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The current status of young endodontists

Endodontics is a specialty that attracts a considerable number of professionals due to its scientific and biological nature, as well as the high degree of involvement of most undergraduate professors. Such factors positively stimulate a tremendous thirst for increasingly up-to-date knowledge which is associated to the most recent technologies.

Despite having dedicated professors, dental surgeons-to-be do not acquire enough endodontic knowledge during college so as to fulfill the clinical needs and complexities of this specialty. Adding well-established protocols — which are continuously discussed and associated to training — to professional clinical practice is an intelligent and necessary measure for those who pursue a successful career.

New dental professionals and young endodontists share the resolution of an imminent and common issue: scientific and clinical preparation necessary to face the daily challenges. The unquenchable thirst for knowledge, the interest in a well-sedimented science and the development of new abilities (continuous psychomotor exercises) favor solution of many issues related to the clinical practice and which may seem impossible to overcome by young endodontists. Those who are open to acquire new knowledge and fearless of making mistakes or being exposed are stimulated to change their attitude and are more likely to successfully overcome the clinical drawbacks they face, all of which favor success and good professional quality of life.

Conversely, some professionals not only believe that they are not able to acquire information, but also do not find pleasure in searching up--to-date science or new knowledge. Working environment and ambience, stress (working routine and fatigue), lack of planning, and daily professional renovation and ability are some of the aspects that must be reanalyzed in order to avoid potential human errors.

Endodontist's professional ability, whether acquired by young or experienced professionals, requires planning and one of the strategies used to achieve clinical success includes the ongoing quest for excellence in the endodontic science.

Carlos Estrela
Editor-in-chief

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Why chronic periapical lesions relapse: 15 situations!

Alberto **CONSOLARO**[1]

ABSTRACT

Some clinical conditions seem to be difficult to explain and/or understand, as it is the case of relapse of chronic periapical lesions. From a pathophysiological standpoint (causes as well as mechanism of action and immune system), a specific approach towards inflammatory periapical lesions may not only broaden one's understanding, but also deepen clinical approach towards such condition. The aforementioned objective comprised the aim of the present study.

Keywords: Chronic periapical periodontitis. Relapse. Dentoalveolar abscess. Phoenix abscess. Periapical granuloma. Pericementitis.

[1] Full Professor, School of Dentistry, FOB-USP and FORP-USP.

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Contact address: Alberto Consolaro
E-mail: consolaro@uol.com.br

Introduction

The onset of inflammation is necessarily triggered in association with phenomena typical of the acute or initial phase of the process. The vascular and exudative phenomena established in the initial, acute phase of inflammation prepare the environment for proteins, enzymes and cells to act against the offending agent, regardless of its nature. Exudate and inflammatory infiltrate cells are able to reach the affected site by means of vascular and exudative phenomena, only.

Ninety minutes after injury, the connective tissue is massively invaded by neutrophils with an average life span of 10 hours in the blood and 24 hours in the site of inflammation. The neutrophils are the only polymorphonuclear leukocytes (PMN) that actively participate in the inflammatory process, especially in its acute phase. Neutrophil function is nearly solely related to phagocytosis of bacteria predominantly found in human microbiota — *staphylococcus* and *streptococcus*.

With pus formation

When neutrophils reach the site of inflammation, they interact with *staphylococcus* and *streptococcus* bacteria, phagocytizing them. At the same time, they overflow the outer environment with proteolytic enzymes, bactericidal oxygenated solutions, such as hydrogen peroxide, and/or chlorine-based, germicidal solutions. These extracellular products act over bacteria, cells and tissue components and dissolve them. As a result, the serous, clear exudate becomes a viscous and yellow fluid known as pus or purulent exudate. For this reason, neutrophils are also known as pyocytes (pus cells) whereas *staphylococcus* and *streptococcus* bacteria are known as pyogenic (marked by pus production).

Whenever neutrophils reach the site of inflammation and do not find this morphotype of bacteria, they usually migrate or disappear by apoptosis or genetically programmed cell death. Thus, it is reasonable to assert that the presence of pus reveals the presence of *staphylococcus* and *streptococcus* bacteria interacting with neutrophil PMNs.

Without pus formation

Swelling, tumefaction, inflammatory edema or inflammatory exudate are the plasmatic content that overflows through the vascular walls. Whether in large or small amounts, inflammatory exudate is always present during inflammation, especially in its acute phase. Initially, should the amount of *staphylococcus* and *streptococcus* bacteria be moderate, the serous exudate remains as a clear and liquid fluid. To become a viscous and yellow fluid, the inflammatory exudate requires an exuberant interaction between bacteria and neutrophils.

During the inflammatory process, should the amount of *staphylococcus* and *streptococcus* bacteria be small, they are easily eliminated by neutrophils without forming an inflammatory, purulent exudate. This phenomenon happens every day, especially with the most superficial and subepithelial tissues. *Staphylococcus* and *streptococcus* bacteria are prevalent in the human microbiota; for this reason, they enter into subjacent connective tissues nearly every day.

The progression of periapical periodontitis and periapical relapse

1) Acute apical pericementitis: a serous acute inflammation

Acute apical pericementitis is the initial inflammatory process established in periapical tissues. It is nearly entirely restricted to the connective tissues of the periodontal ligament and stump, and involves vessels and extracellular matrix near the cementum surface. That is where the term “apical pericementitis” comes from.

Periodontal ligament thickness varies between 2 and 0.4 mm. Its structure is easily affected by inflammatory processes involving the connective tissue near the cementum and alveolar bone surfaces. For this reason, some researchers prefer the term “apical periodontitis” to “apical pericementitis”. Because the latter is predominantly used in reference to the aforementioned process, it is also used throughout this text.

The process of inflammation, from its initial phase to the first 24 – 48 hours, tends to have blood vessels with increased permeability leading to the production of a serous exudate and an infiltrate of neutrophils that, to this point, do not interact with a sufficient amount of bacteria in terms of time and quantity. In this phase, there is not enough time for accumulation of pus, even if enclosed within small spaces in which case it is also known as microabscess. At its initial phase,

inflammation is classified as serous and, although neutrophils may be found in large numbers, pus is not formed. It is necessary to differ inflammation process established in the dental periapex from other types of inflammation. In order to do so, the term acute apical pericementitis is used.

Acute apical pericementitis is the serous acute periapical inflammation process established in periapical tissues. Should pus accumulate within small or large spaces, status of inflammation is no longer considered as acute apical pericementitis, instead, it is referred to as acute dentoalveolar abscess.

Acute apical pericementitis may be caused by: I) infected root canal microbiota; II) products of aseptic pulp necrosis, as it occurs in cases of dental trauma, especially concussion; III) dental trauma inducing periapical inflammatory processes without pulp lesion; IV) traumatic occlusion in which apical pericementitis becomes part of the occlusal trauma lesion.

2) Acute apical pericementitis evolving to repair

Should the cause of acute apical pericementitis be immediately diagnosed as infected root canal microbiota, it must be eliminated by proper endodontic intervention so as to prevent serous inflammation from evolving to pus formation and bacteria from interacting with neutrophils. Additionally, neutrophils die by apoptosis or migrate to other sites. As a result, the process of repair is established and reorganizes the apical periodontal tissues.

The same process of repair is established if root canal is properly treated in cases of acute apical pericementitis associated with aseptic pulp necrosis. Teeth without caries or fracture, but darkened by aseptic pulp necrosis caused by dental trauma, may remain with infected root canal after a few months. In these cases, infection is triggered by bacteria that reach the site by hematogenic or retrograde route.

Should dental trauma induce acute apical pericementitis without pulp lesion or contamination, pericementitis disappears after 48 – 72h by neutrophil migration and/or apoptosis. These cases do not require a direct approach, but long-term follow-ups. Pus formation depends on the interaction between neutrophils and bacteria: pus formation implies secondary microbial contamination.

Cases in which acute apical pericementitis is caused by traumatic occlusion tend to cease when normal occlusion is restored. Similarly, pus formation depends on the interaction between neutrophils and bacteria: pus formation implies secondary microbial contamination.

3) Acute apical pericementitis evolving to acute dentoalveolar abscess

Cases in which acute apical pericementitis is caused by infected root canal microbiota establish inflammatory processes that are no longer serous, but with a purulent exudate that characterizes a dentoalveolar abscess. In these cases, the intense and prolonged interaction between neutrophils and *streptococcus/staphylococcus* bacteria promotes an exuberant overflow of enzymes, peroxides and chlorine solutions that lead to pus formation.

The continuous growth of microorganisms inside the root canal and their exit through periapical tissues promote continuous and increasing pus formation. In these cases, the inflammatory process will go through different clinical phases, from dentoalveolar abscess to final drainage.

4) Acute apical pericementitis evolving to chronic pericementitis

Should neutrophils find a small number of bacteria beyond the limits of the cemental canal after 48 – 72 hours of periapical serous acute inflammation, the interaction between them is restricted to the site of inflammation and hardly ever leads to significant pus formation. This may occur when the infected root canal has great patency with most growing microbiota originating from the oral environment and a small amount of little pathogenic microbiota reaching the cemental canal.

In these cases, neutrophils are limited to the cemental canal, and the periapical ligament located after the apical foramen accumulates a large amount of macrophages and lymphocytes. These cells are slower than neutrophils and only reach the inflammation site a few hours later. Their function is to prevent bacteria and their products, which may have crossed the neutrophilic barrier, from reaching other parts of the body. Macrophages and lymphocytes are associated with chronic inflammatory phenomena that act simultaneously with neutrophils and aim at eliminating,

enclosing and producing immune responses which, as a result, locate the offending agent.

Acute apical pericementitis does not show imaginologic signs. However, inflammation lasts for a longer period of time during its chronic phase and, for this reason, promotes thickening of the lamina dura, interrupts its continuity and gradually and slowly promotes sclerosis of periapical bone. These are the classic signs of chronic apical pericementitis.

5) Chronic apical pericementitis evolving to periapical granuloma

Chronic apical pericementitis is restricted to the limits and structures of the apical periodontium. It promotes thickening of the lamina dura, interrupts its continuity and gradually and slowly promotes sclerosis of periapical bone.

Neutrophils restricted to the cemental canal may allow more or less bacteria and/or bacteria products to enter overtime, thereby creating the need for more macrophages and lymphocytes on the site of inflammation.

