1 through 50, as well as the samples of sodium hypochlorite.

Immediately after the collection, the container with the respective solutions of sodium hypochlorite for each office was taken to an analytical center (CAUNISC - Analytical Center of the University of Santa Cruz do Sul) to carry out the analysis of the content of chlorine through the titulometric test, defined as the process used to experimentally determine the concentration of a particular solution.

A questionnaire was applied along the sample collection (Fig 1) aimed at dentists responsible for the offices, which contained questions regarding packaging, type of package cover and storage site of sodium hypochlorite solutions collected.

The descriptive statistical analysis of data was performed after obtaining the results.

Results

Of the 50 samples of sodium hypochlorite solution that were collected and analyzed, 9 had the concentration indicated by the professional (Fig 1). Regarding the packing that the solutions of sodium hypochlorite were stored, the majority was in milky plastic packing (Fig 2). Regarding the type of cover of the packages where the solutions were stored, most were found in containers with screw cap (Fig 3). And finally, as for the storage of sodium hypochlorite solutions, most were found in cabinets (Fig 4).

QUESTIONNAIRE

Dental office number: _____

Concentration of the solution collected: _____

1) Packing used:

( ) milky plastic ( ) transparent plastic ( ) amber plastic ( ) glass bottle

2) Type of packing cover

( ) screw ( ) pressure ( ) other: _____

3) Storage site

( ) cabinets ( ) refrigerated environment ( ) other: _____

Figure 1. Questionnaire used in this research.

Discussion

In endodontic therapy, part of the capacity of the root canal disinfection is due to mechanical instrumentation, removing debris and microorganisms from the root canal. The other part concerns the actions of chemical cleaning and disinfection promoted by irrigating solutions.

Sodium hypochlorite is the substance that combines the best physical and chemical properties and therefore is the most commonly used.[12] The solution of sodium hypochlorite is found only in aqueous form, having its disinfectant action by the release of chlorine.[13]

Due to the instability of sodium hypochlorite, it was recommended to store it in a fresh place away from light and renewed every three months.[14] Hence, the present study took into consideration the location and storage method of sodium hypochlorite solution, relating these factors to the concentrations indicated by the professionals.

According to previous studies, factors such as light, temperature and storage method of sodium hypochlorite solutions can promote changes in the concentration of active chlorine.[15,16] So, this study sought to analyze the solutions used in dental offices in Santa Cruz do Sul, in order to verify that at the time that sodium hypochlorite was used as a irrigant for cleaning and sanitation of the root canal, it was in the same concentration that when it was acquired.

It is known that the hypochlorite solutions are not stable. According to the method and time of storage, may significantly lose the concentration of active chlorine. This factor must be taken into account, since these solutions may remain stored in the market for a long time, and when they are used, the professional is not aware of the real concentration that the product has at the time of use.[17]

Other authors have evaluated the active chlorine content of different brands,[16] concluding that sodium hypochlorite is an unstable chemical substance and presents reduction on the concentration of available chlorine, which was also concluded in this study.

Previous study confirmed the decreased percentage of active chlorine when sodium hypochlorite was exposed to sunlight.[18] However, this study covered only solutions stored in amber colored glass. In the present study there was a slight difference in results as regards

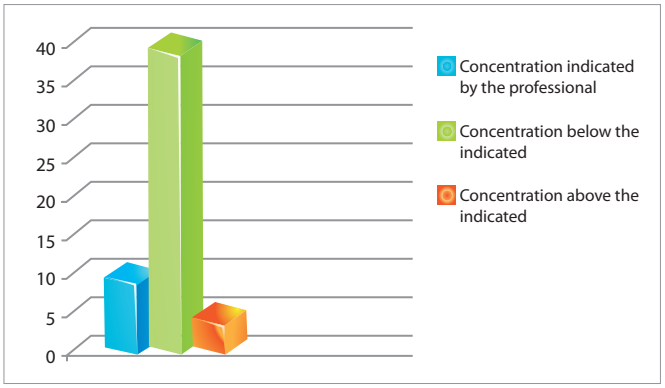

Figure 1. Concentration of samples collected.

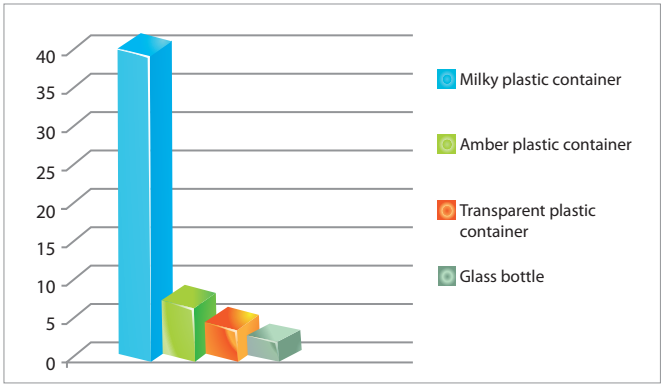

Figure 2. Packing used.

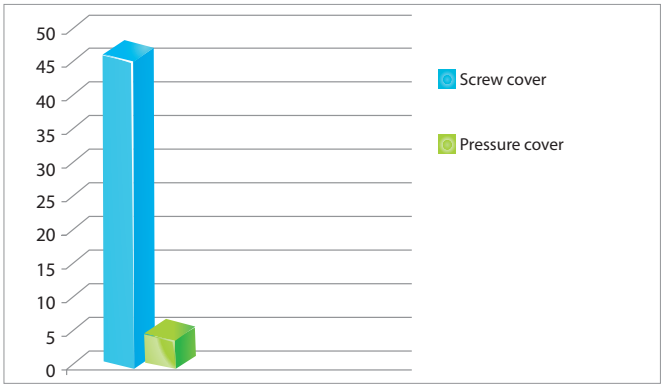

Figure 3. Type of packing cover.

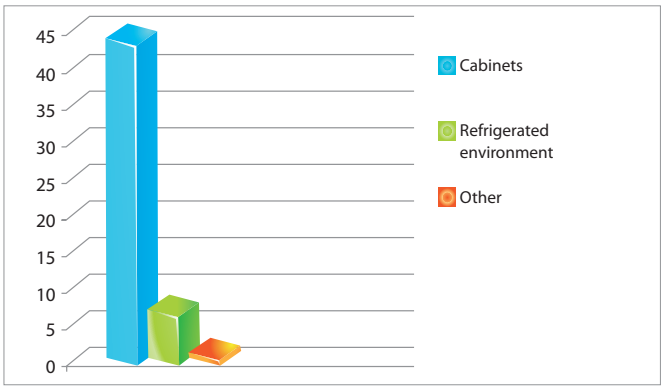

Figure 4. Storage site.

the coloration of the pack. Solutions that were stored either in milky plastic or amber plastic container resulted in very close final concentrations, with a minimum level of variation. The difference of active chlorine can be noticed when comparing the plastic containers with glass bottle (vial of anesthetic), which has a much lower concentration than the first. The reaction of active chlorine with oxygen causes a decrease in its concentration, which could explain the reduction in content of active chlorine when the transport of the substance from the original packing to vials.[17]

These results also showed that when stored under refrigeration, it was observed an increase in active chlorine content of the substance. But when the solution was stored in cabinets, the decrease was the same. Some studies have confirmed that the packing at lower temperatures has brought greater stability to the solutions of 1% sodium hypochlorite,[18,19] which actually occurred in this study.

By the collected data from the analysis was possible to conclude that the vast majority of sodium hypochlorite solutions that were collected and analyzed showed lower percentage of active chlorine than the informed by the professional; were stored in milky plastic containers with screw cover and kept at room temperature in cabinets. Clinically, it is suggested that greater care must be taken to the continued use of this solution, being attentive to the actual concentrations of the same, since this factor may influence the prognosis of endodontic therapy.

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Use of nickel-titanium rotary instruments by endodontists in the state of Rio Grande do Sul, Brazil

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ABSTRACT

Objective: To assess the use of nickel-titanium rotary instruments among endodontists in the state of Rio Grande do Sul, southern Brazil. **Methods:** A survey was conducted with all endodontists registered at the Regional Council of Dentistry (CRO/RS). **Results:** A total of 430 questionnaires were sent to endodontists via regular mail, and 106 returned (25% return rate). The great majority of respondents (88.7%) reported to have already used nickel-titanium rotary instruments, and 44.3% of these reported to have received training as part of lato sensu specialization programs. The main advantages associated with rotary vs. manual instrumentation were less fatigue to the professional and improved comfort to the patient (29%), and faster instrumentation (24.9%). Cost was the most frequent reason for not using or for interrupting use of rotary instrumentation (55.8% and 59.3%, respectively). The most frequent problem observed was file fracture (54%). A longer time working as an endodontist negatively influenced the use of endodontic instruments ($p = 0.03$), but did not affect file fracture. **Conclusion:** Most of the endodontists in the state of Rio Grande do Sul use and recognize the benefits of rotary instrumentation. However, the high costs involved and frequent file fracture impede a more extensive use of this technology.

Keywords: Instrumentation. Endodontics. Diffusion of innovation.

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Introduction

Endodontic instruments are essential elements in the cleaning and shaping of root canals, and several authors have reported, over the last decades, on the great influence exerted by the root canal preparation phase on the results of obturation procedures.[1,2]

In the 60s, endodontic instruments were fabricated from carbon steel. However, the identification of some disadvantages associated with this material resulted in its subsequent replacement with stainless steel. Stainless steel instruments, in turn, were also found to present poor flexibility (especially the higher tapers), potentially leading to procedural errors, especially in curved canals.[3] Moreover, several studies have shown a high incidence of apical transportation associated with stainless steel instruments.[4,5]

More recently, in the 80s, the first endodontic instruments fabricated from nickel-titanium alloys were introduced into the market. These instruments presented two to three times more flexibility when compared with stainless steel instruments, in addition to increased resistance to fracture and shape memory effect.[6] Nickel-titanium rotary instruments have been shown to effectively produce a well-prepared root canal, with a low margin for procedural errors,[7,8] thus improving clinical outcomes.[9]

The advent of nickel-titanium alloys allowed the design and development of rotary instruments with 360-degree rotation, to be used specifically in curved canals. This contributed to a more rapid preparation process and to a lower degree of stress for both the endodontist and the patient.[10,11]

In spite of the many advantages described in the literature for nickel-titanium endodontic instruments, no study so far has provided information on the use of this new technology in clinical practice in Brazil. Therefore, we conducted a survey with endodontists in the state of Rio Grande do Sul, southern Brazil, to assess the use of nickel-titanium rotary instruments and to identify possible reasons for using, not using or interrupting the use of these instruments during the preparation of root canals.

Methods

The study protocol was approved by the Research Ethics Committee of Federal University of Santa Maria (UFSM), state of Rio Grande do Sul, Brazil (protocol No. 0127.0.243.362-08). All dental professionals included in the study signed an informed consent form.

The study sample comprised all endodontists registered with the state dental board, namely Conselho Regional de Odontologia do Estado do Rio Grande do Sul (CRO/RS), at a total of 430 professionals. The addresses of all endodontists were provided by CRO/RS.

Subjects were asked to fill a questionnaire (in Brazilian Portuguese) constructed to address data such as sex, age, time working as an endodontist and nine other questions concerning the use of rotary instrumentation, as follows:

» Question 1: Have you already used nickel-titanium rotary instruments?

» Question 2: If yes, have you attended any training to learn how to use these instruments?

» Question 3: In case you do not use nickel-titanium rotary instruments, can you explain the reasons for this decision?

» Question 4: If you have had previous experience with rotary instruments, but have stopped using them, please explain the reasons for your decision.

» Question 5: How long have you been using (or did use) the instruments, in months?

» Question 6: How often do you use nickel-titanium rotary instruments in a week?

» Question 7: Please list any problems you have experienced during the use of nickel-titanium rotary instruments.

» Question 8: Have you observed any advantages associated with rotary instrumentation when compared with manual instrumentation?

» Question 9: In case you have experienced instrument fracture, what do you think has caused the problem?

Questionnaires were sent to endodontists via regular mail together with informed consent forms and prepaid return envelopes.

A pilot study was initially conducted with nine graduate students of endodontics so as to assess the clarity of questions. The results of this pilot study were used to adjust the questions and to prepare the final version of the questionnaire.

The answers to each question were analyzed and tabulated to allow individual comparison of data.

Results were submitted to the analysis of frequency measures and plotted in graphs and tables so as to facilitate data interpretation. Significance was set at 0.05%.

Results

Of a total of 430 questionnaires sent to endodontists, 106 returned (response rate of approximately 25%). Table 1 describes the sample in terms of sex, age, and time working as an endodontist.

Time working as an endodontist was inversely related with use of nickel-titanium rotary instruments: Professionals working as endodontists for a longer time reported a lower frequency of use of rotary instrumentation, with a statistically significant difference ($p = 0.03$).

With regard to the use of nickel-titanium rotary instruments (question 1), 94 (88.7%) respondents reported to have already used this type of instrument, in contrast with 12 (11.3%) who reported not to use or have used them.

Among the endodontists who reported to use rotary instrumentation, 44.3% had received training (question 2) as part of lato sensu specialization programs, 25.5% had attended specific/commercial rotary instrumentation training courses, 12% did not attend any course, and 6.6% reported that they had received training both as part of specialization programs and at specific/commercial courses; 11.3% did not answer this question.

The reasons for not using nickel-titanium rotary instruments (question 3) and for interrupting their use are shown in Tables 2 and 3, respectively.

In response to question 5 (time using the instruments), 18% of the respondents informed that they had been using or had used the instruments for 0 to 12 months, 13% for 13 to 24 months, 16% for 24 to 36 months, and 33% for more than 36 months; 20% of the participants did not answer this question.

The weekly frequency of use of nickel-titanium rotary instruments was as follows: 19.8% of the respondents used them less than once a week and 20.8% used them more than five times a week; 27.3% reported to use the instruments between one and five times a week, and 32.1% did not answer this question.

Table 1. Rate of use of nickel-titanium rotary instruments according to sex, age, and time working as an endodontist.

Variable	n (%)
Sex	
Female	64 (60.4)
Male	42 (39.6)
Age (years)	
20 to 29	12 (11.3)
30 to 39	52 (49.1)
40 to 49	28 (26.4)
50 or over	14 (13.2)
Time working as an endodontist	
1 to 5 years	23 (21.7)
5 years and 1 month to 10 years	41 (38.7)
10 years and 1 month to 15 years	14 (13.2)
15 years or over	28 (26.4)

Table 2. Reasons for not using nickel-titanium rotary instruments (n = 43 answers)*.

Reason	No. of answers	%
Cost	24	55.8
Long time required to learn the technique	3	7.0
Difficult use	2	4.6
No specific reason	14	32.6
Total	43	100.0

* Respondents could provide more than one answer to the question.

Table 3. Reasons for interrupting the use of nickel-titanium rotary instruments (n = 59 answers)*.

Reason	No. of answers	%
Cost	35	59.3
Instrument fracture	12	20.3
Difficult use	5	8.5
Did not like the results	2	3.4
Long time required to learn the technique	0	0.0
No specific reason	5	8.5
Total	59	100.0

* Respondents could provide more than one answer to the question.

Table 4. Problems observed during the use of nickel-titanium rotary instruments (n = 100 answers)*.

Problem	No. of answers	%
File fracture	54	54.0
Apical deviation	13	13.0
Excessive dentin removal	8	8.0
Zips in curved canals	7	7.0
Root canal leakage	2	2.0
Perforation of curved canals	1	1.0
Other reason	9	9.0
Do not know	6	6.0
Total	100	100

* Respondents could provide more than one answer to the question.

Table 5. Advantages associated with rotary instrumentation (n = 277 answers)*.

Advantage	No. of answers	%
Less fatigue for the professional and improved comfort for the patient	80	29.0
Faster instrumentation	69	24.9
Easier obturation	54	19.5
Maintenance of canal curvature	50	18.0
Maintenance of working length	19	6.8
Other	5	1.8
Total	277	100

* Respondents could provide more than one answer to the question.

Table 6. Reasons for instrument fracture (n = 140 answers)*.

Problem	No. of answers	%
Excessive pressure on the file	43	30.8
Overusage	34	24.4
Complex canal anatomy	26	18.6
Wrong angle of file insertion	9	6.4
Wrong sequence of file use	7	5.0
Insufficient irrigation of the canal	4	2.8
Excessively high rotation	3	2.1
Non-constant rotation speed	3	2.1
Patient bit the handpiece	2	1.4
Other	4	2.8
Do not know	5	3.6
Total	140	100

* Respondents could provide more than one answer to the question.