The cluster of macrophages and lymphocytes that was limited to the area near the mouth of the apical foramen, now occupies a larger area as a result of focal resorption of periapical bone. The cluster of macrophages — with or without associated lymphocytes — which encloses offending agents of difficult elimination is also known in human pathology as granuloma. Thus, in these cases, periapical inflammation is known as periapical granuloma. Periapical granuloma cells hardly ever occupy a periapical space greater than 1 cm in diameter.

6) Chronic apical pericementitis evolving to repair

Proper endodontic treatment restricts chronic apical pericementitis within periodontal limits. As a result, its cells migrate or join the granulation tissue that replaces them so as to restore the normal structure on the site, provided that bacteria and microbial biofilm do not remain. Occasionally, chronic apical pericementitis results in external root resorption established in the tooth apex.

7) Chronic apical pericementitis relapsing into acute dentoalveolar abscess

Chronic apical pericementitis is restricted to the limits and structures of the apical periodontium. It promotes thickening of the lamina dura, interrupts its continuity and gradually and slowly promotes sclerosis of periapical bone.

Should the infected root canal of a tooth with chronic apical pericementitis lose its patency, the microbiota may spread its virulence to periapical tissues. As a result, more bacteria and species will reach the periapical tissues, as they no longer leave the crown to enter the oral environment. Patency loss may be caused by tooth caries, food debris or bacteria, all of which may irregularly block the root canal.

Teeth with root canals inappropriately or partially filled have their microbiota stabilized by lack of nutrients caused by the absence of communication with the oral environment and carbohydrate-based substrates. Whenever the clinician accidently opens or manipulates these teeth, single prostheses become loose and, as a result, suddenly increase microbiota proliferation and virulence. As a consequence, prolonged and latent chronic apical pericementitis relapses and becomes secondary acute apical pericementitis which may evolve to secondary acute dentoalveolar abscess or chronic apical pericementitis within a few hours. These cases are commonly known as silent dentoalveolar abscesses or phoenix abscesses.

Teeth without caries or fracture, but darkened by aseptic pulp necrosis caused by dental trauma, may be clinically presented as chronic apical pericementitis or discrete periapical granuloma. After a few months, dried pulp cavity free of microbial contamination may have the canal secondarily infected by bacteria that reach the site by hematogenic or retrograde route and, as a result, cause the condition to relapse and evolve to acute dentoalveolar abscess.

8) Periapical granuloma evolving to repair

A cluster of macrophages and lymphocytes occupies a larger area as a result of focal resorption of periapical bone. Regardless of the part of the body, a granuloma encloses offending agents of difficult elimination.

Its cells hardly ever occupy a periapical space greater than 1 cm in diameter. Nevertheless, this space encloses enough macrophages and lymphocytes capable of balancing the offending agent coming from the apical foramen. The offending agent of difficult elimination enclosed by the periapical granuloma is represented by the microbiota of the infected root canal, since it is inaccessible

for the defending cells and substances. For this reason, periapical granuloma is established in these cases.

Proper endodontic treatment is able to fill the root canal space after disinfection and filling techniques are employed. The microbiota disappears and the periapical granuloma cells gradually join the granulation tissue which reorganizes the site and originates new periodontal ligament, cementum and alveolar bone. The process of repair is established as the macrophages clean the site by eliminating bacterial, cell and tissue debris.

Tooth resorption is usually present in apexes associated with periapical granuloma, which may hinder or delay the process of repair. Its irregular outer surfaces may host microbial bacteria and biofilm which the endodontic technique cannot directly and safely reach.

9) Periapical granuloma evolving to apical periodontal cyst

Inflammatory granuloma involves the periodontal structure in the apical region, only. Among the periapical granuloma, there are clusters of epithelial cells derived from the rests of Malassez. These clusters are involved in the process by contiguity.

The biochemical conditions and mediators of a chronic inflammatory environment induce epithelial rests to proliferate. The proliferating clusters of epithelial cells are no longer nourished at their core. As a result, they undergo necrosis and form cavities covered with epithelia that grow due to attraction between liquids exerted by the accumulation of cell proteins.

Cavity covered by specialized columnar epithelium is what characterizes the apical periodontal cysts which, in turn, result from a chronic periapical inflammatory process also known as periapical granuloma. As these cavities grow, they tend to occupy the entire space, disorganizing the periapical granuloma and exceeding the structural and organizational characteristics of apical periodontal cysts. These lesions usually occupy a periapical space greater than 1 cm in diameter which seems to be the upper limit of a periapical granuloma without a cystic cavity.

10) Periapical granuloma relapsing into secondary dentoalveolar abscess

Teeth with periapical granuloma usually present apical resorption that protects bacteria, infected dentin tubules and microbial biofilms.

While the endodontic technique is being employed, periapical granuloma may relapse and carry more bacteria and microbial biofilm to the periapex than usual. As a result, sudden relapse and pus formation may occur. In these cases, it is possible to assert that the periapical granuloma relapsed. For this reason, they are diagnosed as dentoalveolar abscess secondary to periapical granuloma.

Teeth with patent infected root canals carry most part of their microbiota to the oral environment. Additionally, low virulence microbiota is carried from the canal to periapical tissues. This allows acute and chronic apical pericementitis to evolve to periapical granuloma.

Occasionally, patency of infected root canals is decreased or eliminated by carious tissue, food debris or microbiota itself. Should that be the case, the amount of bacteria and products suddenly increase. As a result, they leave the site through the apical foramen, causing periapical granuloma to relapse with pus formation. In other words, periapical granuloma may evolve to secondary acute dentoalveolar abscess.

11) Chronic and acute dentoalveolar abscesses evolving to repair

After purulent exudate is drained and the organism is protected by medication, microbiota inside infected root canal is eliminated by endodontic procedures that aim at filling the canal. The root and apex of teeth involved in primary dentoalveolar abscess rarely have extensive areas of resorption. Clasts do not attach to intoxicated root surfaces filled with purulent exudate. In general, proper root canal treatment and well-prescribed medication lead to periapical repair of teeth with dentoalveolar abscess.

As for oral fistulas, they tend to disappear without leaving a trace. Nevertheless, skin fistulas can dry and, during fistulous tract repair, form a fine band of fibrous connective tissue that causes the skin surface to shrink towards its opening in the bone tissue through which pus initially reached the soft tissue on the outer surface of the compromised jaw. In these cases, due to esthetic issues, the fibrous tissue must be surgically removed.

12) Acute dentoalveolar abscess "chronicizing" and relapsing

Once pus formed as a result of acute dentoalveolar abscess reaches a mucous or cutaneous surface, a

process of drainage is established. It promotes deconcentration of pain mediators over free nerve endings and provides the patient with relief, given that pain is a biochemical phenomenon. In the compromised tooth apex, pus formation goes on as a result of continuous and prolonged overflow of microorganisms coming from the infected root canal. And pus continues to flow slowly and gradually through the fistula.

However, despite occasional and discontinued presence of pus in its opening and due to its high regenerative and proliferative capacity, the mucous and cutaneous epithelium is able to close the opening of the fistula even if rudimentarily. This event is enough to reestablish pus accumulation within periapical and bone spaces, since microbiota also loses its components as well as its aggressive capacity due to interrupted drainage. At the site, clinical presentation and process may relapse. In other words, the site may present severe signs and symptoms of acute dentoalveolar abscess.

13) Silent or phoenix dentoalveolar abscess

Teeth with root canals inappropriately or partially filled have their microbiota stabilized by lack of nutrients caused by absence of communication with the oral environment and carbohydrate-based substrates. Some imaging exams often surprise the clinician by revealing inappropriate treatment and the possibility of a severe inflammatory process while the patient does not complain or only reports painful sensitivity at vertical percussion. In general, these cases include teeth with prosthetic screws, full crowns or extensive restorations.

Teeth with compromised root canal require retreatment. Whenever the clinician accidently opens or manipulates these teeth, single prostheses become loose and, as a result, suddenly increase microbiota proliferation and virulence. Reestablishing communication with the oral environment also restores aerobic conditions, carbohydrates-based diet and microbiota components previously latent.

As a consequence, prolonged and latent chronic apical pericementitis, or a discrete periapical granuloma, relapses and evolves to secondary acute dentoalveolar abscess within a few hours: These cases are commonly known as phoenix abscess. In Greek mythology, a phoenix is a bird that dies, bursts into flame and cyclically and surprisingly obtains new life by arising from its ashes (Fig 1).

All cases of pus formation imply in bacterial proliferation and intense interaction with neutrophils. No other mechanism is responsible for relapse and pus formation. Phoenix abscesses imply, one way or another, in communication with the oral environment and changes in environmental and nutritional conditions of root canal microbiota. Although some studies theorize that such changes occur by retrograde and/or hematogenic route, their clinical and biological evidence is scarce.

These cases not only require microbiota control with the use of proper medication, but also require shorter follow-up time and intensive technical as well as clinical care so as to prevent signs and symptoms from relapsing and, as a result, providing patients with clinical comfort. Postponing the procedures employed to correct inappropriate treatment is not an option. Likewise, leaving the root canal open to the oral environment in order to stabilize the clinical presentation with a new situation of communication with the mouth, is not an option either. This procedure used to be indicated a few decades ago, when Endodontics was technically limited and lacked specific medication as well as biological and microbiological knowledge.

14) Apical periodontal cyst evolving to repair

Apical periodontal cysts, whether small or medium, are reversed by proper endodontic treatment, only; since the epithelium remains disorganized and is richly infiltrated by leukocytes, bacteria and bacteria products.

Small and medium apical periodontal cysts have their cystic wall predominantly formed by little fibrous connective tissue richly infiltrated by periapical granuloma cells. For this reason, these cysts are quickly reversed by proper endodontic treatment. Additionally, in these cases, if the process of inflammation undergoes proper endodontic treatment, the cystic content is small and easily phagocytized.

Larger apical periodontal cysts have a larger amount of cystic content to be removed. Additionally, their epithelium is highly organized and their fibrous wall is thick and mature, with thick collagenous fibers and potentially hyalinized areas. For these reasons,

Figure 1. Phoenix: In Greek mythology, it is a bird that dies, bursts into flame and cyclically and surprisingly obtains new life by arising from its ashes.

they require surgical and endodontic treatment for quicker and safer remission.