The longer the professional had been working as an endodontist, the lesser times the instruments were used weekly (p = 0.017).

The problems observed during preparation with nickel-titanium rotary instruments are listed in Table 4.

Table 5 shows the advantages associated with rotary vs. manual instrumentation, and Table 6 shows the reasons attributed to instrument fracture.

The frequency of instrument fracture was not statistically influenced by time working as an endodontist (p = 0.416).

Discussion

The present study assessed the use of nickel-titanium rotary instruments by endodontists in the Brazilian southern state of Rio Grande do Sul. Of all professionals who answered the questionnaire, 88.7% reported to have used or use nickel-titanium rotary instruments. This result is in line with surveys conducted in Australia and in the United States, which have revealed rates of 64 and 98% for the use of this technology among endodontists.

The data collection method employed in the present study, namely questionnaires sent via regular mail to all endodontists registered with the state dental board, aimed to recruit a large sample at a relatively low cost when compared with one-to-one interviews (the CRO refused to provide the emails addresses of the endodontists). Our response rate was of approximately 25%, similar to the response rates obtained in other studies, e.g. 25%,[12] 32%,[13] and 38%.[14] Parashos and Messer[15] obtained a response rate as high as 87%; however, in that study, each questionnaire was sent to the participants three times, and telephone contact was made with those who did not return the material via regular mail.

Among the endodontists who reported to use nickel-titanium rotary instruments, 44.3% had received training as part of lato sensu specialization programs, and 25.5% at specific/commercial rotary instrumentation courses. Reit et al[10] found that a combination of theoretical and hands-on training sessions resulted in a better short-term acceptance rate (94%) when compared with teaching given only in lecture format (53%). Those authors concluded that the short-term acceptance of a new technology

may be influenced by the design of the introductory educational program that professionals attend. Parashos and Messer,[15] in turn, found that 73% of the respondents sought continuing education programs. Koch et al[11] have also assessed the rate of use of nickel-titanium rotary instruments and concluded that the technique was fully adopted by 77% of dental professionals who had attended an educational program on rotary instrumentation; this result was significantly higher than that found in the group who had not attended the program (6%). All these studies emphasize the importance of education/training for the adoption of a new technology. The fact that more endodontists are using rotary instrumentation in the current days is probably a reflection of the significant recent increase in the number of lato sensu programs in Brazil.

For a new technology to be adopted, it is necessary that professionals perceive advantages associated with its use when compared with an already consolidated, successful technique. Rogers[16] suggests that the diffusion of innovations takes place through a five-step process: Knowledge, persuasion (the individual is interested in the innovation and actively seeks information/detail about the innovation), decision (the individual weighs the advantages/disadvantages of using the innovation and decides whether to adopt or reject it), implementation, and confirmation.

In the present study, the main advantages associated with the use of nickel-titanium rotary instruments vs. manual instrumentation were less fatigue for the professional and improved comfort for the patient (29%), faster instrumentation (24.9%), easier obturation (19.5%), and maintenance of canal curvature (18%). Similar results were obtained by Parashos and Messer,[15] who found the following advantages associated with the use of rotary instruments vs. manual stainless steel instruments: Faster canal preparation (80%), maintenance of canal curvature (73%), easier obturation (72%), and maintenance of working length (66%). Bjorndal and Reit[17] observed an apparent influence of nickel-titanium rotary instrumentation on treatment time and also on the number of sessions necessary to complete treatment.

One of the main findings of the present study was that cost was the most influent factor in the decision not to adopt nickel-titanium rotary instruments, cited by 55.8% of respondents. In addition, the main factors determining interruption of rotary instrumentation (for those who used the technology for some time) were, again, cost (59.3% of respondents), followed by instrument fracture (20.3%). Similar results were obtained by Bird et al[14] in a survey on usage parameters of nickel-titanium rotary instruments. Those authors found that the most significant factors affecting use of rotary instrumentation were instrument fracture (52%) and cost (55%), independently of time working as an endodontist or geographic region. Parashos and Messer,[15] in turn, found the following three main (most frequently cited) reasons for not using rotary instruments: No perceived advantages, instrument fragility, and high cost.

Operator experience has been suggested to be an important factor affecting fracture and plastic deformation of files during the shaping process.[18,19] Other authors have shown that, in addition to operator experience, adequate training also contributes to minimizing fracture of rotary instruments.[20,21]

In the present study, the two main causes of file fracture cited by respondents were excessive pressure on the file (30.8%) and overusage (24.4%). These results are in line with those reported by Parashos and Messer[15] who also found excessive pressure (62%) and overusage (43%) as the main reasons for instrument fracture.

Another factor that seems to significantly influence instrument fracture is the number of times that files are used. There is no consensus in the literature with regard to the number of times an instrument can be used without any risk of fracture. In fact, in more complex cases, e.g. curved or calcified canals, studies have recommended that instruments be discarded after only one use.[22,23,24] However, discarding rotary instruments after one use would result in even higher costs, further reinforcing the already strongest reason for not using rotary instruments among the endodontists surveyed in our study. In the study conducted by Bird et al,[14] 21% of the respondents informed that they discarded nickel-titanium rotary instruments after only one use. Parashos and Messer[15] found that 70% of the respondents used the instruments 2 to 5 times, whereas 19% reported to use the files 6 to 10 times; only 12% reported to discard the instrument after one use.

It is possible to observe that the high cost of new technologies significantly influences the decisions made by professionals. However, the inclusion of at least one technique of rotary instrumentation in the core curriculum of undergraduate dental schools is of paramount importance and would allow students to discuss the indications, advantages and disadvantages of this treatment modality. This measure would also ensure a more comprehensive understanding of instrumentation,[25] as well as guarantee that endodontic teaching and training is coherent with the technological development of endodontics.

Conclusions

Our findings allow us to draw the following conclusions:

- Most of the endodontists in the state of Rio Grande do Sul (Brazil), use and recognize the benefits of rotary instrumentation. However, the high costs involved and frequent file fracture impede a more extensive use of this technology.

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In vitro efficiency evaluation of an electronic apex locator in teeth with simulated root resorption

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ABSTRACT

Objective: This *in vitro* study evaluated the efficiency of electronic apex locator Novapex (Forum Technologies, Israel) in determining the working length, when used in different clinical situations, as in teeth with simulated external and internal resorption. **Methods:** Thirty single-rooted extracted human teeth (mandibular canines), with completely formed apices and with the same pattern of volume in the apical region, were used, using only its root portion. Initially, the length of each tooth was visually determined with a #10 K-file until the appearance of the apical foramen, subtracting 1 mm, setting the real work length measurement. The measure was taken again with the use of electronic apex locator apparatus and considered Novapex initial electronic length. Soon after, the wears were prepared to simulate the external and internal resorption. Measurements were taken again with the apex locator, and these were tabulated and analyzed. **Results and Conclusion:** The results showed that Novapex was highly accurate when considering 1-mm changes in the pre-determined measure. Through this study, we found that the apical locator Novapex was effective, showing to be a reliable method and no significant interference in his reading was detected when simulated external and internal resorption were present.

Keywords: Odontometry. Tooth resorption. Endodontics.

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Introduction

The success of endodontic therapy depends crucially on the correct execution of all stages, from diagnosis to the filling. These steps include determining the working length, the so-called tooth length that is a challenge to professional, depending on the anatomy of the apical region.[1] The accuracy in determining the work length plays an important role in reducing contamination and bacterial load in root canals. A non instrumented root canal, especially in cases of infected pulp and apical periodontitis leads to lower rates of success as compared with the complete preparation on the exact work legth.[2]

Several methods have been proposed for determining the length of the root canal, since the patient's response to pain caused by the passing of an instrument at the apical foramen to the use of conventional or digital radiographs.[3] With the advent of electronic apex locators (EALs) an additional feature was available in the endodontic arsenal to determine the correct odontometry.[1,2]

Several studies have shown that electronic odontometry is a fast and safe alternative for performing endodontic procedures. Kaufman et al[4] studied *in vitro* the odontometry precision of two EALs, Root ZX and Bingo 1020, comparing them with the radiographic method in 120 teeth. They found superior results of electronic devices, when compared with the radiographic method. Similar results on the efficiency of EALs has also been observed in several studies in endodontic literature.[5,6]

Despite the efficiency of these EALs, there are situations where may be some interference with the results of the measurements, caused by the influence of various factors, such as the presence of resorptions.[7] Therefore the aim of this study was to evaluate *in vitro* the efficiency of the apex locator Novapex (Forum Technologies, Israel) in teeth with non-communicant simulated external and internal root resorption.

Materials and Methods

To realize this *in vitro* study, were selected 30 single-rooted extracted human teeth that were obtained from the Tooth Bank of the Dentistry Faculty of State University of Rio de Janeiro. The selection criteria were teeth with complete root formation and apical foramen corresponding to a #10 K-file (Dentsply-Maillefer, Ballaigues). Exclusion criteria were teeth with obliterated root canal or with cracks.

The teeth were numbered and divided into four groups: Five teeth belonging to the positive control group (where was simulated a communication channel with the root resorption), 5 teeth belonging to the negative control (healthy crowns and roots), 10 teeth belonging to the group in which an external resorption was simulated and 10 teeth belonging to a group where was simulated an internal resorption. In the preparation of the teeth, coronal portion was removed leaving only the root portion.

The working length (WL) was determined 1 mm short of the foramen. To control the WL, the examiner performed the visual measurements with a #10 K-file until it left the apical foramen and then 1 mm was subtracted. The values were tabulated for comparison with the lengths obtained by the electronic method.

Prior to completion of perforations teeth length was obtained by the electronic method. This measurement was based on the methodology described by several authors.[6,8] The sample was fixed in plastic containers containing 0.9% saline solution, and the root was fixed with a wax layer, leaving a space for placing the labial clip in contact with the saline solution. Measurements were carried out using the EAL Novapex. A #10 K-file, was coupled to handle the device and during its insertion into the canal, the measurements were monitored on the device display, until the instrument reached the "APEX" mark. At this time, cursors were set on the coronal surface and measurements taken with the endodontic ruler (Dentsply-Maillefer, Baillagues, Switzerland). Measurements were recorded and considered as initial electronic length (IEL). The canals were irrigated with 0.9% saline during the measurements.

After this verification, root resorptions were performed. To create the external root resorption, a lateral wear was made, located at 5 mm to the apex, in the mesial wall, with the aid of a #4 low speed drill. To make the internal root resorption, we used a #4 low speed drill to penetrate the interior of the conduct to a depth of 8 mm from the root coronal surface.

After resorption prepare, a new measurement was made with the EAL Novapex, using the same method as described above for determining the IEL. Measurements were recorded and considered final electronic length (FEL).

Results

Measures of working length (WL), initial electronic length (IEL) and final electronic length (FEL) are shown in Tables 1 and 2.

Data recorded in mm were subjected to statistical analysis and the analysis of variance (ANOVA) showed no statistically significant difference ($p>0.05$) between measurements before performing resorption and after completion of resorption.

Table 3 presents in absolute and percentage values, the cases in which were verified the accuracy of electronic root measures in relation to real measurements, considering differences of 0.5 and 1.0 mm. The five teeth considered the negative control group, maintained their measurements within normal parameters, without presenting any interference. The positive control teeth showed changes in the electronic measurement.

Discussion

Much emphasis has been given to the odontometry stage, which aims to establish the apical limit of instrumentation and filling of the root canal system. The apex locators are auxiliary electronic devices of great importance in endodontics. These devices have been developed and have undergone changes in its operating principle over the years, to become more reliable and accurate during the tooth length.

Electronic odontometry has some advantages over the radiographic tooth length as possible to reduce the radiation dose during endodontic therapy[9] and the possibility of locating the apical constriction and the radiographic apex.[10] Is therefore a more reliable method, since the radiographic image distortion often difficult obtaining the correct working length.[11]

Despite the great efficiency of EALs, there are some situations, such as the presence of resorption or root fractures, which may cause some interference in the reading of these devices, affecting the determination of the working length.[7] The *in vitro* accuracy of four apex locators, Propex (Dentsply Maillefer, Ballaigues, Switzerland), Novapex (Forum Technologies, Israel), Root ZX (J. Morita Corp., Kyoto, Japan) and Elements Apex Locator (SybronEndo, Orange, CA) was tested on teeth with horizontal simulated fracture. It was concluded that all locators were able to determine the working length without showing any significant difference. But the EAL Novapex showed higher accuracy when compared to the Root ZX EAL.[12]

Although *in vitro* studies to investigate the accuracy of EALs are problematic due the absence of periodontal ligament, the EALs operate by electricity principles and when extracted teeth used in *in vitro* models are immersed in media with electrical resistance similar to

Table 1. Values of Working Length (WL), Initial Electronic Length (IEL) and Final Electronic Length (FEL) in the teeth with internal resorption (IR).

Tooth number	WL (mm)	IEL (mm)	FEL (mm)
1	18	18	17.5
2	17	17	17
3	17	17	17
4	20	20	19.5
5	17.5	17.5	17.5
6	18	18	18
7	14	14	14
8	16.5	16.5	16.5
9	17	17	17
10	16	16	16

Table 2. Values of the Working Length (WL), Initial Electronic Length (IEL) and Final Electronic Length (FEL) in the teeth with external resorption (ER).

Tooth number	WL (mm)	IEL (mm)	FEL (mm)
11	19	19	19
12	15	14.5	15
13	19	19	19
14	17	17	18
15	17	16	16
16	14	14	14
17	16	16	15.5
18	17	17	17
19	19	19	19
20	18	18.5	18

Table 3. Accuracy of electronic measures in relation to real measures, considering averages smaller than 0.5 mm.

Difference <0.5 mm				Difference <1 mm			
IR		ER		IR		ER	
n=10	100%	n=7	90%	n=10	100%	n=10	100%

the periodontal ligament may provides valuable information to test the correct operation of EALs.[13] Models of alginate were used accurately in several studies.[14,15,16] Another model using 0.9% saline solution and a plastic container was used successfully in several studies.[17,18] The saline solution is an excellent way to establish sufficient electrical circuit for the correct operation of the EALs, due to property impedance similar to periodontal ligament.[18] In this study the method using saline 0.9% was employed.

Similar study in which was detected the influence of non-interacting external resorption, showed no interference with the proper determination of working length using a EAL.[7] In the present study was evaluated the possible interference of external and internal root resorption, non-communicating, in the reading of the EAL Novapex. Results showed a 100% accuracy in the determination of tooth length in both cases of external and internal resorption, when the tolerance was 1 mm. When the used criteria was 0.5 mm of tolerance, in just one element with external resorption was not possible to locate the correct length. However, the tolerance of 1 mm is seen as clinically acceptable for several authors,[19,20] showing no major problems in identifying the correct length of the root canal resorption in cases of non-communicating external and internal resorptions.

Also in this work, the five teeth considered the positive control group, where there was communication with the saline solution, showed the most discrepant between 4 to 5 mm of difference, because the device was able to signal communication with the external environment, indicating that apex locators can be helpful in the diagnosis of perforation and possible communications between the external environment and canal.[16]

Therefore, according to the methodology employed in this study can be concluded that the electronic apex locator Novapex proved an efficient aid in determining the working length of root canals, even in different clinical situations, as in cases of external and internal resorption where there was no communication with the root canal, can still be used as aids in diagnosis of communicating root perforations.

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Incidence of flare-ups in endodontic treatments performed in necrotic teeth in a single and in multiple sessions

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ABSTRACT

Objective: At present, the literature presents many controversies when correlating the incidence of flare-ups with the approach to endodontic treatment in a single session and multiple sessions. **Methods:** The aim of this study was to make a comparative evaluation of the incidence of flare-ups in 117 patients submitted to endodontic treatment in a single session and in multiple sessions. **Results:** The results presented by patients that are attended in a single session showed no statistically significant differences from those who were attended in multiple sessions. **Conclusion:** According to this study, it was concluded that the number of interventions necessary to conclude endodontic therapy has no correlation with the incidence of flare-ups.

Keywords: Pain. Endodontics. Dental caries.

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Introduction

Endodontics undergoes a process of constant evolution, mainly stimulated by the development of increasingly efficient new instruments and materials, bringing about better results in both the technical quality of performing procedures and in their biological results.[1] Nevertheless, there are considerable divergences with respect to the best alternative for concluding endodontic therapy, especially in depulped teeth.[2] Many researchers are in favor of intervention in a single session,[3,4,5] while others are in favor of intervention in multiple sessions.[6,7] For these, the main consideration that prevents treatment in a single session is the concern about pain and failure.