In general, the great majority of larger apical periodontal cysts have foreign body-type granulomas in reaction to extensive accumulation of cholesterol crystals which are not eliminated by a process of repair and, as a result, hinder total remission of the lesion.

15) Apical periodontal cyst evolving to secondary dentoalveolar abscess

Teeth with apical periodontal cysts previously had periapical granuloma with apical resorption that protects bacteria, infected dentin tubules and microbial biofilms.

While the endodontic technique is being employed, periapical granuloma and apical periodontal cysts may relapse and accidently carry more bacteria and microbial biofilm to the periapex than usual. As a result, sudden relapse and pus formation may occur. In these cases, it is possible to assert that the apical periodontal cyst relapsed. For this reason, they are diagnosed as secondary dentoalveolar abscesses.

Teeth with patent infected root canals carry most part of their microbiota to the oral environment. Additionally, its low virulence microbiota is carried from the canal to the periapical tissues. This allows acute apical pericementitis to evolve to chronic apical pericementitis, followed by periapical granuloma and apical periodontal cyst.

Occasionally, patency of infected root canals is decreased or eliminated by carious tissue, food debris or microbiota itself. As a result, the amount of bacteria and bacteria products leaving the site through the apical foramen suddenly increases. Should that be the case, the apical periodontal cyst suddenly relapses with pus formation on its conjunctive wall. As a result, the cyst may evolve to secondary acute dentoalveolar abscess.

Final considerations:

Relapse of chronic inflammatory periapical lesions always occur due to an increase in virulence of infected root canal microbiota as a result of changes in the composition of its species or an increase in the amount of its components. Such alterations imply in changes in the clinical aspect of teeth and lesions involved, including exacerbation of signs and symptoms in addition to pus formation directly associated with greater interaction between neutrophils and the exudate formed by *staphylococcus* and *streptococcus* bacteria — predominant in root canal microbiota.

Local factors, such as root canal patency and communication with the oral environment, explain changes in microbiota profile and consequent relapses. Due to lack of evidence, little importance should be attached to non-measurable factors, such as patient's organic resistance. Conversely, the importance of determining local factors should be emphasized.

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In vitro comparison of the efficiency of two electronic apex locators

Sérgio Henrique Staut **BRUNINI**[1]
Michel Carlet de **LIMA**[2]
Aryele Cristina **SCHMIDT**[3]
Lourival Raimundo dos **SANTOS**[4]
Carlos Marcel C. **BONICONTRO**[4]

ABSTRACT

Introduction: Radiography has been widely used to determine working length in Endodontics, even though its limitations have been extensivelly recognized. In order to render the assessment of working length increasingly accurate, different electronic apex locators have been developed. **Objective:** The objective of this study is to compare *in vitro* the effectiveness of two electronic apex locators: Root ZX and Apex DSP. **Methods:** After coronary opening and preparation of the cervical and medium thirds of the root canal, a K-type file was inserted into the canal as far as the most cervical edge of the apical foramen. Subsequently, the teeth were placed into containers and embedded in alginate together with the lip clip of the apex locator so as to determine tooth length. **Results:** Comparison between measurements showed an 87.5% accuracy rate for Root ZX *vs.* 77.5% for Apex DSP, suggesting that there is no statistically significant difference between the two apex locators. **Conclusions:** Electronic apex locators appear to be efficient and provide a reasonable alternative method to determine the correct working length.

Keywords: Odontometry. Root canal preparation. Endodontics.

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[1]Associate Professor, Department of Dentistry, Paranaense University.
[2]Specialist in Orthodontics.
[3]Degree in Dentistry, Paranaense University.
[4]Undergraduate student of Dentistry, Paranaense University.

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Contact address: Sérgio Henrique Staut Brunini
Rua Bartira, 2745 – Jardim São Marcos – Umuarama/PR — Brazil
CEP: 87.501-440 – E-mail: brunini@unipar.br

Introduction

Despite recent technological advances that allow Endodontics to become a highly successful practice, the apical limit of the working length in root canal treatment cannot be easily determined. This is because the working length is indirectly determined on the basis of clinically visible tooth crowns in their early stages, and the apical foramen which is not clinically visible.[1] As a result, a series of methods (from tactile sensitivity to radiography) and equipment have been developed to identify apical limits.

Radiography has become a widespread method for determining the working length. However, radiography is widely known for presenting its own limitations, namely: distortions produced by variation in vertical and horizontal angles, viewing of the mesiodistal plane only, and overlapping of anatomical structures.

Nevertheless, the main difficulty relates to the inability of radiographic imaging to determine variability in apical anatomy. This may inadvertently result in apical perforations, overinstrumentation, overfilling, postoperative pain, as well as deficient and incomplete instrumentation and obturation. Such events can evidently lead to unsuccessful endodontic therapy.

Proper endodontic treatment completion requires correct assessment of root canal length through preparation and obturation of root canals up to the vicinity of the canal-dentin-cement (CDC) limit. With the purpose of rendering this limit increasingly accurate, electronic apex locators, of which main features are speed, convenience and efficiency, have been developed and can now be used both for working length determination and for defining communication points between the root canal and the periodontium, fractures and resorption.

The applicability of these electronic devices has been thoroughly investigated. Moura et al[2] compared odontometry conducted by radiography and by two electronic apex locators and achieved similar results; thus concluding that the electronic method is indeed effective.

A similar method was employed by Marques and Marques[3] to assess Justy II™ apex locator on 202 teeth of patients undergoing endodontic treatment, achieving 100% success proven radiographically. However, the authors basically regard the electronic method as an auxiliary tool in odontometry. They do not support the routine use of apex locators as they consider odontometry radiography to be essential for viewing curvatures and furcations.

To demonstrate the clinical accuracy of apex locators Fouad and Reid[4] compared the number of radiographs necessary to obtain adequate working length with and without an electronic estimate preceding odontometric radiography, noting that the prior use of Root ZX apex locator allowed for a reduction in the number of radiographs. Similar conclusions were reached by Sousa and Teixeira[5] whose results show that the electronic technique was more economical and less time consuming than the radiographic method used to confirm the working length on 130 teeth.

When potential distortions resulting from a radiographic procedure are taken into account, it appears to be more effective to confirm the reliability of apex locators by comparing measurements obtained with locators to the actual size of the tooth.

An example of this procedure is found in the research by Coutinho and Siqueira[1] who observed that measurements on the Apit™ apex locator coincided with those obtained directly from 40 extracted teeth used in their study.

The purpose of this study was to compare the effectiveness and reliability of two electronic apex locators (Apex DSP and Root ZX) in correctly determining the root canal length of extracted teeth.

Material and Methods

A total of 40 human teeth were extracted by therapeutic recommendation of the Department of Surgery in the Dentistry undergraduate course at Paranaense University (Unipar). Only single-rooted, single-canal teeth were used with undamaged, straight roots and fully formed apices. Patients were informed about the procedures and signed an informed consent form approved by Paranaense University Institutional Review Board. The form was duly registered and approved by the Brazilian Research Ethics System (SISNEP: 0276.0.375.000-09) (file #16579).

After extraction, the teeth were kept in a sodium hypochlorite solution at 1% (Miyako, São Paulo, Brazil). Crown and pulp chamber were accessed with the aid of a spherical diamond bur #1014 (KG Sorensen, São Paulo, Brazil) under air/water refrigeration, abrading the tooth until it felt like an empty space, thus indicating that the pulp cavity had been reached. Subsequently, the diamond tip was replaced with a trunk cone-shape burs

without active edge #3082 (KG Sorensen, São Paulo, Brazil) to create the contour shape.

After removal of pulp chamber roof, orifice openers #1, #2 and #3 (Dentsply, Switzerland) were used with a 5-face pyramid-shaped active tip. Next, the cervical and medium thirds of the root canal were expanded with Gates-Glidden drills #03, #02 and #01 (Dentsply, Switzerland) used in descending order.

Once this phase was completed, a 10x magnifying glass (Motic, China)was used to explore the root canal with a Kerr-type file (Dentsply, Switzerland) and gauge compatible with the canal diameter. A K-type file was inserted until it could be viewed through the apical foramen, thus ensuring that the path was indeed unobstructed (Fig 1).

Thereafter, the K-type file was pulled back to the most cervical edge of the apical foramen (Fig 2) and grasped with a hemostat (S.S.White, Rio de Janeiro) placed on the highest apex of the dental crown. The distance between these two points was measured with the aid of a digital caliper (LEE Tools, China) (Fig 3) to obtain root canal length by direct method. Values were recorded in a form for later comparison.

Subsequently, teeth were placed in plastic containers and embedded in alginate (Jeltrade, Petrópolis, Brazil) along with the lip clip of the apex locator for assessment by electronic method using Root ZX (J. Morita, Japan) and Apex DSP (Septodont, France) apex locators (Fig 4).

The root canal was then rinsed with a 1% sodium hypochlorite solution to lubricate the passage, and a Kerr-type file of the same caliber was inserted by the direct method and connected to a clamp on the device while monitoring the proximity of the foramen until the apex locator reached the zero mark. Afterwards, the K-file was held with a hemostat using the same external reference to obtain the root canal length by direct method. The file was then pulled out from the canal and remeasured with a digital caliper.

The procedure was repeated on each tooth with both electronic apex locators.

The values obtained for each apex locator by direct method were statistically analyzed using Student's t-test with a 0.05 significance level to ascertain the reliability of the electronic method and assess the individual performance of each electronic apex locator.

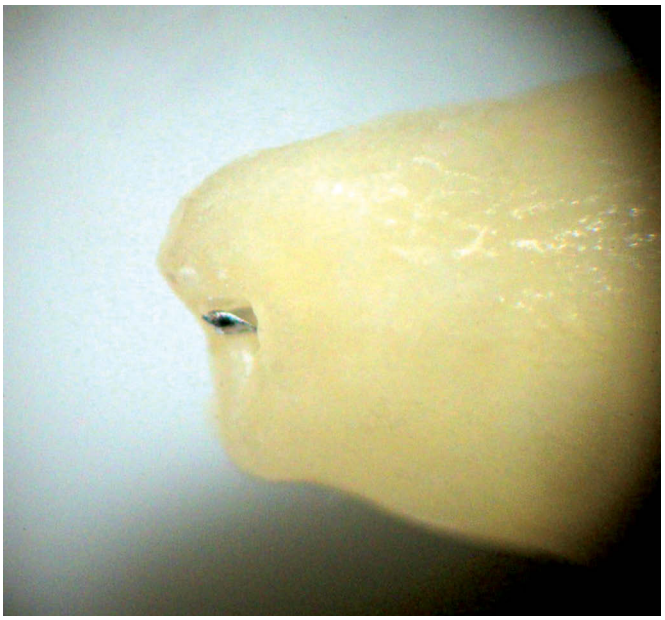

Figure 1. K-type file inserted into the root canal, surpassing the apical foramen.