In spite of judicious and careful procedures in treatment, complications such as pain, edema or both may occur. The extrusion of debris and antigenic substances through the root apex is the main cause of flare-up; that is to say, intensified acuteness of an apical pathologic process after endodontic treatment or between sessions, which requires an emergency consultation.

The researchers that defend multiple sessions affirm that intracanal medication eliminates, or at least minimizes the proliferation of the bacteria remaining after chemical mechanical preparation, acts as a physical chemical barrier against re-infection by bacteria from saliva and neutralizes the action of endotoxins (LPS, a constituent of Gram-negative bacteria cell walls).[8]

On the other hand, researchers who defend finalizing endodontic therapy in a single session affirm that intracanal medication has no significant influence on the endotoxins, this being the exclusive function of the chemical mechanical preparation technique and of the body itself, which results in the regression of the edematous site that would find favorable biological conditions after the infection is controlled. They also point out the antimicrobial properties found in the compositions of filling cements used at present and the capacity of an adequate filling technique to promote a physical chemical barrier that is as efficient as the intracanal medication.[3,6]

The argument about the number of sessions required is related mainly to the effectiveness of the methods of disinfection and their influence on the clinical results. The comparative evaluation of the clinical result of endodontic treatment in necrotic teeth, with regard to post operative pain, when performed in a single and in multiple sessions, makes it of fundamental importance to clarify whether the number of interventions during endodontic treatment has an influence on the post-operative inflammatory response, therefore helping to make an adequate decision about the best time to perform the final filling. Therefore, the aim of the present study was to make a comparative evaluation of the incidence of flare-ups in endodontic treatments performed in a single session and in multiple sessions.

Materials and Methods

Data were collected on the attendance provided to patients referred to the post-graduation ambulatory clinic for endodontic treatment, at the "Centro Baiano de Estudos Odontológicos (CEBEO-BA)", in the Specialization Course in Endodontics, Salvador, Bahia, Brazil.

The inclusion criteria were established as follows:

- Presence of pulp necrosis, diagnosed by means of anamnesis exam and performing the test of pulp sensitivity to cold, with the aid of cooling spray at -50 °C, Endo-frost Roeko® (Wilcos, Petrópolis, Rio de Janeiro, Brazil).
- Radiolucent image compatible with periapical lesion, detected by taking periapical radiographs, as well as cases in which no images suggestive of peri-radicular lesion were shown.
- Patients without painful symptomatology and who were not making use of any type of medication, particularly analgesics, anti-inflammatory and antibiotic medications.
- Patients who had not undergone any type of endodontic intervention, even of an urgent nature.

Using these criteria, the sample obtained consisted of 117 patients, with 90 treatments having been performed in a single session and 27 treatments in multiple sessions. The groups of teeth involved as well as the periapical bone condition are shown in Table 1.

All patients were attended by post-graduate students in the Endodontic Specialization Course, following the same attendance protocol. Initially access surgeries were performed with a #1014 spherical diamond bur (KG Sorensen, São Paulo, Brazil). After absolute

Table 1. Types of teeth treated in a Single Session and in Multiple Sessions.

	Group of Teeth	With Lesion	Without Lesion
Single Session	Molars	22	19
	Premolars	13	10
	Anterior teeth	20	6
Multiple Session	Molars	12	5
	Premolars	1	1
	Anterior teeth	8	0

isolation of the operative field opening of the posterior teeth was concluded with the aid of a tapered trunk multi-bladed bur with a blind tip Endo Z (Maillefer, Ballaigeus, Switzerland) and for the anterior teeth a tapered trunk diamond bur with a blind tip 3082 (KG Sorensen, São Paulo, Brazil). After this biomechanical preparation was performed by the Segmented Preparation Technique, using Ni-Ti endodontic files of the Easy Pro Design (Easy Produtos Odontológicos, Belo Horizonte, Brazil) rotary system. The working length established by taking periapical radiographs was the same as the Patency length; that is to say 0 mm from the radiographic apex. The auxiliary irrigant solution used during the instrumentation process was 2.5% sodium hypochlorite (Água Sanitária Q-BOA® brand (sanitary solution), São Paulo, Brazil) and after concluding the preparation for smear layer removal, the entire root canal was filled with 17% EDTA (The Formula - dispensing pharmacy, Bahia, Brazil) and agitated in the root canal with the aid of a Lentulo bur #40 (Maillefer, Ballaigeus, Switzerland) driven by a micromotor, for 30 seconds. This solution remained at rest in the canal for 5 minutes. After this procedure, the root canals were again irrigated with 2.5% sodium hypochlorite (sanitary solution Q-BOA® brand) and then irrigated with physiological solution. The root canals were dried with absorbent paper cones (Tanari - Tanariman Industrial, Ltda., Amazonas, Brazil).

The technique used for filling was the vertical condensation of gutta percha heated by means of Thermopack Easy (Easy Produtos Odontológicos, Belo Horizonte, Brazil), together with the filling cement Sealer 26® (Dentsply Indústria e Comércio Ltda., Rio de Janeiro, Brazil).

The teeth treated in multiple sessions were filled with calcium hydroxide-based intracanal medication, Calen (S.S. White/Duflex, SP - Brazil), for the period of 30 days, using an ML syringe (S.S. White/Duflex, São Paulo - Brazil).

After the treatment, a single professional called all the patients by telephone, at the following time intervals: 24 hours, 48 hours and 1 month after the first and second sessions, in the cases of multiple sessions. In the treatments performed in a single session, the same time intervals were used right after filling. The participants in the research were asked about the presence or absence of post-operative pain; pain intensity (light, moderate or severe); use of analgesic and/or anti-inflammatory medications. In this study flare-up was considered the presence of severe pain and/or swelling which required a consultation outside of treatment planning, of an urgent nature.

Data were collected on all the incidences of post-operative discomfort and expressed as a percentage of the total number of teeth evaluated. The incidence of pain was evaluated for each studied variable.

Results

After the experimental period, the data were tabulated and it could be observed that there was no occurrence of flare-up in any of the tested groups. Nevertheless, there was presence of light to moderate pain 24 hours after the endodontic treatment in 63% of the patients treated in a single session, diminishing to 51% on the second day; 78% of the patients submitted to therapy in multiple sessions reported painful symptomatology 24 hours after the first intervention, diminishing to 66% after 48 hours. In the second session, 24 hours after the conclusion of treatment, 18% still complained of some type of symptomatology that persisted in only

8% after 48 hours (Fig 1). These data were evaluated statistically by the Chi-square test, in which there was no statistically significant difference between the treatments in a single session and the first session of treatments in multiple sessions, both in the first 24 hours (p=0.224) and in the 48 hours after treatment (p=0.249). It was also observed that there was no statistically significant difference 30 days after treatment.

In order to investigate the pain intensity presented in the different groups, a more specific evaluation was made, and it was found that of the 63% patients who were treated in a single session and presented painful symptomatology after the first 24 hours, 40% had pain of light intensity and 23% of moderate intensity. After 48 hours, 36% reported light intensity, 16% moderate intensity and 11% no longer reported the presence of pain. After one month, there was absence of pain in the total number of patients treated (Figs 2 and 3).

Treatments

In the therapy performed in multiple sessions, of the 78% of patients who presented painful symptomatology 24 hours after the first intervention, 48% reported pain of light intensity and 30% moderate intensity. After 48 hours, 63% reported light intensity, 7% moderate intensity and 8% no longer reported the presence of pain. After one month, there was absence of pain in the total number of patients treated.

For statistical analysis, the Chi-square test was used, in which it was shown that there was statistically significant difference between the light symptomatology after 48 hours. However, there was no statistically significant difference between the light symptomatology after 48 hours and between moderate after 24 and 48 hours.

When correlating the treatments performed in a single session with the presence or absence of periapical lesion, it was seen that the incidence of pain was higher in the patients that presented a radiographic image compatible with periapical lesion (Fig 4).

Similarly, in the treatments performed in multiple sessions there was also an incidence of pain after the first session, higher in patients who did not present a radiographic image compatible with periapical lesion (Fig 5).

Statistical analysis to evaluate the symptomatology between a single session and the first of the treatments in multiples sessions, the Chi-square test was used, revealing that there was statistically significant difference between the symptomatology 24 hours (p=0.003) and 1 month (p=0.000) after the treatments performed in the cases in which there was no radiolucent periapical image compatible with lesion. Whereas, after 48 hours, there was no statistically significant difference.

In the treatment performed in teeth that presented a radiolucent periapical image compatible with lesion, no statistically significant difference was presented after

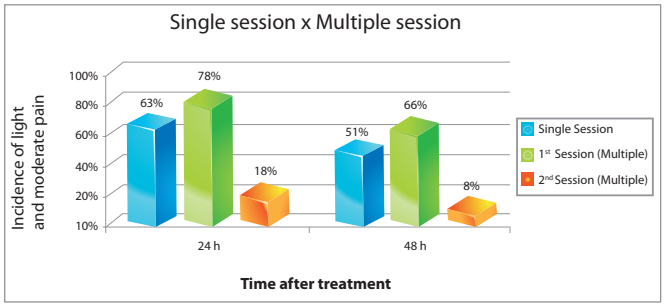

Figure 1. Incidence of light-moderate pain 24 hours and 48 hours after endodontic treatments in a single and in multiple sessions.

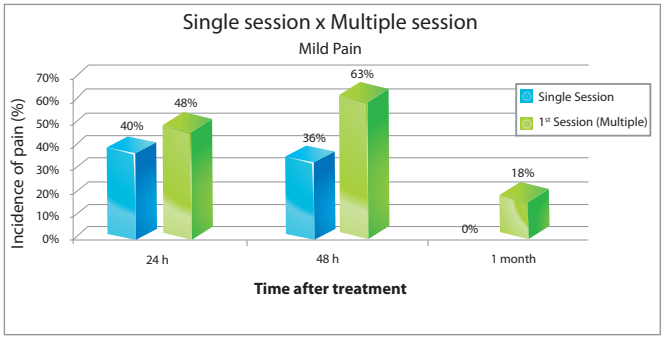

Figure 2. Incidence of mild pain at 24 hours, 48 hours and 1 month after root canal treatments in one session and multiple session.

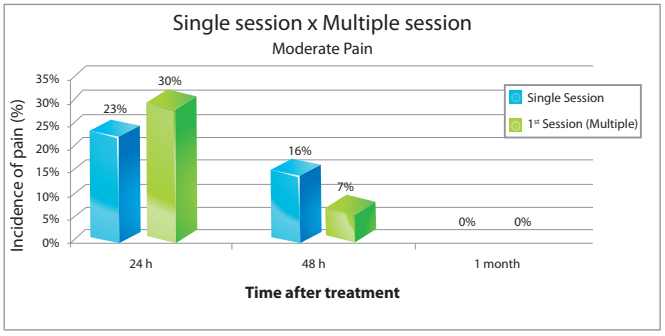

Figure 3. Incidence of moderate pain at 24 hours, 48 hours and 1 month after root canal treatments in one session and multiple session.

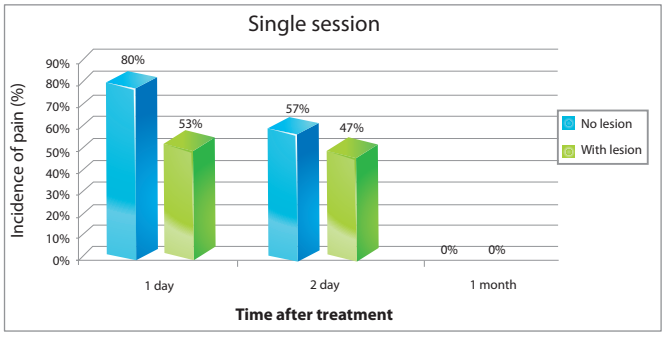

Figure 4. Comparison of the incidence of pain among teeth with and without lesion treated in a single session.

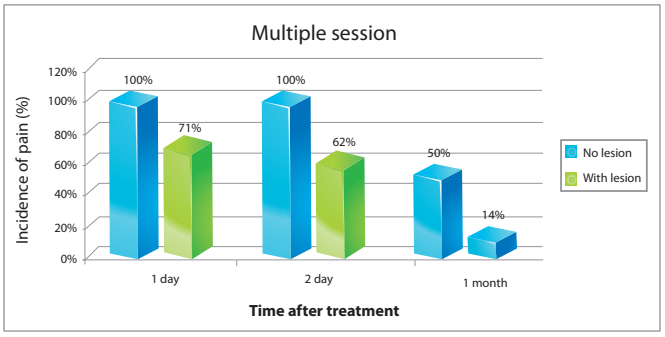

Figure 5. Comparison of the incidence of pain among teeth with and without lesion treated in multiple sessions.

24 hours (p=0.245), and 48 hours (0.361). However, a statistically significant difference was found 1 month (p=0.030) after the intervention.

Discussion

The number of sessions required for concluding endodontic treatment is still a much-debated matter. Many professionals prefer an intervention in two sessions to ensure a post-operative period with the absence of symptoms before filling. Whereas others are in favor of intervention in a single session.

In this study, the incidence of flare-up both in a single and in multiples sessions was 0%. DiRenzo et al[9] in a similar manner, obtained 0% flare-up in cases in a single session and in cases of multiple sessions a minimum incidence of 1.3% was obtained. Although there are not many studies in the literature showing this value (0%), more recent findings, generally speaking, point towards relatively low values of the occurrence of flare-up. Al-Negrish and Habahbeh[10] reported an occurrence of 3.7% for teeth treated in a single session and 5.2% in multiple sessions; Oginni and Udoye[11] reported 8.1% in a single session; Alaçam and Tinaz[12], 7.1% in multiple sessions; Siqueira Jr. et al[18], 1.9% in multiple sessions; Eleazer and Eleazer[13], 3% in a single session and 8% in multiple sessions.

As regards pain intensity, it was seen that after treatments performed in a single session light and moderate pain intensity values were significantly reduced from 24 hours to 48 hours, attaining complete absence of symptomatology after the time of 1 month. Whereas in treatments performed in multiple sessions, light pain intensity present after the first 24 hours of the first session (48%), increased in the time interval of 48 hours (63%) after which its values diminished to 18% after 1 month. This increase in values observed represents a regression in intensity, whereas the moderate symptomatology after 24 hours fell from 30% to only 7% in the 48 hours subsequent to treatment. This means that a portion of the patients that were feeling pain of moderate intensity in the first 24 hours of treatment performed in multiple sessions had a reduction in intensity to a light degree, which led to an increase in these values presented after 48 hours. Similarly, Glennon et al,[14] Menhinick et al[15] and Walton et al[16] verified that the intensity of pain is always more frequent in the first 24 hours after the endodontic intervention, and tends to diminish as the days pass, until complete absence of symptoms is attained.

According to some authors,[2,17] it is difficult to compare the results of different studies on account of the great differences, such as, for example: Study model, treatment protocol, scale used to measure pain, pre-operative condition of the tooth, and instrumentation and filling techniques.

The instrumentation techniques are considered responsible for the apical extrusion of contaminated debridement debris, and consequently have direct influence on the occurrence of flare-ups.[18] In the present study the automated instrumentation technique was used, in which the file design and dynamics significantly diminish the extrusion of debris to the periapical region. This makes comparison with other studies unfeasible, due to the scarcity of researches that compare the incidence of flare-ups with the use of motor driven rotary systems.

A factor that has been well discussed with respect to this subject is the relationship existent between pre-operative and post-operative pain. While some opinion formers affirm that there is no correlation whatever,[9,12,19] others agree that the symptomatologic conditions prior

to treatment have a direct influence on the post-operative results.[10,11,18,20] With the purpose of making this study as faithful as possible, only asymptomatic patients were included, who had not used any type of medication before endodontic treatment.

Another point to be evaluated is the correlation between the presence of a radiographic image compatible with peri-radicular lesion and painful post-treatment symptomatology. The results of this study showed that in the presence of periapical lesion the symptomatology was less frequent and less intense than in the cases in which there was no peri-radicular lesion. These data are compatible with the findings of Polycarpou et al,[20] Glennon et al,[14] Alaçam and Tinaz.[12] This could be due to the lack of space for internal pressure generated when there is no presence of resorbed bone.[18]

When speaking of multiple sessions, authors who defend this line of treatment allege that the calcium hydroxide-based intracanal medication between sessions is capable of diminishing the number of remaining bacteria during biomechanical preparation of teeth with pulp.[21] In contradiction with this, other authors[2,19] affirm that calcium hydroxide has limitations and does not appear to interfere significantly in the remaining endodontic microbiota. With reference to pain, there are studies such as that of Fava[22] and Ehrman, Messer and Adams,[23] that have proved that calcium hydroxide-based medication is capable of reducing the painful symptomatology. DiRenzo et al,[9] Walton, Holton and Michelich[16] have affirmed that this type of medication has no influence whatever on pain control. Whereas Mickel et al[24] affirmed that calcium hydroxide medication between sessions, increases the painful symptomatology and Silva, Almeida and Sousa[25] point out calcium hydroxide as being a potent tissue irritant, suggesting natural medications as an efficient alternative.