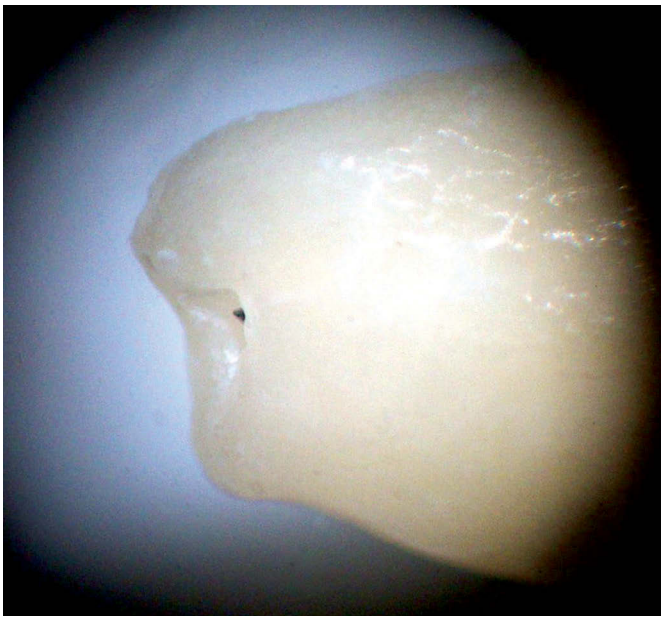

Figure 2. K-type file inserted into the root canal and pulled back to the most cervical edge of the apical foramen.

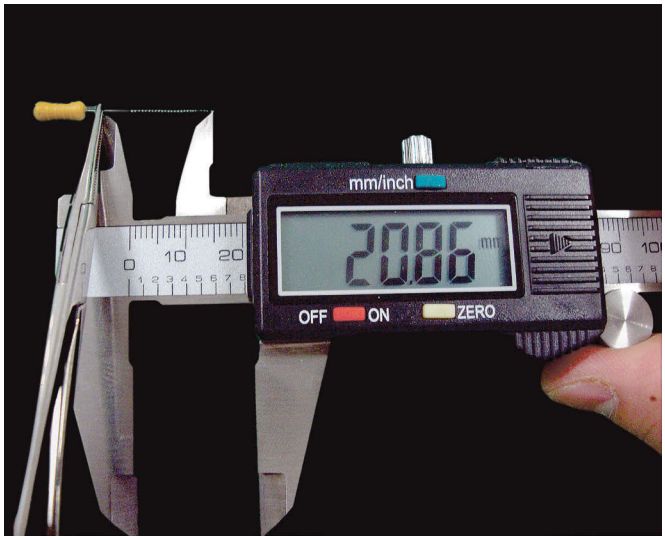

Figure 3. K-type file removed from inside the root canal and measured using a digital caliper.

Figure 4. Teeth embedded in alginate with lip clip of apex locator.

Results

Result analysis indicates that Root ZX apex locator achieved 87.5% acceptable results for working length determination of the root canal, while Apex DSP locator achieved 77.5%.

A comparison between the values recorded by means of direct and the electronic method (Table 1) revealed that Root ZX apex locator presented coincident measures with the actual length of the root canal in 25 cases (62.5%), whereas in 10 cases (25%) the distance between the K-file tip and apical foramen showed a difference of approximately 0.5 mm. Of these, the K-file exceeded the measurement limit by direct method in only two cases, and in only five cases (12.5%) the difference was more than 1.0 mm short of the root apex. Apex DSP locator, on the other hand, showed coincident measurements with the actual length of the root canal in 14 cases (35%). The apex locator remained 0.5 mm short of the apical foramen in 17 cases (42.5%) and in nine cases (22.5%) the distance between the K-file and the root apex was greater than 1.0 mm.

Table 1. Distance from the file tip to the apical foramen.

Distance	Root ZX	Apex DSP
+0.5 mm	02	0
0.0 mm	25	14
-0.5 mm	08	17
-1.0 mm	05	09
Total	40	40

Discussion

Accurate determination of tooth length (odontometry) is one of the most challenging phases of endodontic treatment, since the radiographic method is the technique most widely used to achieve working length. Nevertheless, this method has proven unequivocally ineffective to identify the CDC limit, which has been considered an ideal reference to assist in the preparation and obturation of root canal.[6] Some studies indicate that in 75% of teeth in which the instrument is positioned next to the radiographic apex, it has in fact surpassed the apical foramen.[2] For this reason, in this study, we used extracted teeth, and by doing so it was possible to determine the actual root canal length by the direct method.

Since the last century, endodontists have sought alternatives to overcome the limitations of radiographs in determining root canal length.[7] As stated by Serota et al,[8] loss of 1 mm working length in cases where a periapical lesion is present increases the chance of endodontic treatment failure by 14%.

According to Soujanya et al,[9] the requisites for an ideal method of working length determination are:

» Quick location of apical constriction regardless of canal content;

» Easy measurement, even when the relationship between apical constriction and radiographic apex is unusual;
» Patient's fast and comfortable monitoring;
» Patient's minimal radiation exposure;
» Ease of use on special patients or patients with limited mouth opening;
» Beneficial for pregnant patients;
» Low cost.

To this end, in 1962, Sunada[7] developed an apex locator that allows the passage of an electric current through the dental structure/periodontal ligament. This provided optimal results when the root canal was dry.

The electronic method aims to facilitate working length determination for instrumentation of the root canal. This method is easy, fast, efficient and accurate and contributes to the reduction of radiation exposure.[3]

According to Renner et al,[10] apex locators act as capacitors that promote accumulation of electric charges in the periodontium and inside the tooth, while the dentin serves as an insulator making the electric current propagate in a different manner through the canal. This is also known as impedance.

The development of new apex locators, as described in the current literature, has led to highly encouraging results; thus overcoming the need for prior emptying and drying of the root canal.[7] According to Brito-Júnior et al,[11] state-of-the-art impedance-frequency dependent type apex locators can now be used with 75%-100% efficiency and accuracy regardless of the solution applied, be it sodium hypochlorite, saline, xylene, chlorhexidine, EDTA, or in the presence of blood and pulp tissue. This occurs because apex locators perform the calculation of different impedance values within the canal by using two frequency signals.

The decision to use the apex locators tested in this study stems from the fact that both are last generation apex locators, namely, impedance-frequency dependent devices. The Root ZX apex locator has been widely studied and, therefore, its results can be used as a benchmark for verification of the methodology applied. On the other hand, since the Apex DSP locator was launched recently there are only a few studies in literature describing its efficiency in measuring tooth length. Furthermore, its affordability has boosted its sales thanks to the use of LED lights to indicate the position of the instrument instead of a liquid crystal display.

Several studies[6,12-16] report that an error margin or tolerance limit of more or less 0.5 mm relative to the actual tooth length is clinically acceptable. This is related to problems inherent in the apex locator operator. Therefore, in this experiment an 87.5% rate of acceptable values for the Root ZX was achieved and this is in agreement with similar studies which demonstrate a high level of accuracy in measurements with the Root ZX. Fouad and Reid[4] achieved a 72% accuracy rate, Goldberg et al,[17] 100%, Meares and Steiman[14] 83%, while Welk et al[16] attained 90.7%.

For the Apex DSP locator a 77.5% rate of acceptable values was observed. Although the rate was lower than that achieved by the Root ZX, this is considered a highly satisfactory value. It should be noted yet again that the Apex DSP is scarcely described in the literature. Moshonov et al[18] reported 84% of compatible measures, Lewiska et al[19] reached 88.2% accuracy rate and Lipski et al[20] 90%.

Conclusions

Based on the methodology employed and the result analysis it is reasonable to conclude that:

» Electronic apex locators afford a satisfactory alternative method to determine the correct working length.
» Root ZX apex locator achieved a high success rate in determining the root canal length (87.5%) and performed better than Apex DSP locator (77.5%), but this difference was not statistically significant.

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Influence of hypertension on oral infections and endodontic treatment

João Eduardo **GOMES-FILHO**[1]
Christine Men **MARTINS**[2]
Gustavo **SIVIERI-ARAUJO**[3]
Ludmilla Mota da Silva **SANTOS**[2]
Índia Olinta de Azevedo **QUEIROZ**[3]
Marcelo Tadahiro **WAYAMA**[4]
Guilherme Hiroshi **YAMANARI**[5]
Eloi **DEZAN-JÚNIOR**[1]
Luciano Tavares Angelo **CINTRA**[6]

ABSTRACT

Hypertension is characterized by peripheral vascular resistance that leads to blood pressure increase and several systemic changes that may negatively influence one's oral health. Thus, the aim of this study was to conduct a literature review on the influence of hypertension over oral conditions and endodontic treatment. Hypertension mainly affects the blood vessels, brain and kidneys. A hypertensive condition can lead to increased levels of parathyroid hormones, abnormal vitamin D metabolism, reduction in the concentration of ionized calcium and decreased calcium absorption. Therefore, hypertension can be closely associated with oral problems such as periodontal diseases, implant loss, difficulty in bone healing, reduced salivary flow and protein concentration in saliva, increased number of neutrophils and, as a consequence, favoring of inflammatory processes. It has also been suggested that the success rate of endodontic treatment in hypertensive patients is lower than in normotensive ones. The response of hypertensive patients to root canal treatment, intracanal medications and sealers should be further studied in order to provide knowledge on the changes, failures and success of endodontic treatment.

Keywords: Hypertension. Endodontics. Endodontic medicine.

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[1]Full professor of Endodontics, School of Dentistry — State University of São Paulo/Araçatuba.
[2]Doctorate student of Dental Science, FOA-UNESP.
[3]Postdoc in Endodontics, FOA-UNESP.
[4]Masters student of Endodontics, FOA-UNESP.
[5]MSc in Endodontics, University of Marília (UNIMAR).
[6]Postdoc in Endodontics, State University of Maringá (UEM).

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Contact address: João Eduardo Gomes-Filho
Faculdade de Odontologia de Araçatuba, UNESP/Araçatuba
Rua José Bonifácio, 1193 – CEP: 16015-050 – Araçatuba/SP — Brazil
Email: joao@foa.unesp.br

Introduction

Hypertension or "high pressure", as it is popularly known, occurs when blood pressure is equal or higher than 140/90 mmHg for a young adult. Such increase in pressure is due to vascular remodeling that hinders the passage of blood during its journey in the arteries, causing the heart to work harder than it usually does.[1-4] Heart and blood vessels can be simply compared to a system of taps connected to several hoses. If the tips of the hoses are closed, the pressure inside the taps will increase.

Hypertension is considered a "silent and democratic" chronic disease. It is silent because patients rarely have evident signs or symptoms, which contributes to late diagnosis and treatment. Moreover, it is democratic because it attacks all kinds of people, regardless of sex, age, social class or physical type.[4]

Hypertension is a chronic disorder of multifactorial etiology.[5] Its incidence has increased in the last few years due to changes not only in the dietary pattern and lifestyle of the general population, but also in the growth of the elderly population as well as an increase in human longevity.[6] For this reason, the Brazilian Society of Hypertension and the World Health Organization understood the importance of waging campaigns to raise public awareness about healthy eating habits and physical exercising.[1,7]

Moreover, hypertension is considered a very common disease, even among different age groups. It attacks 25% of the Brazilian adult population[1,7] (data that corroborates the findings of other countries.[8,9]), 50% of people older than 60 and 5% of children and adolescents,[1] affecting not only blood vessels, but also their heart, brain and kidneys.[3,5,10]

Blood vessels present a very thin and delicate inner layer that can be injured by high pressure. Consequently, blood vessels are narrowed and hardened, and can be blocked or broken over time.[1,3,5]

The blockage of a heart vessel causes angina that can lead to a heart attack. On the other hand, blockage or breakage of brain vessels lead to a stroke. High pressure is currently responsible for 40% of cases of myocardial infarction and 80% of cases of stroke. Therefore, the World Health Organization considers it a deadly disease for 9.4 million people worldwide.[1,3,5]

Changes in kidney filtration as well as renal failure can occur. In fact, researches reveal that 25% of renal failure cases are due to hypertension.[1,11] In addition to that, hypertension also causes systemic changes such as increase in the levels of parathyroid hormones, abnormal vitamin D metabolism, reduction in the concentration of ionized calcium and decreased absorption of calcium.[12] Therefore, a hypertensive condition may increase the mobilization of calcium from the bones and its consequently excretion by the kidneys. Furthermore, it may lead to a secondary activation of parathyroid hormones of which main function is to increase the level of calcium in one's blood by stimulating the breakdown of osteoclasts, as well as by increasing calcium absorption in the intestines via vitamin D activation and calcium resorption of the kidney; thus resulting in loss of calcium in the body. In addition to that, hypertensive patients present alterations in the activity and differentiation of bone cells mediated by angiotensin II.[13-16]

According to the above, clinical and experimental studies have demonstrated a causal relationship between the presence of hypertension and increased loss of calcium from the bones.[12,17,18] More than that, it can be inferred that hypertension may be closely related to dental problems such as periodontal diseases,[19,20,21] high levels of implant failure due to defects that occur during osseointegration,[22] and also difficulty in bone healing after extraction.[23-25]

Therefore, the aim of this study was to conduct a literature review about the influence of hypertension on oral problems and endodontic treatment.

Relationship between oral health problems and hypertension

Periodontal problems are closely related to hypertension.[19,20,21] Periodontal infection is a source of pathogenic species and inflammatory mediators that can create a systemic inflammatory burden and increase the risk of developing hypertension and other cardiovascular diseases.[26-32]

Bonato et al[26] observed that after induction of inflammation (periodontitis), there is an additional recruitment of neutrophils due to the increased presence of TNFα and other cytokines involved in the emission of signals to the onset of immune responses.[26]

In other words, the presence of local inflammation, such as apical periodontitis, may be systemically interfering due to the fact that hypertensive patients show an increased amount of cells, proteins and chemical mediators involved in the immune response processes.

Relationship between hypertension and oral health problems

Hypertension causes high blood pressure that may affect the arterioles along the surface of the alveolar bone, leading to a minor hemorrhage.[20,33,34] Patients with systemic diseases may have decreased resistance to bacterial infection as well decreased tissue repair after endodontic treatment.[35,36] Thus, an inflammatory process characterized by circulation of cytokines and chemical mediators with the presence of a microbiota, may be established.[20,33,34] Within this context, Bonato et al[26] observed that hypertensive rats present a higher number of neutrophils in comparison to normotensive rats. Therefore, hypertensive condition seems to favor the inflammatory process that, in turn, is potentiated.

The relationship between oral chronic inflammatory processes of infectious origin, for example, apical periodontitis and periodontal disease, and systemic health is a very interesting aspect that should be covered. In a retrospective study, Segura-Egea et al[37] found that there is a higher prevalence of chronic apical periodontitis in hypertensive patients than in normotensive patients.[37] In 2011, the authors reported that the association between higher blood pressure and smoking habits further increased this prevalence.[38]

Hypertension can also be associated with a high susceptibility to the development of pathologies that impair oral health, which can decrease salivary flow and protein concentration of saliva. Elias et al[39] found that salivary flow and average concentration of proteins in saliva were reduced, but with no changes in salivary amylase activity in hypertensive cases. Additionally, the authors also observed, by means of microhardness analysis, that teeth of hypertensive rats have lower enamel and dentin resistance.[39] Furthermore, Inoue et al[40] suggested that the mechanism of mineralization in hypertensive rats is abnormal, given that their trabecular bone presented a lower mineral state in both young and adult rats.

Moreover, hypertension can cause negative histometric and molecular changes in the alveolar bone, even in the absence of an inflammatory process. According to Bastos et al,[24] there is an increased expression of RANKL protein and a higher ratio of RANKL/OPG proteins that, when combined with other factors, decrease bone density. RANKL protein is closely related to the activation of osteoclasts responsible for the reabsorption process, whereas OPG protein is an osteoclastogenesis inhibitory factor. These data suggest that a hypertensive condition may directly affect the alveolar bone. Zhang et al[41] also found that bone mineral density is lower in hypertensive rats in comparison to normotensive rats, thus confirming increased bone loss in the presence of high blood pressure.

Corroborating and further investigating these results, Bastos et al[25] conducted a study in hypertensive rats and observed that not only the bone density of pre-existing bone is affected by hypertension, but also the newly formed tissue of the spinal region. In that study, the trabecular bone area of normotensive 150-day old rats was considerably larger than in hypertensive rats. Moreover, 8 days after bone defect was carried out, bone formation in hypertension rats was significantly lower.

It has been suggested that hypertension may contribute to difficult in retention of endodontically treated teeth. Mindiola et al[42] observed that 7.8% of endodontically treated teeth of hypertensive patients were not satisfactory. Additionally, further aggregation of diabetes to this systemic condition increased that rate. Altogether, these data justify the hypothesis that systemic diseases, such as diabetes mellitus, coronary artery disease and hypertension, increase the risk of tooth extraction after endodontic treatment or retreatment.[43]

Relationship between hypertension and Endodontics

According to the aforementioned information, hypertension promotes systemic changes that are directly related to the oral condition, healing and bone formation, mineralization processes and the process of speeding up an infection. Furthermore, these changes may be responsible for endodontic treatment failure in those patients.

Periodontal disease and chronic apical periodontitis share a common microbiota composed of anaerobic gram negative bacteria, in addition to being similar inflammatory processes.[44,45] Therefore, in this context, a possible association can be established between hypertension and endodontic treatment.

Endodontic treatment aims to restore the normality of lost apical and periapical tissues[46,47] by means of not only deeply cleaning and disinfecting the root canal system so as to control pathogenic microorganisms,

but also through complete three-dimensional sealing of the root canal with filling materials that present adequate physical and biological properties for tissue repair, by means of inducing mineralization.[48-50]

Some materials used in endodontic treatment function as anti-inflammatory and antibacterial drugs, as well as inducers of osteogenesis and cementogenesis.[48-52] Calcium hydroxide is widely used during endodontic treatment, given that it eliminates bacteria and their toxins, has an anti-inflammatory action, neutralizes acid products and activates alkaline phosphatase. All these functions are associated with tissue and bone repair processes. In addition to calcium hydroxide, MTA also induces osteogenesis and cementogenesis.[48,52-57]

Hence, the response of hypertensive patients to endodontic treatment, intracanal medications and sealers should be further studied in order to provide knowledge on the changes, failures and success of endodontic treatment.

Conclusion

Based on the results of this study it is reasonable to conclude that hypertension influences patients' overall oral health and seems to be related to success in endodontic treatment. The response of hypertensive patients to root canal treatment, intracanal medications and sealers should be further studied, in order to provide knowledge on the changes, failures and success of endodontic treatment.

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Factors that favor tridimensional and hermetic obturation of root canal system

Jefferson J. C. **MARION**[1]
Déric Meschiari **BATISTA**[2]
Sueli Satomi **MURATA**[3]
Valdir de **SOUZA**[4]
Roberto **HOLLAND**[4]

ABSTRACT

Objective: This study aims at demonstrating the possibility and importance of filling different types of accessory canals in different teeth. **Methods:** The sample comprised 11 cases in which detailed knowledge of the inner anatomy of root canal systems associated with good use of the crown-down preparation technique — irrigation with 1% sodium hypochlorite and 17% trisodium EDTA for cleaning and removing smear layer — enabled different types of filling cement to drain. **Results:** Endométhasone, SealapexTM and Zinc Oxide - Eugenol filling cements proved to be efficient in root canal filling with the aid of the Tagger technique. **Conclusion:** It could be concluded that a combination of knowledge about anatomy, techniques and substances yield satisfactory results in 3D filling and hermetic seal of root canals, which leads to successful endodontic treatment.