Other factors, such as for example, the pre-operative condition of the tooth and the instrumentation technique used appear to have more influence on the occurrence of symptomatological exacerbations, irrespective of the number of sessions in which treatment is performed. Further studies are necessary, particularly with the use of automated instrumentation systems, to seek to obtain greater predictability of the post-operative symptomatology, and consequently, offer patients greater comfort.

Conclusion

According to the results of this study, it could be concluded that the number of interventions necessary to conclude endodontic therapy does not appear to have any correlation with the incidence of flare-ups.

Other factors, such as the pre-operative condition of the tooth and the instrumentation technique used appear to have more influence on the occurrence of these exacerbations, irrespective of the number of sessions in which treatment is performed. Further studies are necessary, particularly with the use of automated instrumentation systems, to seek to obtain greater predictability of the post-operative symptomatology, and consequently, offer patients greater comfort.

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Filling of a C-shaped canal using the Epiphany System and McSpadden compactors

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Marili Doro Andrade **DEONIZIO**[3]

ABSTRACT

The aim of this paper was to report two cases of lower second molars, presenting C-shaped root canal systems. The procedures for root canal treatment were described and discussed along with those presented in the literature. Root canal preparation was performed using a reciprocating system, and the root canal filling was performed using the Epiphany system associated with the McSpadden compactor.

Keywords: Root canal filling. C-shaped canal. Endodontics.

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Introduction

Knowledge of internal anatomy, and possible variations that can occur in the root canal system, is essential to the success of endodontic treatment. Some dental groups may present a C configuration in the cross section of the root. Cooke and Cox[1] first described these cases. The literature shows variation in the prevalence of C-shaped root canals, depending upon the population studied, from 2.7% to 45.5%.[1-7] The difficulties in diagnosis, instrumentation and filling of root canals with this variation have been reported.[1,8-12] The aim of this paper was to present two clinical cases with C-shaped root canals, filled using the epiphany system and the McSpadden technique.

Case report 1

A 32-year-old female patient presented with spontaneous pain, exacerbated by cold and heat, in the lower right second molar. Clinical examination revealed extensive caries; radiographic examination revealed fused roots (Fig 1A). Upon completing the access cavity, the pulp chamber floor appeared to be in a C-shaped configuration (Fig 1B). After exploration, the distal, mesiolingual and mesiobuccal canals, the latter located between the first two, were found. After the clinical exam and the working length radiographic exam (Fig 1C), it was found that the root canals ended in the same foramen.

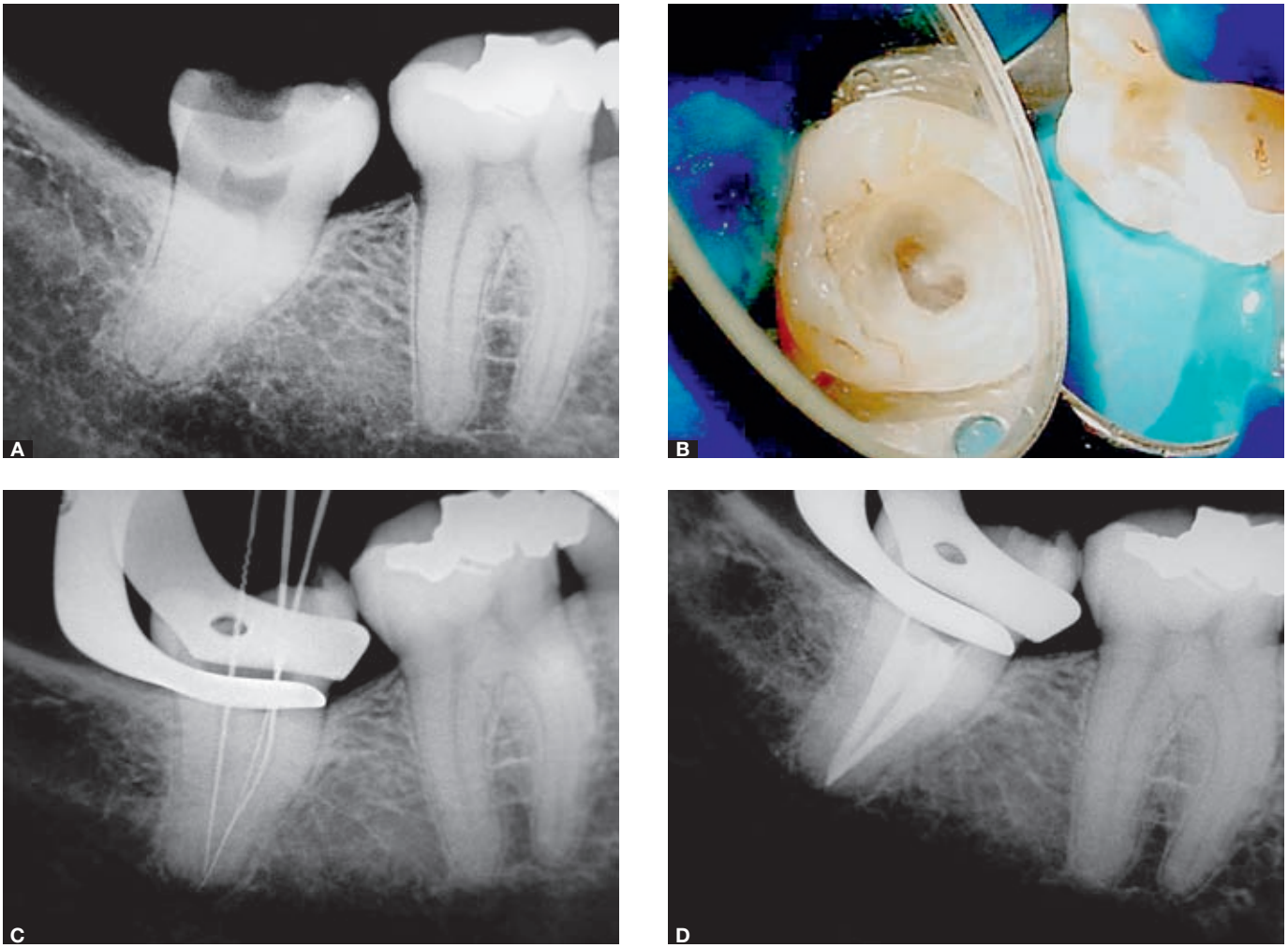

Figure 1. A) Preoperative radiograph. **B**) Image showing the C-Shaped canal. **C**) Working length radiograph. **D**) Final radiograph.

Case report 2

A 56-year-old female patient presented with large cavities, communicating with the pulp chamber, in the lower right second molar. The tooth was asymptomatic, and apical periodontitis (Fig 2A) was observed following radiographic examination. After removing the metal crown and caries, the floor of the pulp chamber presented a C-shaped configuration. After exploration, the distal, mesiolingual and mesiobuccal root canals, which are the most central, were located. The working length radiograph revealed the presence of a foramen for each root canal (Fig 2B). During instrumentation, there was an isthmus revealed from the entry to the region near the apical third, between the mesial canals.

In both cases, the preparation and filling of the root canals were performed the same way. After exploration with #10 and #15 K-files; #1, #2 and #3 Gates-Glidden drills (Maillefer, Ballaigues, Switzerland) were used, aiming for a straight access to the root canals. The Root ZX apex locator (Morita, Kyoto, Japan) established the working length 1.0 mm from the apex. The root canals were prepared using the crown-down technique[13] with a reciprocating system (Kavo, Biberach, Germany) and Flexo-file files (Maillefer). For both cases, the apical thirds of the distal canals were prepared using a #40 instrument, and of the mesial canals using a #35.

Throughout the preparation, the canals were rinsed with 2.5% sodium hypochlorite solution. Final

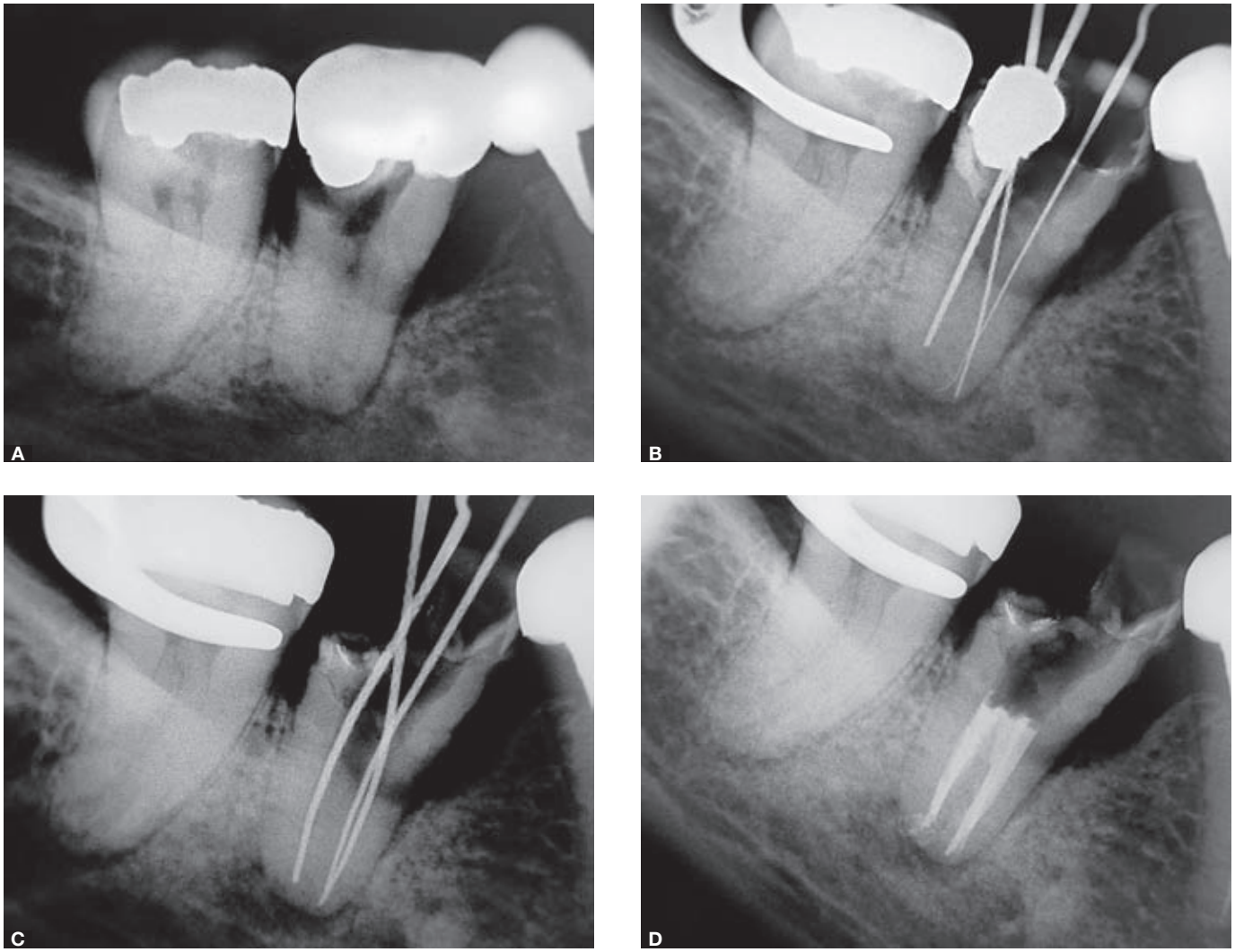

Figure 2. A) Preoperative radiograph. **B**) Odontometry radiograph. **C**) After instrumentation. **D**) Final radiograph.

irrigation was performed using a 17% EDTA solution and a saline solution.

For filling, the Epiphany system (Pentron, Wallingford, USA) and McSpadden compactors (Maillefer, Ballaigues, Switzerland) were used. The primer was applied to the walls of the canals to the working length using sterile absorbent paper points, and the excess was removed. Resilon master cones and an accessory cone M were selected, corresponding to the diameter of the last file to reach the working length of each root canal. Using the master cone, the sealer was inserted into the root canals, repeating until the final part of the cone was sealed.

The cones were kept within the canals and an accessory cone M was introduced into each root canal. A #50 McSpadden compactor was introduced using an in-and-out motion, oscillating a few millimeters. The filling material was plasticized and the root canal system was filled. The depth of compaction was determined by the anatomic conditions and took only a few seconds.[14] After plasticization, vertical condensation and polymerization of the coronal portion of the filling was performed for 40 seconds.

Discussion

Knowledge of internal dental anatomy and variations is very important for endodontic therapy. Among the variations, root canal systems with C-shaped configurations may be noted. Some authors have shown the prevalence of these cases among the Asiatic,[6,15,16] Lebanese[4] and Saudi Arabian[5] populations; although, in the reported cases, the patients were Caucasian and European.

The literature reports the higher frequency cases in the lower second molars, although occurrences in first molars, lower molars and premolars were also reported.[1,3,8,9,11,17-21] Cook and Cox[1] reported the difficulty of radiographic diagnosis of C-shaped root canals. However, Haddad et al[4] observed radiographic features common to almost all cases: The presence of fused roots, or very close roots; a large distal canal; a narrow mesial canal; and lack of clarity in the image of the third mesial canal. These characteristics were also found in the initial radiographs of presented cases, with the exception of the image of a large distal canal, although a clinically proven, large-diameter canal has also been found. Results from the studies by Fan et al[22] and Jung et al[23] suggest that it is possible to identify these cases in the radiographic exam by taking additional radiographs with 20 degrees of angulation in the mesial or distal directions. However, the identification of a C-shaped canal can be made only after access cavity and observing the pulp chamber floor. In these cases, endodontic treatment may be difficult due to the complexity of the anatomy. Melton et al[24] showed that the C-shaped configuration can change at different levels in the same tooth. Marroquin et al[25] and Green[26] found high incidences of irregularities in these cases, such as lateral or accessory canals and apical deltas, suggesting that cleaning, shaping and filling can present challenges. Cheung et al[27] showed that most teeth had two or three main canals, and a few specimens had four or more. Accessory canals, inter-communication canals and apical deltas ranged from 11% to 41% of cases. Bolger et al[8] reported a case of a first molar with a C-shaped canal with four canals and four foramina. Marroquin et al[25] showed an incidence of 69% of teeth with one foramen; of only 31% with two foramina in the mesial root; and, of 87% and 13%, respectively, in the distal roots of mandibular second molars. Rocha et al[28] showed an incidence of 61% of teeth with one foramen; of 38.8% with two foramina in the mesial root; and, 97.4% and 2.6%, respectively, in the distal roots of mandibular second molars. Manning[16] showed that most C-shaped canals had three main canals, all with lateral canals and a high incidence of apical deltas. The reported cases had three root canals: one distal and two mesial. The first case suggests the presence of one foramen for the three root canals (Fig 1C). In the second case, the radiography of the working length shows the presence of one foramen for the distal canal and separated foramina for the mesial canals (Fig 2B). However, after preparation of the mesial canals, it was not possible to maintain the instruments at the same time on the same working length established initially. This shows that the canals met each other, 1.0 mm from the apex (Fig 2C).

Fan et al[29] studied 54 extracted teeth with C-shaped root canals, collected from the Chinese population, using computed tomography. They reported that the average length of roots from the dentin-enamel junction to the root apex was 12.1 mm, ranging from 9.5 to 16.5 mm. The beginning of the bifurcation of the

canals occurred 2.0 mm from the apex in most cases, reaching a maximum of 4.0 mm in all cases. This emphasized the presence of the isthmus connecting the mesial and distal canals, which was more pronounced in the cervical third. This makes it difficult to visualize the entry of the canals, depending on the depth of the pulp chamber. The mesial and distal canals could be instrumented normally; but, the isthmus should be slightly larger, depending on the thickness, to avoid perforation.[30,31] Therefore, irrigation and intra-canal medication is fundamental, especially in mortified pulp treatment. Preparation of the root canals with the reciprocating system provided instrumentation of most of the walls of the canal system, allowing use of the instrument in the region of the isthmus.