Keywords: Transverse anatomy. Endodontics. Root canal filling.

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[1]PhD resident in Clinical Dentistry/Endodontics, State University of Campinas (UNICAMP). Professor, Department of Endodontics, Brazilian Dental Association (ABO) and Ingá College (UNINGÁ)

[2]Degree in Dentistry, Ingá College (UNINGÁ).

[3]PhD in Pediatric Dentistry, School of Dentistry – UNESP / Araçatuba.

[4]Professor of Endodontics, Department of Restorative Dentistry, School of Dentistry – UNESP / Araçatuba.

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Contact address: Jefferson J. C. Marion
E-mail: jefferson@jmarion.com.br

Introduction

The main purposes of endodontic therapy are root canal cleaning achieved by removing pulp tissue; and root canal disinfection achieved by removing remaining necrotic pulp tissue, microorganisms and infected dentin.[1,2] Knowing the inner anatomy of root canals is key for endodontic treatment success. Such knowledge allows endodontic treatment planning; however, anatomical changes may significantly hinder successful endodontic results.[3] Despite being extensively studied, the clinical relevance of tooth anatomy has to be highlighted so as to emphasize its potential influence over the final results of endodontic treatment.[4] According to Guldener,[5] one must remember that a tooth root has one or more than one main canals which may be divided into several accessory root canals.

Knowledge about tooth anatomy is of paramount importance for the dental specialties. In other words, knowledge of canal morphology and its frequent variations before satisfactory infection control and advanced operating techniques strongly influence daily dental practice.

According to Pucci and Reig,[6] the root portion of the pulp cavity often presents furcations or fusions. Depending on their location, root furcations are named as: main canal, collateral canal, lateral canal, secondary canal, accessory canal, intercanal, recurrent canal, reticular canals or apical deltas. Moreover, the classification by Kuttler[7] also mentions an accessory canal in the furcation. According to De Deus,[8] it is important to highlight, especially to beginners in the endodontic practice, that the aforementioned furcations are not found in one single root at the same time.

Duque[9] assessed 15 endodontically treated teeth using a viewing box with a magnifying glass, and found no lateral canal. Nevertheless, De Deus,[10] Vertucci[11] and Hess[12] proved that the aforementioned furcations are observed in all types of teeth. However, for Weine[13] they are not enough demonstrated.

Rubach and Mitchell[14] revealed that lateral and accessory canals are found in 45% of teeth with periodontal lesions, regardless of disease severity. Likewise, Kirkham[15] concluded that lateral canals were found in 23% of periodontally compromised teeth. The author also highlighted that these pathways favor bacterial accumulation and may lead to pulp contamination, both of which hinder periodontal healing.

According to Murata,[16] the mechanical action of files during biomechanical preparation of root canal dentin walls not only increases light inside the root canal, but also causes dentin debris which may be associated with organic debris and, for this reason, need to be removed by irrigating solution and suction.

Silva et al[17] assert that effective removal of organic and inorganic compounds of dentin debris (smear layer) relies on the use of EDTA followed by sodium hypochlorite. The use of EDTA to remove smear layer has been effectively demonstrated by the literature.[18-27]

According to Panzarini et al,[28] removing the smear layer after root canal biomechanical preparation has four major advantages: enhances dentin permeability[29,30] and, as a result, favors the deep action of intracanal dressing inside the dentin tubules and furcations of the main canal;[31] 2) favors adhesion of the filling cement to the root canal dentin walls;[32] 3) provides better marginal, apical sealing;[33,34] 4) allows the filling cement to drain through the furcations of the main canal.[35,36]

The study conducted by Fachin and Salles[37] revealed that cleaner dentin walls, as a result of removing the smear layer, allow better adhesion of the filling cement to dentin tubules, which results in a better sealing.

As for Spängberg,[38] since the oral cavity is home for a wide variety of pathogenic microorganisms, the filling material must have physicochemical properties that favor permanent and effective root canal sealing, and, as a consequence, protects the apical and periapical tissues against microbial contamination and further infection and inflammation.

Some authors[39,40,41] lay the responsibility of unsuccessful endodontic therapy to incomplete or inappropriate root canal filling.

With a view to increasing adhesion of filling material to root canal system walls, endodontic cements have also been used.[42]

Whenever thermoplastic filling is carried out, we consciously decrease the amount of cement.[43] Nevertheless, the thin pellicle layer of cement must be well adhered to the dentin walls and, if possible, must have entered into the dentin tubules.[44] According to Schilder[45] as well as Sen, Piskin and Baran,[42] the filling cement is the fragile portion of filling procedures; however, it plays an important role in controlling apical percolation as it flows through root

canal furcations and, as a result, provides the irregularities of the dentin-filling material interface with better sealing.

The literature describes that there is a tendency for future cementing material to adhere to dentin tubules, fuse with organic and inorganic dentin, destroy or neutralize microorganisms as well as their by-products, induce cementum neoformation and strengthen the root canal system. However, it is worth noting that, from this point of view, the endodontic cements used nowadays are considered inappropriate.[46]

We believe that the main canal must be well prepared and the root canal system must be properly and effectively filled. Based on that, the objective of this study is to demonstrate the possibility and importance of filling different types of accessory canals of different teeth. We report 11 cases in which different accessory canals at different locations were filled with 1% sodium hypochlorite and 17% trisodium EDTA irrigation, as well as three types of endodontic cement that, all together, favored tridimensional and hermetic sealing of the root canal system.

Methods and case report

This study comprises a sample of endodontic cases selected to demonstrate the possibility and need for tridimensional and hermetic filling of the root canal system. Biomechanical preparation and filling techniques were the same, whereas the endodontic cement varied for all cases.

Root canals were accessed by coronal portion. Tooth length was determined by odontometry. Working length was established at 1 mm below the radiographic root apex. Root canals underwent instrumentation carried out by means of the crown-down technique. After instrumentation, a FlexoFile file #15 (Dentsply Indústria e Comercio Ltda, Petrópolis/RJ - Brazil) was inserted into the apical foramen with a view to cleaning the cemental canal. Irrigating solution with 1% sodium hypochlorite (ASFER Indústria Química Ltda, São Caetano do Sul/SP - Brazil) was used as an additional instrumentation agent during root canal biomechanical preparation. After biomechanical preparation, root canals were dried with absorbent paper points (Dentsply) and filled with 17% trisodium EDTA (Biodinâmica Quim. e Farm. Ltda, Ibiporã/PR - Brazil) for 3 minutes, with mechanical agitation to remove the smear layer.[47] A last irrigation procedure was carried out with saline solution (Eurofarma Laboratórios Ltda, São Paulo/SP - Brazil), after which root canals were dried with absorbent paper points and filled with intracanal dressing. Before final root canal filling, intracanal dressing was removed and the protocol with EDTA was repeated.

Root canal filling was performed by means of the Tagger's hybrid technique (first introduced in 1984). This technique associates active lateral condensation of the apical third to McSpadden thermo-mechanical compaction in the cervical and middle thirds, with vertical condensation carried out by Paivaconductors (GolgranIndústria e Comércio de Instrumentos Odotológicos, São Paulo/SP - Brazil). The aforementioned procedures allow sealing of the root canal system to be performed as best as possible, The following filling cements were used: zinc oxide (Biodinâmica Quim. e Farm. Ltda, Ibiporã/PR - Brazil) (Fig 1), Endométhasone (Septodont, France) (Fig 2) and Sealapex (SybronEndo [SBS] Glendora, USA) associated with iodoform (Quimidrol Com. Ind. Imp. Ltda) (Fig 3). After the filling procedure, all teeth were radiographed. Radiographic exams revealed main canal and its furcations completely filled with filling cement.

Discussion

The literature does not reach a consensus regarding the need for routine filling of lateral and accessory canals. In spite of that, detailed knowledge of the inner anatomical shape of root canal systems, as well as of instrumentation, irrigation and filling techniques, in addition to the use of biologically compatible material are key to the success of endodontic treatment. With regard to the inner anatomical shape of root canal systems, several researches[48-51] have highlighted the high incidence of furcations in the main canal. De Deus[10] observed that 27.4% of the teeth studied had some type of furcation which were generally found in the apical region of the root.

According to Hatton et al,[52] furcations of the main canal do not usually affect bone repair after treatment. Conversely, the study by Nicholls[53] reveals that periapical lesions of the main canal occurred in 4.4% of teeth studied. The cases report herein corroborate the study by Nicholls,[53] since periapical tissue repair was observed in cases presenting periapical lesion (Figs 1A, 2A, 2B, 2D, 3A, 3C, 3D).

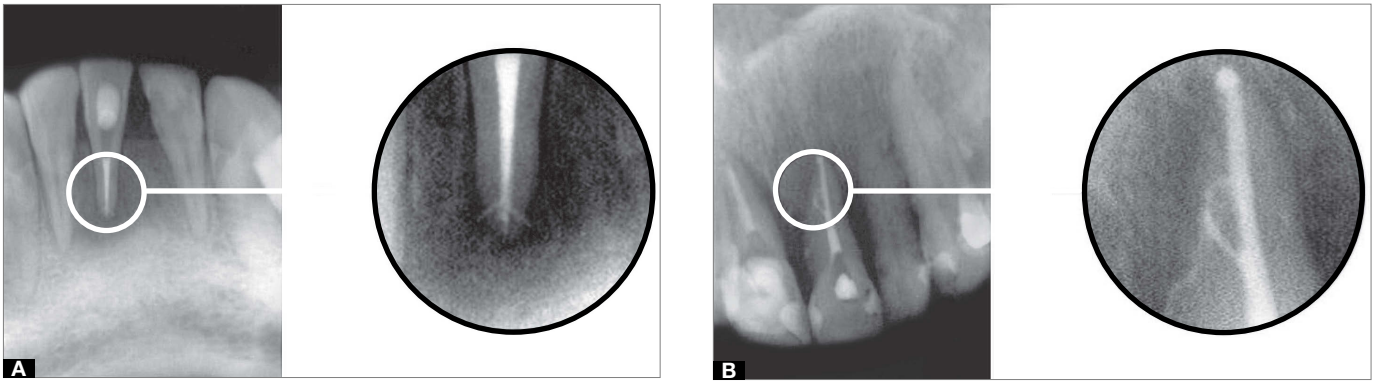

Figure 1. A) Main canal (the most important and complex root canal, it goes through the long tooth axis and may directly reach the root apex) and apical delta filling (multiple furcations of the main canal in the apical region, they originate multiple foramina that replace the main foramen) with zinc oxide filling cement and Eugenol. **B**) Main canal and recurrent canal filling carried out with zinc oxide filling cement and Eugenol. The recurrent canal originates in the main canal, follows a long trajectory in the dentin and returns to the main canal before reaching the root apex).