The filling of this region can be facilitated with a technique that promotes the plasticization of the filling material, although good results were reported with the lateral condensation technique.[9,20,31,32] In both cases presented, the filling was performed using the Epiphany system and McSpadden technique, highlighting the filling of the isthmus at the cervical third (Figs 1D and 2D). Michelotto et al[33] found good results for the quality of the filling and the flow of filling material using this combination; Veríssimo et al[34] presented good results in terms of infiltration.

The cases reported show that, by combining knowledge of anatomic variations with a treatment protocol, the professional can achieve good clinical and radiological results in these situations.

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Apical surgery in complement to the endodontic treatment: Case report

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ABSTRACT

Introduction: The failure of endodontic treatment may be related primarily to complications arising from the execution of technique, such as the persistence of microorganisms in the canals and iatrogenies. However, even after an endodontic treatment considered technically correct, the persistence of infection may be related to the complexity of the root canal system and extraradicular factors located within the inflamed periapical tissue. The resolution of failures or accidents in endodontic treatment can be achieved through the retreatment and if necessary, an apical surgery. **Objective:** This article describes a case of endodontic treatment followed by apicectomy surgery with retrofilling using Mineral Trioxide Aggregate (MTA) with a 5 years follow-up. **Conclusion:** In view of the clinical case follow-up, we can conclude that in teeth with persistent periapical lesions and fistula, after having undergone an appropriate endodontic treatment, surgical retreatment with retrofilling can be an efficient option in the resolution of the infection and periapical tissue repair.

Keywords: Root canal treatment. Surgical retreatment. Root-end filling. Retrofilling. MTA.

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Introduction

Periapical lesions resulting from an inflammatory response in front of a bacterial infection can be prevented or resolved by endodontic treatment.[1] The failure of endodontic treatment may be related to complications in the execution of endodontic technique, leading to contamination or allowing the persistence of microorganisms in the root canals.[2,3,4] There is also the influence of anatomical complexity, the presence of calcifications[4] and a pre-operative periapical lesion.[3,5]

When the steps of endodontic treatment are properly executed, the persistence of periapical disease may be related to extra-radicular contamination located within the inflamed periapical tissue, such as an infection, a true cyst or a reaction to a foreign body remaining from endodontic treatment.[1,2] The resolution of failures or accidents in endodontic treatment can be achieved by retreatment or periradicular surgery, which includes various forms of procedures.[4] One is the retrograde filling that aims to seal the root canal system by means of an apical preparation and root filling, using a material with physical, chemical and biological appropriated properties to allow or induce apical healing and deposition of mineral tissue.[4,6]

The Mineral Trioxide Aggregate (MTA) is the retrofilling material with better properties than amalgam, gutta-percha, composite resin, glass or zinc oxide ionomer and eugenol, intermediate restorative material (IRM) and Super-EBA.[4,7] The biocompatibility and the potential of inducing cementoblasts and osteoblasts, makes the MTA a material capable of carrying a full histological repair after periapical surgery and retrofilling.[8-11]

This article describes a clinical case of root canal treatment complemented by an apicectomy surgery with retrofilling using MTA with a five years follow-up.

Case report

A 13-year-old boy presented to the dental clinic in August 2004, with the chief complaint of pus in the region of mandibular right first molar tooth. On examination, the tooth had oclusal amalgam restoration, vestibular and lingual fistulas, with purulent secretion and granulomatous tissue, with no increase in volume, but with pain to percussion and palpation. According to the report of the patient and their responsible, the fistula appeared two months before the first appointment, with local pain, spontaneous and exacerbated by chewing.

In the cold thermal pulp test, the tooth showed a negative response and in radiographic examination (Fig 1A), the amalgam restoration was close to the pulp chamber and had an extensive radiolucent area in the periapical region of the mesial and distal roots. The diagnosis of this tooth was pulp necrosis with endo-perio lesion in the vestibular.

After two weeks, endodontic treatment was initiated and after chemical and mechanical cleaning of the three root canals, calcium hydroxide medication associated with saline solution was placed in the tooth and replaced after 15 days. After one month of the permanence of this intracanal medication, it was clinically observed the repair of the fistula, the absence of exudate and pain. The tooth was obturated by lateral condensation technique with gutta-percha and zinc oxide and eugenol based sealer (Fig 1B).

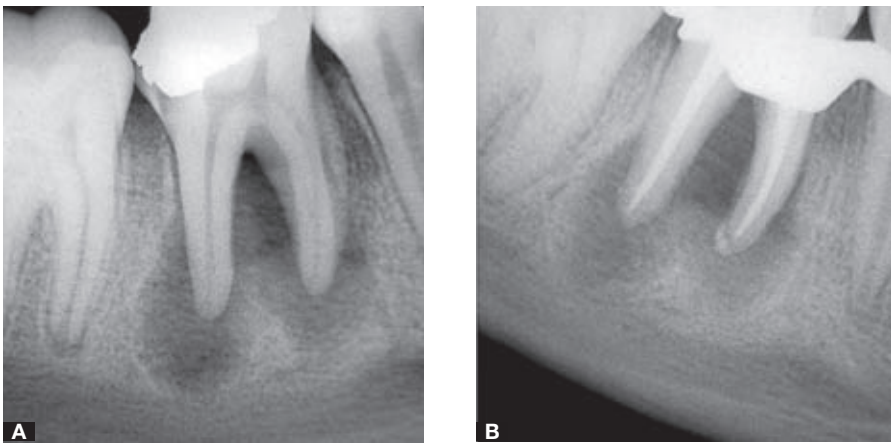

Figure 1. A) Diagnostic radiograph. **B**) Radiograph after root canal filling.

In the clinical control 17 months after the root filling, the tooth clinically presented an increased gum volume in the vestibular region and pain symptoms. Radiographically, the periapical lesion of the mesial roots was repaired, however, the periapical region of the distal root showed greater radiolucency than at the beginning of treatment (Fig 2A). As the endodontic treatment was satisfactory and without complications, the apicectomy surgery with retrofilling was indicated.

In April 2006, it was carried out apicectomy with retrofilling using gray MTA (Angelus®) in the distal root and collecting of the material from the periapical region for histopathological examination (Figs 2B, 3 and 4), confirming the case of a periapical granuloma.

In the follow-up after surgery it was observed that the tooth had no signs and symptoms of infection and it was noticeable the healing of the periapical region of distal root (Fig 5). Such repair occurred despite the patient had started orthodontic treatment three months after surgery and had not put the definitive restoration, with only a core filling of glass ionomer and zinc oxide and eugenol sealer.

Discussion

The success rate of endodontic retreatment is usually between 70 and 86%,[5] however when there is a preoperative periapical lesion this rate is 49% lower than when there is no lesion.[1] The influence of the periapical condition in endodontic retreatment may support the hypothesis that the infection in the root canal with persistent periapical lesions could be more resistant because of inaccessible location of the infection inside the root canal.[2,5]

Figure 2. A) Follow-up after 17 months. **B**) Immediately after apical surgery.

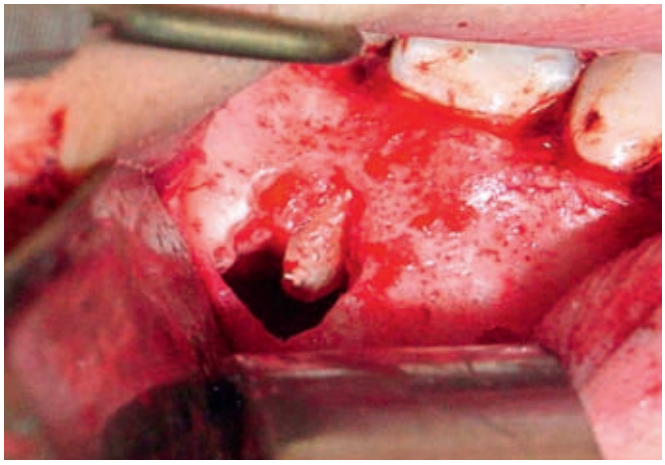

Figure 3. Enucleated periapical lesion and apicectomy of distal root apex, with visualization of the root filling material.

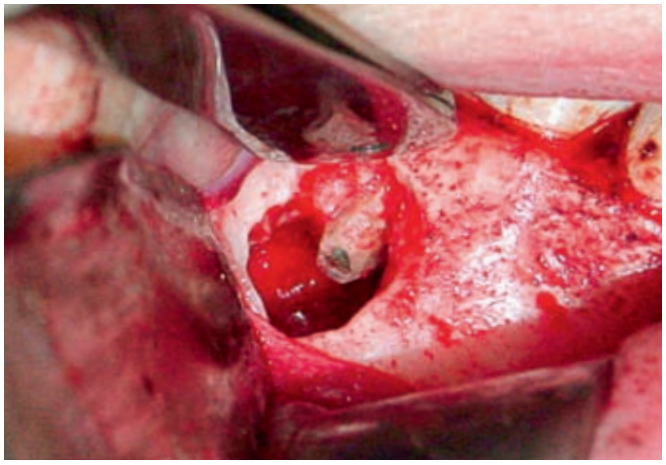

Figure 4. View of the MTA in apical retrofilling.

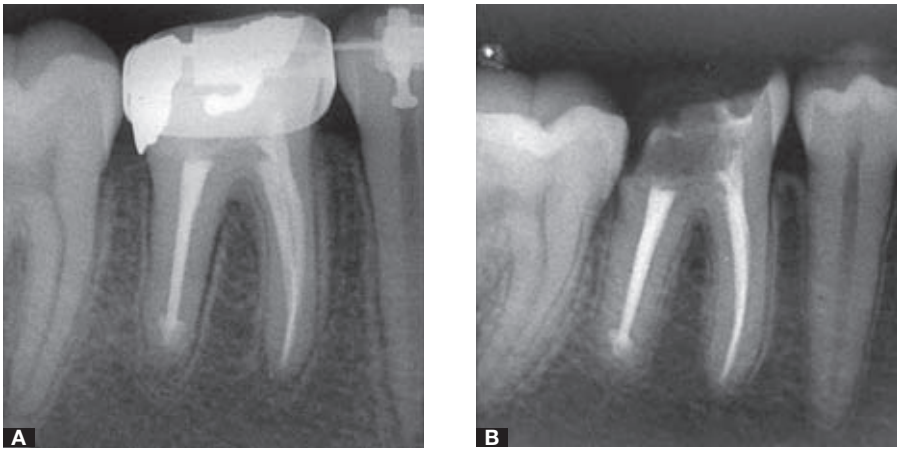

Figure 5. Follow-up of bone formation in the distal root: **A**) After 8 months, **B**) after 5 years.

The success rates of endodontic treatment were found to decrease by 14% for every 1 mm increase in the diameter of the lesion before treatment.[1] The negative influence of large periapical lesions is due to the presence of greater diversity of bacteria, consequently, more resistant to the treatment. This type of chronic injury, characterized by long duration, allows the microorganisms to penetrate deeper into dentinal tubules. This contamination may even extend to the level of the apical cementum causing failures in chemical and mechanical decontamination procedures.[1] In addition, large lesions may also cause cystic transformation or extra-radicular infections, which render nonsurgical root canal treatment ineffective.[2]

The presence of fistula significantly reduces to 48% the success rate for endodontic retreatment.[1] In a tooth with pulp necrosis, the fistula characterizes this lesion as a chronic apical abscess, which is the result of the exit of irritant substances from the infected root canal to the periapical tissues or may result from an acute apical abscess that became chronic. The fistula may facilitate the influx of bacteria from the oral cavity to colonize the periapex and predispose to extra-radicular infection.[1]

The reason for the choice of surgical retreatment in this clinical case was the persistence of periapical lesion in the distal root, despite its repair in the mesial roots after adequate root canal filling. It was taken into account when opting for the apical surgery that radiographic follow-up has a questionable accuracy, as the use of conventional radiographic images for detection of apical periodontitis shows a high likelihood of false-negative diagnosis. This is because you can only identify the apical periodontitis with these methods if it is already at an advanced stage of bone mineral loss.[12]

The persistence of the lesion in this reported case can happen due to the difficulties in the instrumentation of canals recesses, the isthmus and accessory canals, and extra-radicular infection.[2] Apical surgery provides an opportunity to remove the periapical lesion and the apical portion of root that has the highest anatomical variations of the root canal and can, in combination, sustain the periapical lesion after endodontic treatment. Simultaneously allows a retroprepare and apical retrofilling, which aims to seal the canal system, preventing microorganisms that might still remain within the canal system, to reach the periapical tissues.[2]

The use of MTA as retrofilling material is justified because it has excellent physical properties,[9,10] is biocompatible with the periapical tissues[9,10,11] and has the potential of conducting and inducing cementoblasts and osteoblasts, and the ability to release the main cationic components and trigger the surface of precipitates

chemically and structurally similar to hydroxyapatite.[4,7,9] The ability of MTA to induce the cellular response is due to the phase of calcium phosphate, which can cause a change in cell behavior, simulating the adhesion of osteoblasts to this material.[14] In addition, the MTA is non-mutagenic or non-neurotoxic and produces no side effect on microcirculation.[10]

The drawbacks of MTA are related to difficulty in controlling the length of the filling, the chance of producing voids[10] and the absence of solvent material for removal.[10,11] Besides the presence of difficult handling, long setting time and high material cost.[11]

Placing a good quality coronal restoration after root filling is considered the final step for completion of root canal treatment, because it prevents contamination of the root canal.[1] Although the patient presented along the follow-up without the final restoration and only with the glass ionomer filling core and the provisional sealing, which is not advised, there was apical repair.

Conclusion

Based on results found in literature and in the follow-up of this clinical case, we can conclude that in teeth with persistent periapical lesions and fistula, after having undergone an appropriate endodontic treatment, the surgical retreatment with retrofilling can be an efficient option in resolving the infection and periapical tissue repair.

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The distance from the intraradicular post tip to the dental apex influences the degree of apical periodontitis

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ABSTRACT

Objective: The objective of the present study was to investigate the relation between the distance from the intraradicular post tip to the radiographic apex (D) and the degree of apical periodontitis (AP). **Methods:** Full mouth periapical radiographs (n=14) were randomly selected from patients of the clinic of orthodontics of Centro Universitário do Maranhão (São Luiz/MA, Brazil). The sample was composed by the first 270 teeth presenting posts (convenience sample). The radiographic analysis was performed using the Periapical Index (PAI). An ordinal regression was used to test the null hypothesis that the degree of AP does not change according to D. The odds ratio (OR) with an confidence interval of 95% (CI 95%) was calculated to estimate the risk of occurring PAI scores 4 and 5 in the teeth with D≤5 mm. **Results:** A significative relation between D and PAI was found. Teeth with lower values of D were more prone to present greater values of PAI (R^2_N =0.167, p<0.05). The risk of teeth with D≤5 mm to present PAI scores 4 and 5 was 2.82 times bigger (OR = 2.82, p<0.001, CI 95%: 1.6-4.76). **Conclusion:** The distance from the intraradicular post to the dental apex had influenced over the degree of AP. The closer the post was from the apex, the higher was the degree of apical periodontitis. Teeth with D≤5 mm showed a 3-fold greater chance of presenting high indices of apical periodontitis.

Keywords: Periapical periodontitis. Root canal filling. Endodontics.

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Introduction

Apical Periodontitis (AP) is the result of inflammatory and immunological tissue response to the presence of microorganisms and their by-products in the root canal system.[1] Root canal treatment aims to eliminate or minimize bacterial population enabling periapical tissue to repair.

Despite this aim, several cross-sectional epidemiological studies have reported 40 to 65% prevalence of AP in endodontically treated teeth.[2,3,4] Friedman[5] suggested that this high prevalence reflects the real outcome of root canal treatment and indicates that AP constitutes a public health problem affecting a large part of the population. The majority of these reports correlate the periapical status to the quality of the root canal treatment, following criteria including root filling density, remaining apical root canal filling and the occurrence of overfilling.[6,7,8] Moreover, despite of the root filling quality, other factors have been correlated with the periapical condition after root canal treatment, such as the quality of coronal restoration[9] and the distance between the tip of the intraradicular post and the residual gutta percha filling.[10]

Endodontically treated teeth are frequently restored using intraradicular posts aimed at retaining the restoration and distributing the force throughout the root.[11] However, for post placement, removal of part of the root filling is required, which can compromise the root canal seal resulting in possible leakage of bacteria and/or toxins. According to Metzger et al,[12] and Mavec et al,[13] the seal is proportional to the length of the remaining filling. Although the association between the length of residual gutta-percha and the occurrence of AP is well documented, assessment of the quality of the residual root canal filling is generally performed by the endodontist rather than the restorative dentist. In the daily routine of oral rehabilitation, restorative dentists usually rely on the distance from the intraradicular post tip to the radiographic root apex in order to assess which would be the most appropriate post length for the case. However, the question of whether the distance from the intraradicular post to the root apex could be related to the degree of AP has never been investigated. This information could be of great value to the restorative dentist, since the occurrence of AP after post placement could be reliably predicted using a very simple measurement tool.

Thus, this study was conducted to test the null hypothesis that no relation exists between the distance from the intraradicular post tip to the radiographic root apex of the tooth (D) and the degree of apical periodontitis determined by the Periapical index (PAI).

Materials and Methods

The study was approved by the Research Ethics Committee of the Federal University of Maranhão (UFMA), under protocol number 42/07.

Periapical radiographs of the entire mouth (14 radiographs) from patients attending the orthodontics clinic of the University Center of Maranhão (São Luis, MA, Brazil) were used as a pool for sample selection. The first 270 teeth with intraradicular posts displaying some degree of AP were selected. The Periapical Index (PAI) was used for radiograph analysis, as proposed by Orstavik et al,[14] which consists of categorizing periapical status into one of five scores: 1, normal periapical structures; 2, small changes in bone structure; 3, changes in bone structure with some mineral loss; 4, periodontitis with well defined radiolucent area; and 5, severe periodontitis with exacerbating features. Only teeth with a score ≥2 were included in the study, since a score of 1 represents teeth with no radiographic signs of apical inflammation. In cases of multirooted teeth, the root presenting the greatest score was considered. Third molars were not included in the study. Besides the degree of AP, the variables shown in Table 1 were also recorded.

Table 1. Distribution frequency of radiographs presenting apical periodontitis.

Categories		Frequency	
		n	%
Sex	Female	93	34.4
	Male	177	65.6
Age range	20-29	27	10.0
	30-39	87	32.3
	40-49	84	31.1
	50-59	54	20.0
	60-69	6	2.2
	≥70	12	4.4
Arch	**Teeth**		
Maxilla	Anterior	79	29.3
	Premolar	42	15.6
	Molar	32	11.9
Mandible	Anterior	7	2.6
	Premolar	27	10.0
	Molar	83	30.7

The distance (in mm) from the most apical part of the post and the root apex on the radiographs (D) was recorded with the aid of a millimetric scale (Trident Ltda, Itapuí, SP, Brazil) and further scored for statistical analysis as follows: Distances greater than 7 mm (>7), greater than 5 mm and smaller than or equal to 7 mm (>5 ≤7), greater than 3 mm and smaller than or equal to 5 mm (>3 ≤5) and smaller than or equal to 3 mm (≤ 3).

An endodontist and a radiologist, both with ten years of clinical experience each, examined the radiographs. Prior to radiographic evaluation, both examiners were calibrated while evaluating 30 radiographs which were not included in the study. The inter-observer agreement was considered adequate, as determined by the Kappa coefficient (0.92); thus, the observers performed their own analysis independently. All radiographs were examined in a dark room using a liquid crystal negatoscope (Kaiser, Germany) with a magnifying lens (3x) (Intex, USA).

In order to categorize the sample, the distribution frequency of the remaining independent variables (sex, age range, tooth groups and arch) was determined according to PAI and the Pearson Chi square test was used to certify that PAI scores were not associated with the independent variables, sex, age range and arch.

Since two categorical variables (D and PAI) were obtained, an ordinal regression (PASW Statistics 17.0, Inc., Chicago, IL, USA) was used to test the null hypothesis that D is not related to the PAI index.

An apical residual canal filling remnant of 5 mm is commonly recommended.[15] Thus, the odds ratio (OR) with 95% confidence interval (95% CI) was calculated to verify the odds of a D<5 mm result in higher PAI (scores 4 and 5).

The level of significance for rejecting the null hypothesis was $p<0.05$.

Results

The frequency distribution according to sex, age range, tooth group and arch is shown in Table 1. Analysis verified that none of the independent variables (sex, age range and arch) influenced the PAI score distribution (Pearson Chi-square test, $p>0.05$).

Ordinal regression demonstrated that D is significantly associated with PAI ($p<0.05$), since teeth with larger distances from the post tip to the apex are more likely to be associated with lower PAI (Fig 1). However, the variability in PAI scores is partially explained by the variation in D, according to Nagelkerke's R^2 (R^2_N=0.167). Analyzing Table 2, it is possible to numerically observe the inverse relationship between D and PAI. At line D>7 mm, for instance, the cumulative percentage for lower PAI scores (2 and 3) was 69.7%, whereas the remaining percentage (30.3%) was linked to higher PAI scores (4 and 5). On the other hand, at line D≤3 mm, the cumulative percentage for lower scores (2 and 3) was 22.0% while the remaining percentage for higher PAI scores (4 and 5) was superior (78.0%). Thus, higher PAI scores were significantly more linked to lower D values, whereas lower PAI scores were related to higher D values (Fig 1).

Table 3 displays the frequency of teeth classified as D≤5 mm and D>5 mm and their relation with the degree of AP. Teeth categorized as D≤5 mm showed a 2.82 odds ratio of being classified as PAI 4 or 5 scores (OR=2.82, 95%CI=1.82-4.759, p=0.0001).

Discussion

Various epidemiological studies concerning AP have used either panoramic[3,16] or periapical radiographs[17,18,19] to provide information on the periapical status. It is well known that greater exam accuracy can be obtained with the use of periapical radiographs rather than the

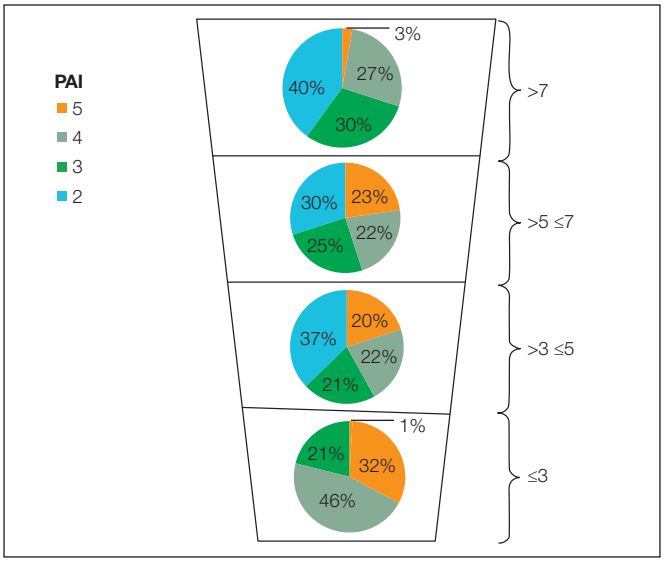

Figure 1. Percentages of higher and lower PAI categories. Observe the inverse relation between the distance from the intraradicular post to the radiographic apex and the PAI scores. PAI scores significantly increased as the distance from the post to the apex decreased.

Table 2. Frequency distribution of the number, percentage and cumulative percentage {n [%] (Pat)} of teeth according to the distance from the post tip to the apex (D) and the PAI score (R^2_N =0.167, p<0.05).

D \ PAI	2	3	4	5	
>7	13 [39.4] (39.4)	10 [30.3] (69.7)	9 [27.30] (97.0)	1 [3.0] (100.0)	33 [100.0]
>5 ≤7	17 [30.4] (30.4)	14 [25.0] (55.4)	12 [21.4] (76.8)	13 [23.2] (100.0)	56 [100.0]
>3 ≤5	25 [37.3] (37.3)	14 [20.9] (58.2)	15 [22.4] (80.6)	13 [19.4] (100.0)	67 [100.0]
≤3	1 [0.9] (0.9)	24 [21.1] (22.0)	53 [46.5] (68.5)	36 [31.5] (100.0)	114 [100.0]

Table 3. Odds Ratio (OR) with 95% confidence interval (CI) estimating the risk of PAI 4 and 5 related to distance from the intraradicular post tip to the radiographic apex (n=270).

Distance post - apex	Total No. of teeth	PAI		OR (95%CI)	P-value
		4 and 5 (%)	2 and 3 (%)		
≤5	181	117 (64.6)	64 (35.4)	2.82 (1.671-4.759)	0.0001
>5	89	35 (39.3)	54 (60.7)		

panoramic counterparts.[20] Periapical radiographs provide more image details and less radiographic distortion.[21] However, cone beam tomography has been suggested as a more sensitive exam to track periapical changes.[20,22] Although the increase in accuracy by cone beam tomography was nearly 20%, as demonstrated by previous reports,[20,22] periapical radiographs are still the most widely used method to evaluate the periapical status after root canal treatment,[23] due to their low cost and easy clinical application.

The question of whether the results of studies with transversal design are able to express the real outcome of periapical status has been discussed, since radiographs project a static image of a dynamic process and, therefore, no information is provided regarding the status of AP regression or progression. Nonetheless, the studies by Petersson[24] and Kirkevang et al[25] demonstrated that the relation between the number of teeth with regressed AP and newly developed cases in the same population after 10 years was similar. This means that in studies using a transverse design, the apparent static information does not influence the outcome, given that new AP cases will develop and others will regress, maintaining the relation.

In the present study, periapical status was categorized using the Periapical Index (PAI) and further correlated to the distance from the post tip to the apex (D). Due to its good accuracy and reproducibility,[14] PAI is the most frequently used measuring tool to verify the prevalence of AP.[3,18,25] Although it is capable of providing information regarding the severity of the periapical lesion, the index is generally used as a reference to determine categories, such as treatment success and failure. Thus, any radiographic or clinical findings are usually correlated to either endodontic success or failure and no information is provided concerning their relation with the degree of severity of AP.[2,25] However, in this study, in order to track for a possible relationship between the distance from the post tip to apex and the degree of AP, an ordinal regression test was used. This test allows for correlation between groups of variables with more than two categories each. Thus, for statistical analysis, the absolute D values obtained in the periapical radiographs were allocated to one of four categories, based on a previous report.[12]

The results of the present study demonstrated that the remaining length from the post tip to the radiographic root apex significantly influenced the degree of AP in an inverse relationship; i.e., the shorter the distance from the post tip to root apex, the greater the severity of AP (Fig 1). This is an important finding, since an elevated prevalence of post-restored endodontically treated teeth has been reported in several epidemiologic studies.[26,27,28] Thus, when planning a post-retained restoration, clinicians should rely on the results of the present study to avoid severely influencing the outcome of root canal treatment.

Kvist et al[29] observed a higher prevalence of AP in endodontically treated teeth with remaining apical filling less than 3 mm in length. This study is in line with their results, since the D value observed is directly related to the length of the remaining root canal filling material. Although some studies were unable to detect a relationship between the frequency of periapical lesions and the presence of the intraradicular post,[26,27] none of these investigated the influence of the distance from the post tip to the root apex. This is the first study to directly correlate the degree of periapical inflammation to the remaining apical intraradicular post-free canal length.

Even though a significant relationship between D and PAI was observed in the present study, the variation in the PAI score is only partially explained (16.7%) by the variation in post length (R^2_N =0.167). This could be due to the reported prevalence of other radiographic findings influencing the periapical conditions. The quality of root canal filling, the presence of coronal restorations, the length of remaining apical filling, the occurrence of overfilling, have been reported to influence the periapical status.[7,23,29] Thus, the observation of a low R^2 in the present correlation is comprehensible, since other factors that were not studied in this work could also have influenced PAI variation.

Furthermore, the frequency distribution and the Chi square test performed ensured that the data source was not influenced by demographic variables, such as sex, age range or arch, which might cause bias in the subsequent ordinal regression performed.

Following endodontic treatment, the placement of a post-retained restoration is usually required. In order to create a clear cutoff point for clinicians, the D value was dichotomized into ≤5 mm and >5 mm to calculate the odds ratio of D≤5 mm being allocated to higher PAI scores (4 and 5). It was observed that teeth with intraradicular posts show a 3-fold greater chance of being categorized as presenting elevated PAI scores (4 and 5) when the 5 mm apical remnant is not respected (OR=2.82, 95%CI=1.82-4.759, p=0.0001). It is known that short apical fillings result in poorer sealing ability.[12] Although not consistently proven, lower root canal sealing ability would negatively influence the regression of AP after root canal treatment. Furthermore, it is likely that most of the root canals in this study had their intraradicular post not definitively cemented immediately after filling, which, according to Solano at al,[30] contributes to greater leakage compared to those immediately cemented. In addition, Grecca et al[31] confirmed that the presence of residual root canal filling delays, but cannot prevent bacterial invasion into the root canal.

It is well-known that various factors can influence the survival of post-retained endodontically treated teeth.[32] Analysis of the results of the present study demonstrated that the remaining apical post-free canal length significantly influenced the degree of PAI and should be considered by clinicians and restorative dentists during intraradicular post placement.

Conclusions

Within the limits of the method and given the results obtained in this study, it can be concluded that the radiographic appearance of periapical periodontitis was intimately linked to the distance between the intraradicular post tip and the radiographic root apex; the closer to the apex, the higher the periapical index. Teeth with distances from the post tip to root apex less than or equal to 5 mm showed almost three times the odds of being categorized as presenting severe degrees of apical periodontitis.

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Modern endodontic microsurgery treatment improves the outcome of challenging cases: A series report

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ABSTRACT

Objective: The aim of this report was to describe challenging cases of modern endodontic microsurgery in teeth with persistent periodontitis following previous endodontic treatment. **Methods:** Four challenging cases of modern endodontic microsurgery were evaluated. **Results:** Healing has occurred at 6 and 12-month review appointments. **Conclusion:** The removal of the contamination and satisfactory sealing of the root canal system were paramount for the success observed in these cases. Modern microsurgery protocol with the use of a magnified view, ultrasonic tips and biocompatible materials are an important component of endodontic surgery, improving the success when compared to traditional technique.

Keywords: Root canal therapy. Biocompatible materials. Dental infection control. Microsurgery.

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Introduction

Once conventional endodontic treatments have failed, surgical endodontic treatment is an option for teeth with apical periodontitis.[1] The aim of this procedure is to remove the root canal infection and create a seal using a biocompatible material to prevent possible bacterial leakage. Over the years, traditional surgical root canal treatment has been performed by root-end resection with a 45-degree bevel, retrograde preparation of the canal with burs and root-end filling.[2] The success rate of this procedure, however, has been demonstrated to be only moderate (60%).[3,4] The use of unsuitable surgical instruments, inadequate vision, and frequent postoperative complications often result in tooth extraction.

In the late 1990s, the introduction of magnified vision, microinstruments, ultrasonic tips, and more biologically acceptable root-end filling materials marked the beginning of the modern endodontic microsurgery era. The use of microsurgery in surgical endodontic cases is an attempt to minimize trauma and improve results.[5] With these developments, greater understanding of the apical anatomy has been gained, and a success rate of over 90% has been reported.[6,7,8]

We report here a series of cases of modern endodontic microsurgery in teeth with persistent periodontitis and significant bone loss following previous endodontic treatments.

Case Reports

Case 1

A 52-year-old female patient was referred to a private dental office for an evaluation of swelling associated with a fistula on the apical portion of the second left maxillary premolar. According to the patient, symptoms had been present for 12 years (Fig 1A). Endodontic treatment had been performed unsuccessfully twice previously, leaving the patient with sporadic pain and facial discomfort. Clinically, the mobility and probing depth of the tooth were within normal limits. A percussion test showed no discomfort, and occlusal disharmony was not detected. Radiographic examinations revealed a uniform radiolucent lesion surrounding the root with a radius of approximately 10 mm (Fig 1B). Radiographic images showed that the original path of the root canal had deviated and that apical perforation had occurred. Despite having been treated twice, the root canal filling was unsatisfactory, which lead to the decision to perform endodontic retreatment with periapical microsurgery in order to establish satisfactory periapical healing.

An access cavity was created, and the tooth was isolated with a rubber dam. Briefly, the root canal filling was removed using rotary NiTi files (ProTaper Universal Retreatment®, Ballalgues, Switzerland) without any solvent. The canal was chemomechanically instrumented with NiTi rotary files (ProTaper Universal®, Ballalgues, Switzerland) and 2.5% sodium hypochlorite, and calcium hydroxide with 2% aqueous chlorhexidine paste was inserted as root canal dressing. After 21 days, the paste was removed, and the root canal was sealed using Tagger's hybrid technique. During thermoplastic condensation, sealer was scattered in the lesion (Fig 1C). Subsequently, the access cavity was restored with composite resin. After 10 days, the fistula was still present.