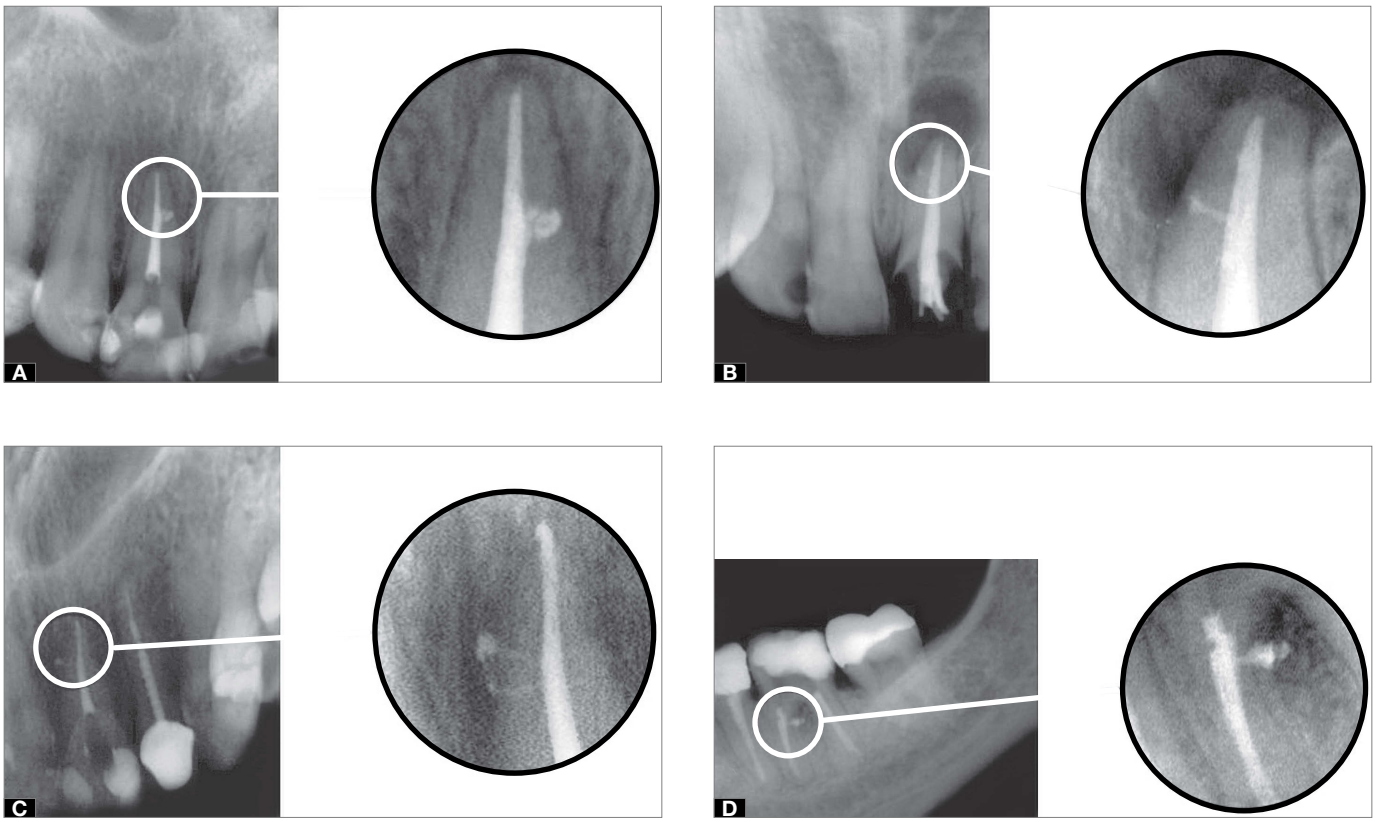

Figure 2. A) Main canal and lateral canal filling carried out with Endométhasone filling cement. The lateral canal originates in the main canal and reaches the outer surface of the root in its cervical or middle thirds). **B**) Main canal and secondary canal filling carried out with Endométhasone filling cement. The secondary canal originates in the apical portion of the main canal and directly reaches the outer surface of the root). **C**) Main canal and secondary canal filling with Endométhasone filling cement. **D**) Main canal and lateral canal filling with Endométhasone filling cement.

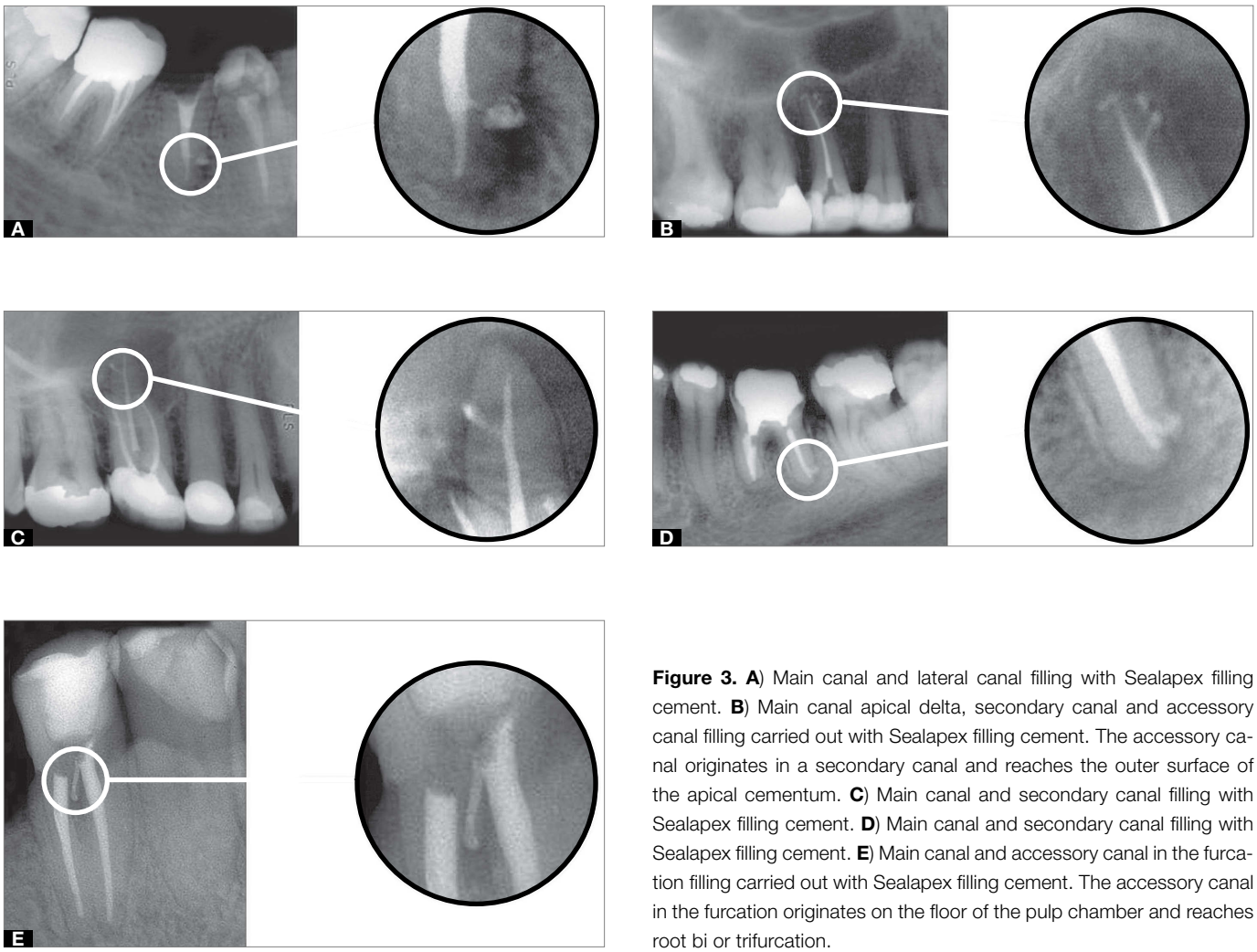

Figure 3. A) Main canal and lateral canal filling with Sealapex filling cement. **B**) Main canal apical delta, secondary canal and accessory canal filling carried out with Sealapex filling cement. The accessory canal originates in a secondary canal and reaches the outer surface of the apical cementum. **C**) Main canal and secondary canal filling with Sealapex filling cement. **D**) Main canal and secondary canal filling with Sealapex filling cement. **E**) Main canal and accessory canal in the furcation filling carried out with Sealapex filling cement. The accessory canal in the furcation originates on the floor of the pulp chamber and reaches root bi or trifurcation.

Wada et al[54] conducted a study in which 70% of cases had apical furcations of the main canal. They also observed the impossibility of mechanically accessing these furcations, highlighting the need for performing a few procedures that allow the intracanal dressing to effectively act and ease the flow of filling material throughout the entire root canal system. Studies by Goldman et al[55] reveal that, after instrumentation, root canal walls are covered by a residual layer known as smear layer. It consists of organic and inorganic matter and hinders intracanal medication and filling material penetration inside the dentin tubules and small furcations of the main canal. De Deus et al[56] concluded that the smear layer negatively affects the penetration capacity of endodontic cement inside dentin tubules.

EDTA has proved more effective[26,27] than 2.5% sodium hypochlorite in removing smear layer as well as cleaning dentin tubules and the opening of accessory canals. The study by Holland et al[36] demonstrates that radiographic exams of filled root canals of teeth with lateral and apical furcations reveal the presence of filling cement in 90% of cases when, before performing the filling procedure, EDTA was applied for 3 minutes inside the root canal. On the other hand, the presence of filling cement occurred in 35% of

cases in which EDTA was not used. In the present study, irrigation with sodium hypochlorite associated with EDTA applied for 3 minutes increased the activity of filling cement in a higher number of cases as well as in accessory canals after the filling procedure, thus corroborating Holland et al.[36]

Tam and Yu[50] assert that failure to seal accessory canal openings may lead to unsuccessful treatment results. Guimarães et al[58] concluded that drainage of endodontic cement is responsible for closely fitting the material to the irregularities of the root canal walls, an essential factor that favors hermetic filling.