A Newman's surgical access flap was created (Fig 1D), and curettage of the periapical lesion was conducted (Fig 1E). The presence of perforation in the apical root surface was confirmed. A 3-mm apical resection was then performed without a bevel in an attempt to remove apical ramifications, lateral canals and necrotic, infected tissue (Fig 1F). A magnified view revealed anatomical details of the canal system, including an isthmus created by deviation between the anatomic and surgical canal during the initial root canal treatment. A cavity was prepared using an ultrasonic tip under copious irrigation with sterile saline to unify the perforation and the original canal path. The cavity was then filled with white mineral trioxide aggregate (MTA) (WMTA - Angelus, Londrina- Brazil), which was inserted using a small amalgam carrier and condensers (Fig 1G). After the excess material was removed and the surgical site was cleaned, the flap was repositioned and sutured. The extracted periapical lesion was histopathologically evaluated and diagnosed as a regular cystic inflammatory lesion. After one month, improvement was observed in the patient's clinical signs and symptoms, and one year later, radiographic evaluation showed an intact periodontal ligament (Fig 1I).

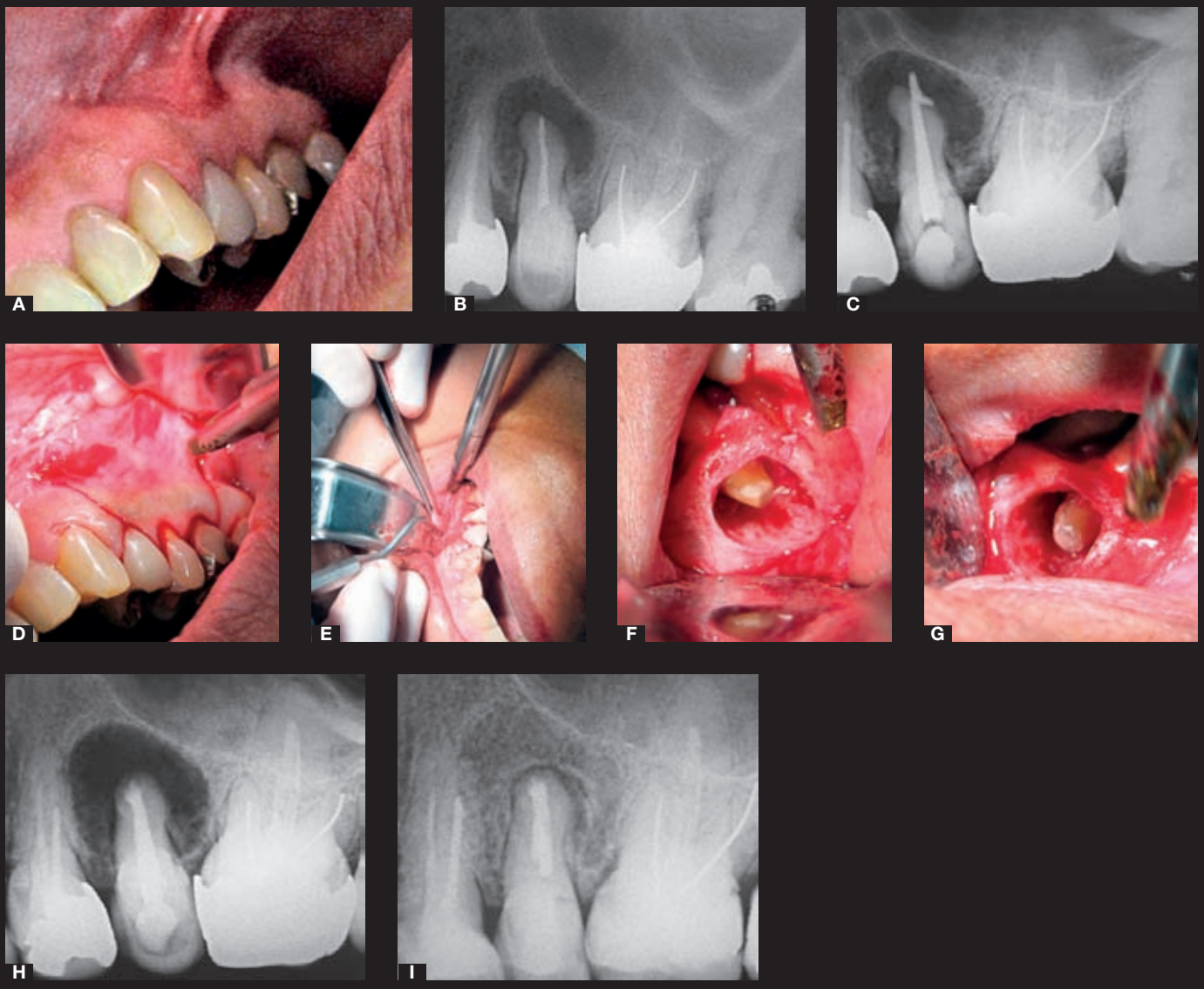

Figure 1. A) Initial clinical presentation including the presence of swelling associated with a fistula on the left maxillary second premolar. **B**) Periapical X-ray of tooth #25 showing a deviation in the root canal trajectory and unsatisfactory root canal filling prior to root canal retreatment. **C**) Periapical radiograph after thermoplastic condensation using Tagger's hybrid technique. **D**) Newman's incision (**E**) and excision of the periapical lesion. **F**, **G**) Apicoectomy without beveling and retrofilling with white MTA. **H**) Periapical X-ray showing the extension of bone loss after surgery. **I**) Radiograph showing significant signs of bone healing at one year postoperative.

Case 2

A 32-year-old woman patient was referred for endodontic assessment following severe pain one month after root canal treatment of the tooth #24. The periapical radiograph revealed a fractured endodontic instrument and periapical radiolucency (Fig 2A). The tooth was treated under the same protocol as described for Case 1. During apical root canal assessment with ultrasonic tips, it could be noticedtwo fractured instruments. They were removed and the retro-preparation realized with the ultrasonic tips. The retro-filling was realized with MTA. After the excess material was removed and the surgical site was cleaned, the flap was repositioned and sutured. The definitive diagnosis from the pathology report was periapical granuloma. As shown in Figure 2B, a 6 month postoperative radiograph shows an apical plug of MTA with an interconnecting isthmus. At the 6 month review the tooth was completely asymptomatic and satisfactory healing could be appreciated.

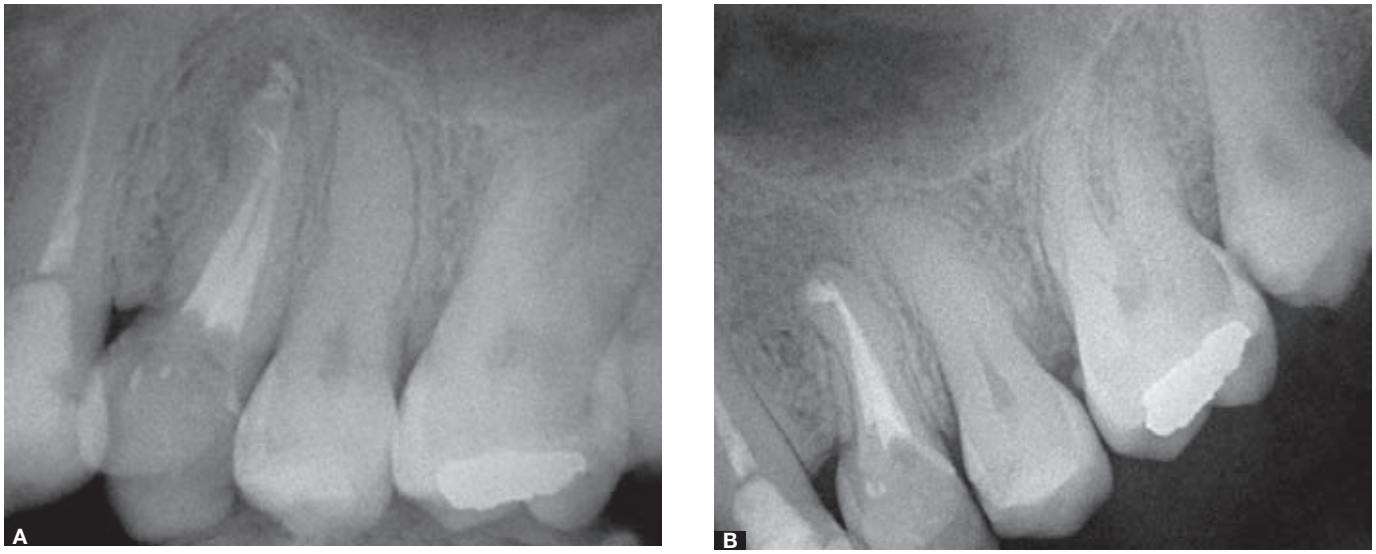

Figure 2. A) Pre-operative radiograph. A fractured endodontic instrument can be noticed. The patient was experiencing pain and discomfort after root canal sealing. **B**) Six month review radiograph. It can be noticed the MTA apical plug in surgical canal path. Satisfactory healing can be appreciated.

Case 3

A 35-year-old woman patient was referred for endodontic assessment. She was experiencing intense pain. According to patient's report, she had experienced an episode of facial trauma four years earlier. The patient had been previously submitted to an endodontic emergency procedure, and the lateral incisor had been accessed (Figs 3A and B). According to clinical exam, the adjacent teeth were in healthy conditions. During endodontic assessment, it could be noticed an intense exudation with a citric orange fluid, indicating a cystic inflammatory pathology. Three clinical appointments (30 days intervals) with change of root canal dressing (calcium hydroxide with 2% aqueous chlorhexidine paste) were performed. As exudation was still persistent after this period, the surgery was indicated. As the lesion involved both adjacent teeth, it was decided to perform the endodontic treatment of all the three involved elements before surgical procedure. The canals were chemo-mechanically instrumented with NiTi rotary files (ProTaper Universal®, Ballalgues, Switzerland) and 2.5% sodium hypochlorite and sealed using Tagger's hybrid technique. A surgical access flap was created and curettage of the periapical lesion was conducted carefully, as the lesion presented a communication with nasal cavity. With magnified view, an area of root resorption could be noticed. Apical plastic resection was conducted in order to remove irregularities that would harbor microorganisms. As the microscopic view demonstrated an excellent apical sealing in the lateral incisor after root resection, with the absence of isthmus or micro-cracks, other root-end procedures were no longer necessary. The definitive diagnosis from the pathology report was periapical inflammatory cyst. At the 6 month review appointment, the signals had completely disappeared and the tooth was asymptomatic. At the radiographic examination, it could be observed a satisfactory healing (Figs 3D and E).

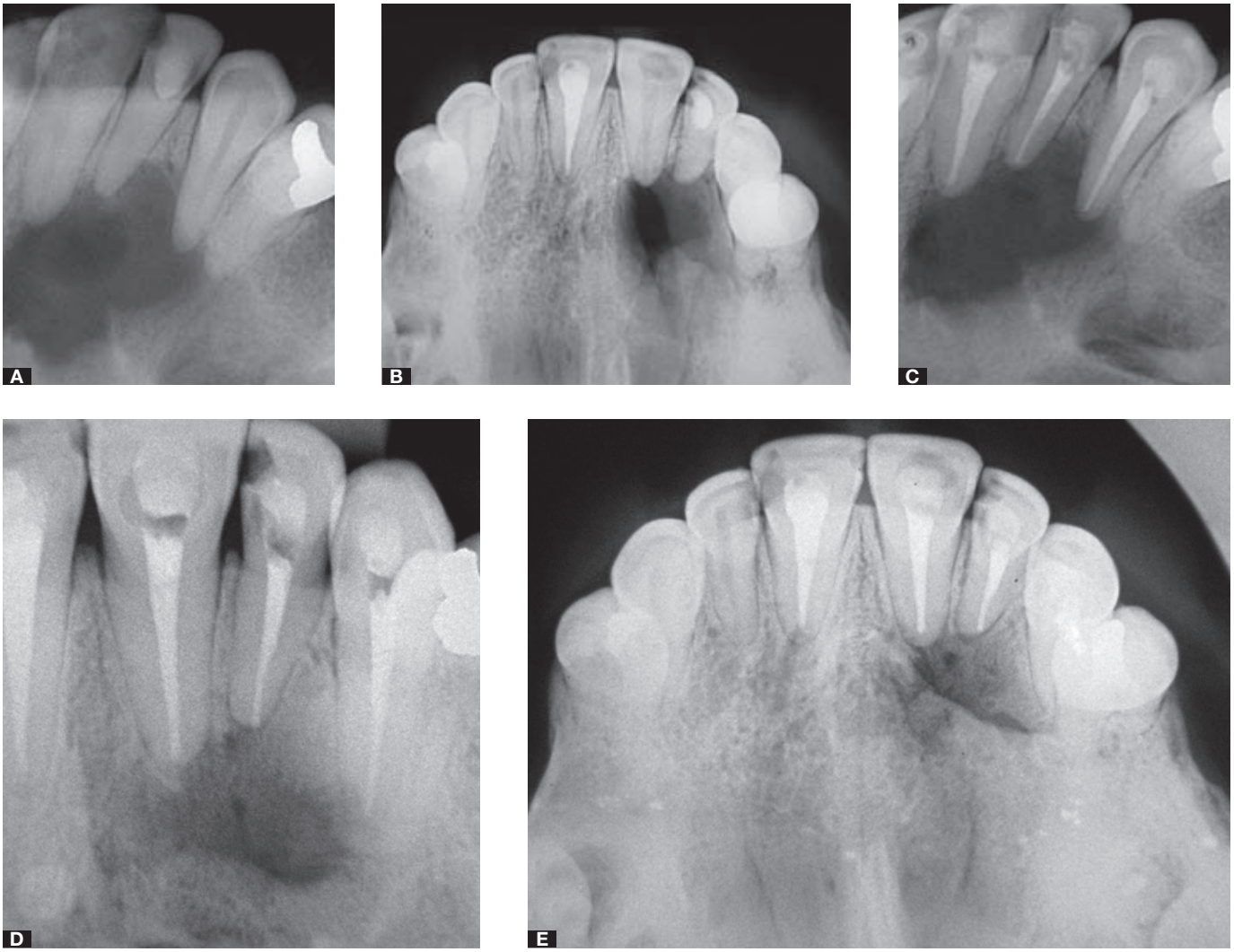

Figure 3. A) Pre-operative radiograph. Presence of severe maxillary bone resorption. Patient presented swelling and pain. **B**) Occlusal radiograph. **C**) Pre-operative radiograph after root canal treatment. Absence of healing can be noticed. **D**) Six month review radiograph. A satisfactory healing can be appreciated. **E**) Six month review occlusal radiograph.

Case 4

A 45-year-old man patient was referred for endodontic assessment. In radiographic examination, it was observed an extended periapical lesion involving the central inferior incisors. The patient was asymptomatic and no swelling was observed. Endodontic treatment was performed according to the protocol previously described in Case 3. After 6 month follow-up, the lesion was still present without any sign of healing and apical surgery was indicated. A Newman's surgical access flap was created, and curettage of the periapical lesion was conducted (Fig 4B). Within magnified view, it was observed a lack of apical sealing. A 3-mm apical resection was then performed without a bevel angle in an attempt to remove apical ramifications, lateral canals and necrotic, infected tissue. Using magnified examination, it could be noticed a satisfactory sealing of guta-percha, without any gaps. The flap was repositioned and suture was performed. The definitive diagnosis from the pathology report was periapical granuloma. At the six month follow-up appointment, the teeth were completely asymptomatic. In the radiographic examination it could be observed a partial healing (Fig 4E). At the 12-month review the teeth were asymptomatic and the periapical radiograph revealed a favorable healing outcome (Fig 4F).

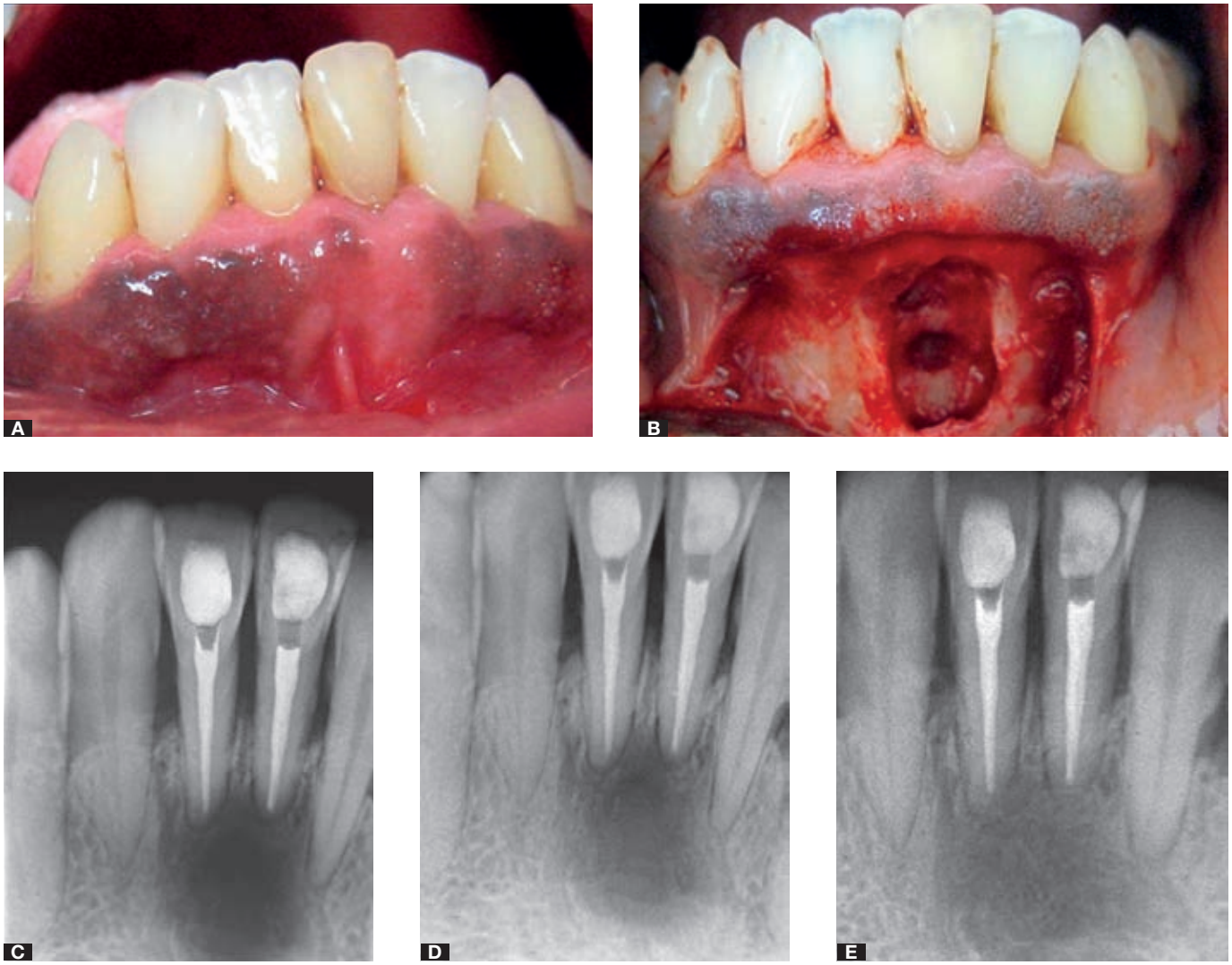

Figure 4. A) Pre-operative clinical aspect. **B**) Newman's surgical access flap. Clinical aspect after bone lesion curettage and 3 mm apicoectomy. **C**) Immediate post-operative radiograph. **D**) Six month review radiograph. **E**) Twelve month review radiograph.

Discussion

The complexity of the root canal system may not allow for predictable success rates of all endodontic treatments. The presence of ramifications and lateral canals can sustain microorganisms and impair the healing process, making root-end resection an important step in endodontic surgery. The success of endodontic surgery, however, is intimately related to the quality of conventional endodontic treatment. If this quality is unsatisfactory, then the prognosis of surgery is uncertain. A 2 mm apical resection accounts for a 78% and 86% reduction in the frequency of apical ramifications and lateral canals, respectively.[9] In Case 1, the root canal was retreated, and during microsurgery, in Cases 1, 2 and 4, root resection was performed in the last apical 3 mm as recommended by Kim et al.[9] These authors observed a 98% and 93% reduction in the frequency of apical ramifications and lateral canals, respectively, using this approach.

In traditional endodontic surgery, a typical apical resection used to be performed with a 45- to 60-degree bevel to achieve a better vision and access during the procedure.[2,10] Because the instruments used to retrogradely prepare the canal were large, a bevel angle was inevitable. In fact, larger root resections may weaken the root structure and cause unnecessary periapical tissue removal.[11] In addition, beveled angles expose a larger amount of dentinal tubules to

periapical tissues, which may increase contact between the remaining bacteria in the tubules and periapical tissues.

In modern endodontic microsurgery protocols, however, minimal or no bevel is typically used in root resection.[12] Given that the ultrasonic tips used in retrograde preparation do not require a large osteotomy or bevels due to the design of the instruments, the structure of the root is preserved. In the same way, the original root canal trajectory is maintained more efficiently during retrograde preparation with ultrasonic tips than with burs, achieving deeper, more effective debridement of the root canals.

With the advent of microscopes and loupes, as well as specifically designed micro-mirrors, a more detailed view of apical anatomy can be obtained. The presence of an isthmus, collateral canals, ramifications, cracks, and other varied anatomy can now be easily identified during surgical procedures. Furthermore, the apical magnification associated with the use of ultrasonic tips can provide more predictable results for retrograde cleaning and preparation. (Figs 5A and B). In Case 3, the use of magnified view was determinant in choosing the clinical approach. As it could be noticed absence of sealing gaps, canal ramifications, isthmus, or microcracks after apical resection, a more conservative procedure could be performed, without the necessity of ultrasonic retrograde preparation.

Root-end prepared cavities must be filled with a biocompatible material. In this study, MTA was chosen based on its biological and physical properties.[13-17] In addition, MTA promotes the overgrowth of cementum and bone formation, inducing regeneration of the periodontal ligament.[18] Moreover, no significant differences have been observed in microsurgery results using MTA compared to IRM.[19] Still, modern surgical endodontic treatment using an operative microscope and ultrasonic tips significantly improves the prognosis of the tooth compared to traditional techniques.[12]

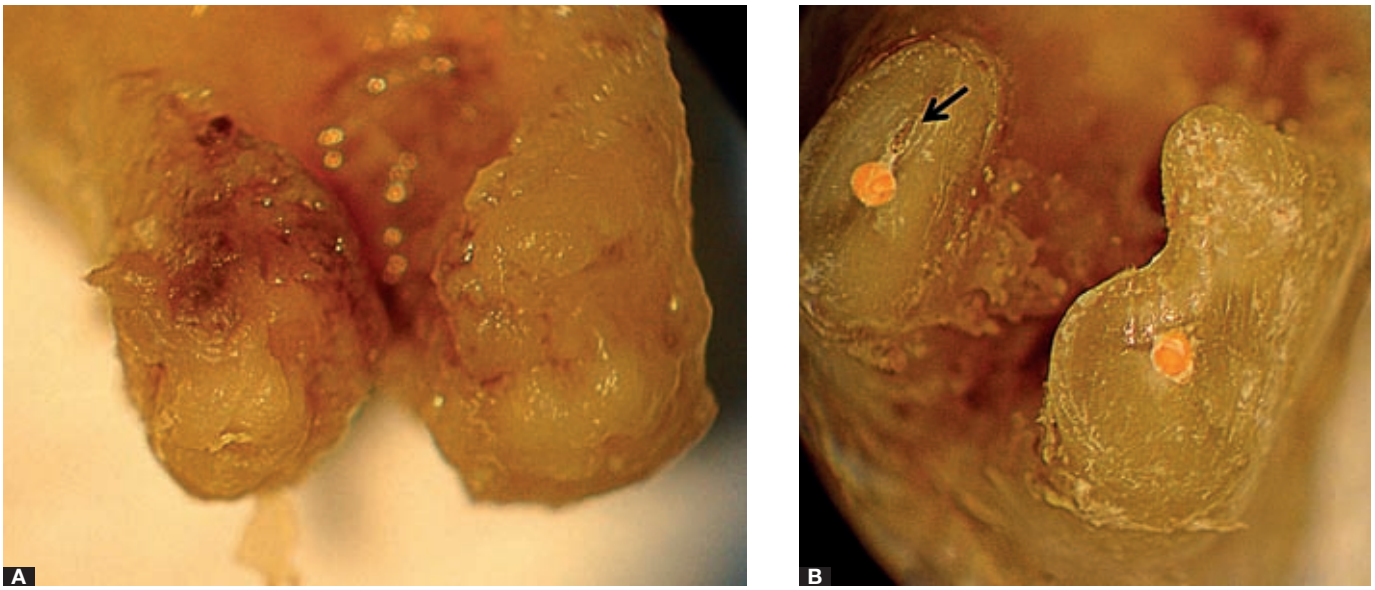

Figure 5. A) Apical view of a freshly extracted tooth presenting lesion refractory to endodontic microsurgery. The procedure was performed without the use of the modern surgery protocol. **B**) After apical extracted tooth curettage, magnified view demonstrates an isthmus in distal root canal (arrow). The absence of apical sealing was the cause of surgery insuccess.

Conclusion

We attribute the success observed in these cases to removal of the contamination and satisfactory sealing of root canal system. Additionally, the results reinforce the use of a modern microsurgery protocol with a magnified view, ultrasonic tips and biocompatible materials as an important component of endodontic surgery.

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Accidental swallowing of a Protaper® file during root canal treatment

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ABSTRACT

Objective: To demonstrate to the general practitioner the importance of the use of rubber dam during endodontic treatment through a case report where was described the monitoring employed with a patient who accidentally ingested a rotary file S1 ProTaper® (Dentsply Maillefer, Switzerland) during the root canal preparation. **Case report:** A 28 years-old patient underwent root canal treatment without rubber dam and during the root canal therapy, swallowed a ProTaper® S1. He was accompanied to the hospital where, at first, was performed a gastrointestinal high endoscopy and a CT scan. He remained asymptomatic after these two early interventions, was monitored over four days, through X-rays of chest and abdomen, until the foreign body was eliminated. **Conclusion:** General practitioners who do endodontics should be aware of the risks involved in swallowing and/or accidental aspiration of foreign bodies during endodontic treatment, and know how to avoid this problem by adopting a simple measure, the use of rubber dam.

Keywords: Deglutition. Rubber dams. Root canal preparation.

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Introduction

The placement of the rubber dam is considered the first step of security before endodontic procedures.[1] During the management of patients at the time of clinical procedures, the use of rubber dam serves to prevent ingestion or inhalation of the irrigation syringes, isolation clamps, drills and endodontic files.[2]

Currently rare, the ingestion of endodontic instruments during treatment can result in clinical complications and, therefore, even in legal proceedings.[3]

Grossman[4] noted that 87% of foreign bodies passed to the digestive tract. In contrast, 13% were aspirated into the respiratory tract.

More serious complications caused by ingestion of instruments include impaction, obstruction or perforation of the digestive or respiratory tract.[5] However, 1% or less requires surgical intervention.[6]

In this case reported, the patient accidentally swallowed an endodontic file during root canal treatment of the lower left first molar without a rubber dam.

Case description

Male patient, 28 years-old, submitted to endodontic treatment of left mandibular first molar, without the use of absolute isolation, swallowed a Protaper® S1 file, 25 mm in length. After referral to the Emergency Room, chest X-rays were performed 24 hours after the accident and medical recommendation was implemented. 12 hours after the radiographies, a computed tomography (CT) was performed, suggesting that the instrument was found in his stomach (Fig 1). By the gastroenterologist advice, the patient underwent an upper gastrointestinal videoendoscopy in order to remove the instrument by laparoscopy, but it was unsuccessful. The patient was then referred to the endoscopist, who warned about the fact of a possible overlap of the bowel, creating a false impression of a foreign body in the stomach. It was then requested an abdominal radiography, which was performed 2 hours after the laparoscopic surgery, noting that the instrument was located close to the angle of the cervix or spleen (Fig 2). The medical advice

Figure 1. Stomach computer tomography.

Figure 2. Abdominal X-ray showing the S1 file located close to the angle of the spleen.

was to perform radiographic monitoring every 12 hours, without food restrictions, discarding the need for hospitalization. After 15 hours the instrument was in the large intestine descending colon (Fig 3). Radiographs of the 2 subsequent days showed that the instrument was located in the pubis and rectum, respectively (Figs 4 and 5). The foreign body was expelled naturally by the patient 72 hours after the last radiography, and he did not want to do other radiography to confirm the file elimination.

Figure 3. Abdominal X-ray in the large intestine descending colon.

Figure 4. Abdominal X-ray, S1 file in the pubis (lateral view).

Figure 5. Abdominal X-ray, S1 file in the pubis.

Figure 6. Abdominal X-ray, S1 file in the rectum.

Discussion

Security during treatment is an important component, and the use of rubber dam is undoubtedly essential to avoid accidents. Furthermore, the isolation of the tooth to be treated has many purposes, including the patient protection from aspiration or swallowing of instruments, increased visibility and also prevention of the root canal system against contamination.[7] When the instrument is lost in the oropharynx, it is immediately essential to determine its location and further penetration (into the respiratory or digestive tract), as when foreign bodies aspirated or ingested are not diagnosed or treated properly, serious complications can occur.

The examination and radiographic monitoring is mandatory for the differential diagnosis of the location, nature and size of the foreign body. Radiolucent objects often require endoscopy, computed tomography or simply physical monitoring.[8] In this case, the radiopacity of the instrument allowed to follow its path through the abdominal X-ray without being necessary to submit the patient to the supine position. Because of the shape and sharp edge of the endodontic files, they present a high risk of perforation.[9] However, usually the files that penetrate into the gastrointestinal tract are asymptomatic and atraumatic, and on average they are expelled within 4 days to 2 weeks.[10] In this case report, the patient was also asymptomatic and the file expulsion time was short. The file position over the gastrointestinal tract, from the stomach until the rectal evacuation, did not result in complications.

Conclusion

Dentists should be aware of the risks involving the accidental swallowing and aspiration of foreign bodies of dental origin during endodontic treatment and this type of accident can be avoided through the use of rubber dam.

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1. Registration of clinical trials

Clinical trials are among the best evidence for clinical decision making. To be considered a clinical trial a research project must involve patients and be prospective. Such patients must be subjected to clinical or drug intervention with the purpose of comparing cause and effect between the groups under study and, potentially, the intervention should somehow exert an impact on the health of those involved.

According to the World Health Organization (WHO), clinical trials and randomized controlled clinical trials should be reported and registered in advance.

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

2. Portal for promoting and registering clinical trials

With the purpose of providing greater visibility to validated Clinical Trial Registers, WHO launched its Clinical Trial Search Portal (http://www.who.int/ictrp/network/en/index.html), an interface that allows simultaneous searches in a number of databases. Searches on this portal can be carried out by entering words, clinical trial titles or identification number. The results show all the existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and http://isrctn.org (International Standard Randomized Controlled Trial Number Register (ISRCTN). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

WHO proposes that as a minimum requirement the following information be registered for each trial. A unique identification number, date of trial registration, secondary identities, sources of funding and material support, the main sponsor, other sponsors, contact for public queries, contact for scientific queries, public title of the study, scientific title, countries of recruitment, health problems studied, interventions, inclusion and exclusion criteria, study type, date of the first volunteer recruitment, sample size goal, recruitment status and primary and secondary result measurements.

Currently, the Network of Collaborating Registers is organized in three categories:

- Primary Registers: Comply with the minimum requirements and contribute to the portal;
- Partner Registers: Comply with the minimum requirements but forward their data to the Portal only through a partnership with one of the Primary Registers;
- Potential Registers: Currently under validation by the Portal's Secretariat; do not as yet contribute to the Portal.

3. Dental Press Endodontics - Statement and Notice

DENTAL PRESS ENDODONTICS endorses the policies for clinical trial registration enforced by the World Health Organization - WHO (http://www.who.int/ictrp/en/) and the International Committee of Medical Journal Editors - ICMJE (# http://www.wame.org/wamestmt.htm#trialreg and http://www.icmje.org/clin_trialup.htm), recognizing the importance of these initiatives for the registration and international dissemination of information on international clinical trials on an open access basis. Thus, following the guidelines laid down by BIREME / PAHO / WHO for indexing journals in LILACS and SciELO, DENTAL PRESS ENDODONTICS will only accept for publication articles on clinical research that have received an identification number from one of the Clinical Trial Registers, validated according to the criteria established by WHO and ICMJE, whose addresses are available at the ICMJE website http://www.icmje.org/faq.pdf. The identification number must be informed at the end of the abstract.

Consequently, authors are hereby recommended to register their clinical trials prior to trial implementation.

Yours sincerely,

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