With a view to enhancing the properties of filling cements, some authors[36,59,60] increased/decreased its ratio or added new substances. In the present study, root canals were filled with three different types of cement — Zinc oxide, Eugenol and Endométhasone — which had the following physical and chemical properties: drainage; working/setting time; and widely studied solubility and radiopacity in accordance with ISO-DIS 6876.2 (re-edition of ADA n° 57). Sealapex cement, however, was criticized with regard to some of its physical and chemical properties, including lower radiopacity in comparison to what is required by ADA n° 57. For this reason, iodoform was added to its original formulation.[61] In the cases reported herein, Sealapex cement was associated with iodoform so as to achieve higher radiopacity, as suggested by Holland et al.[36]

Today, however, such association is no longer necessary, given that the original formulation of Sealapex cement was modified with barium sulfate replaced by bismuth trioxide. According to Guimarães et al,[58] drainage of Sealapex cement is nearly null, for this reason, this type of cement hardly enters into accessory canals. Nevertheless, Holland and Murata[62] filled root canals of extracted human teeth with natural apical and artificial lateral furcations. Their study revealed that after filling performed by means of lateral condensation, the cement drained into the furcations of all specimens. The aforementioned data explain the results yielded in the present study, since the cases presented herein demonstrate that even though Sealapex cement has lower drainage properties in comparison to other types of cement, it has ideal consistency when properly proportioned and applied, which allows it to enter into the root canal system.

Finally, root canal system filling also depends on the appropriate use of the technique which eliminates the empty gaps of the main canal and, as a result, favors cement drainage. We have produced successful results by initially performing lateral condensation of the apical third, followed by thermoplastification of gutta-percha cones carried out by means of McSpadden condensers. Nevertheless, it is worth noting that using demineralizing substances, good drainage cement and good filling technique significantly increase the chances of performing successful filling procedures; however, they do not assure success in 100% of cases.[36]

Conclusion

Based on the results of this study it is reasonable to conclude that:

- Detailed knowledge of the inner anatomical shape of root canal systems is essential for clinicians who aim at performing successful endodontic treatment.
- The main canal and its furcations may be effectively filled after decalcifying solutions are applied (EDTA).
- The physical, chemical and biological properties of filling cements must be considered when carefully choosing and correctly applying them.
- The filling technique of choice has to provide hermetic sealing of the main root canal. The latter has to allow filling cement to drain to the root canal system during lateral and vertical condensation associated with Tagger filling technique.

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Restorative perspective for endodontically treated teeth: Anatomic post

Maria Geovânia **FERREIRA**[1]
Myrane Cruvinel Nascimento **CAMAPUM**[2]
Guido Cirilo **FERREIRA**[1]
Marcus Vinícius **PERILLO**[1]
Paula de Carvalho **CARDOSO**[3]
Julio Almeida **SILVA**[4]

ABSTRACT

Introduction: Individualized anatomic posts favor adaptation of prefabricated posts to root canal walls and reduce resin cement thickness. **Objective:** The aim of this study was to report a case of reconstruction of previously endodontically treated teeth by means of an individualized anatomic post. **Methods:** Replacement of endodontically treated central incisor restorations and previous deficient restorations was reported. Initially, deficient resin composites and the individual cast post of tooth #11 were removed. Root canal was endodontically retreated. The amount of residual dentine walls of the root canal were low after removing the endodontic post. Treatment plan included the use of an anatomic post for tooth #11. Composite resin was applied after anatomic post placement. Root canal was shaped by a glass fiber post and composite resin. Subsequently, crown restoration was completed with composite resin. **Conclusion:** The technique used to manufacture direct anatomic posts seem to be a good alternative treatment for restoring wide root canals.

Keywords: Nonvital teeth. Posts. Cores. Dental esthetics.

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[1]Professor, Postgraduate program in Cosmetic Dentistry, Brazilian Dental Association (ABO) – Goiás.

[2]Undergraduate student, Postgraduate program in Cosmetic Dentistry, Brazilian Dental Association (ABO) — Goiás.

[3]PhD in Cosmetic Dentistry, Federal University of Santa Catarina (UFSC). Professor, Postgraduate program in Cosmetic Dentistry, Brazilian Dental Association (ABO) — Goiás.

[4]Phd in Health Sciences, Federal University of Goiás (UFG).

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Contact address: Julio Almeida Silva
Avenida Portugal, 138 – Apt. 701 – Ed. Antares – Setor Oeste
Goiânia/GO – Brazil — CEP: 74.140-020
E-mail: juliojas@gmail.com

Introduction

Endodontically treated teeth often have little coronal tissue remaining and as such require a post to retain core and restoration.[1] It is a common belief that the likelihood of survival of a pulpless tooth is directly related to the quantity and quality of remaining tooth structure. For many years, the idea of using a post for restoration of endodontically treated teeth was based upon the philosophy that the post would "reinforce" the tooth, and that additional retention was needed for core restoration. A post was generally placed in the attempt to strengthen the tooth. However, as dentin has to be sacrified, especially when a metal post is used, a post does not strengthen the root, but serves solely to improve retention of the core.[2-6]

The amount of remaining tooth structure necessary to warrant post insertion, or a decision to use other methods is not clearly defined.[1] In cases of teeth with a high degree of destruction where no cavity wall remains, inserting a post proves necessary to provide core material retention.

The cavity wall must be at least 1-mm thick to ensure resistance to functional loads of the crown-root complex. Hard tissue thicknesses below 1 mm cannot be subjected to crown preparation without loss of all remaining substances. Thickness greater than 1 mm provides sufficient amount of hard tissue to stabilize the core material even after crown preparation. Therefore, cavity wall less than 1mm thick cannot be taken into consideration.[4]

Additionally, the ferrule effect also influences resistance to fracture, especially in decoronated teeth. The cavity wall must be at least 2 mm to provide sufficient ferrule effect.[4,5,6] Isidor et al[6] assert that selection of post length depends on many criteria. It has been proved that post length is less important for fracture resistance than the ferrule effect. Adhesive fixation is preferable, as it produces higher fracture resistance in comparison to cemented post and cores, in addition to offering higher fracture resistance.[1]

Duret et al[7] described a non-metallic material for the fabrication of posts based on the carbon-fiber reinforcement principle. Laboratory-based studies have shown that these posts have high tensile strength[8] and modulus of elasticity similar to dentine. Previously, rigid metal posts resisted lateral forces without distortion and this resulted in stress transfer to the less rigid dentine, thereby causing potential root cracking and fracture. It is thought that fiber-posts flex under load and as a result distribute stresses between the post and the dentine.

Recent articles support the use of fiber posts to restore endodontically treated teeth.[9,10,11] Fiber-reinforced posts have demonstrated the ability to fracture at the coronal portion of a tooth restoration with the presence of catastrophic forces without fear of root fracture.[12] This may be the single most compelling reason for their use.

However, the mismatch between fiber post and post space diameters remains a clinical challenge.[13] Although the use of size-matched drills supplied by post manufacturers permits good fitting of posts to the canal walls, some canals have an elliptical shape in cross-section while posts have a circular shape.[14]

In some cases, if the post does not fit well, especially at the coronal level, the resin cement layer is excessively thick, and bubbles are likely to form, thus predisposing it to debonding.[15] The solution to overcome this problem is to reline the fiber post with composite resin.[16] This individual anatomic post favors the adaptation of the post to root walls and reduces resin cement thickness.[15]

The procedure of "individualizing" the post through resin layer, although advisable in all cases, appears to be particularly effective to improve post retention when dealing with canals of elliptic shape, or exhibiting a reduced amount of residual root structure after endodontic treatment. This latter situation obviously contraindicates further removal of dentin to make the canal shape match the post shape.[17,18] The creation of an anatomic post, i.e., shaping the post to root anatomy instead of vice versa, is the procedure of choice in these clinical situations of which the described case is an example.

The aim of this study was report a case of reconstruction of endodontically treated teeth by using posts and cores based on a literature review.

Case report

In 2013, a 13-year-old patient fell down while playing at school. Trauma led to a complicated crown fracture with extensive pulp exposure on tooth #11 and enamel-dentin fracture without pulp exposure on tooth #21.

On that occasion, endodontic treatment was performed followed by post placement on tooth #11. Tooth #21 was restored with composite resin (Fig 1).

Six years later, clinical and radiographic examination revealed deficient endodontic treatment. Additionally, the direct composite restorations on tooth #11 and #21 were found stained. Radiographic examination showed the presence of inadequate root canal filling and a short individual post (with the presence of a suggestive image of empty space between the post and the root canal walls, which impairs adhesion and favors coronal leakage and darkening of the tooth) (Fig 2). The clinician decided to endodontically retreat teeth #11 and to restore #11 and #21 with composite resin until prosthetic treatment could be performed.

Initially, deficient resin composites (Fig 3) and the individual cast post were removed from the root canal of tooth #11 by means of a spherical diamond tip #1011HL (KG Sorensen, Brazil) and ultrasonic inserts (EN3, Gnatus, Brazil) (Fig 4). Figure 4 shows the cast post removed. Subsequently, the root canal was endodontically retreated. After post removal and endodontic retreatment, root canal anatomy did not allow the prefabricated post to satisfactorily adapt. The amount of residual dentin on the canal walls was so little that further tissue removal to make the canal shape adapt to that of the post was contraindicated. For this reason, the clinician decided to use an anatomic post for tooth #11 – that is, shaping a pre-fabricated fiber post with composite resin according to the dimensions of the root canal.

The first steps of retreatment were preparation of the coronal third and the middle/apical third of the root canal. Gates-Glidden drills, K-files and Hedstroen-files (Dentsply/Maillefer, Switzerland) were used to remove root canal filling (Fig 5). During operation, debris were periodically removed through constant irrigation with 1% sodium hypochlorite.

Figure 1. Preoperative smile photograph shows deficient and stained direct composite restoration in the maxillary left central incisor.

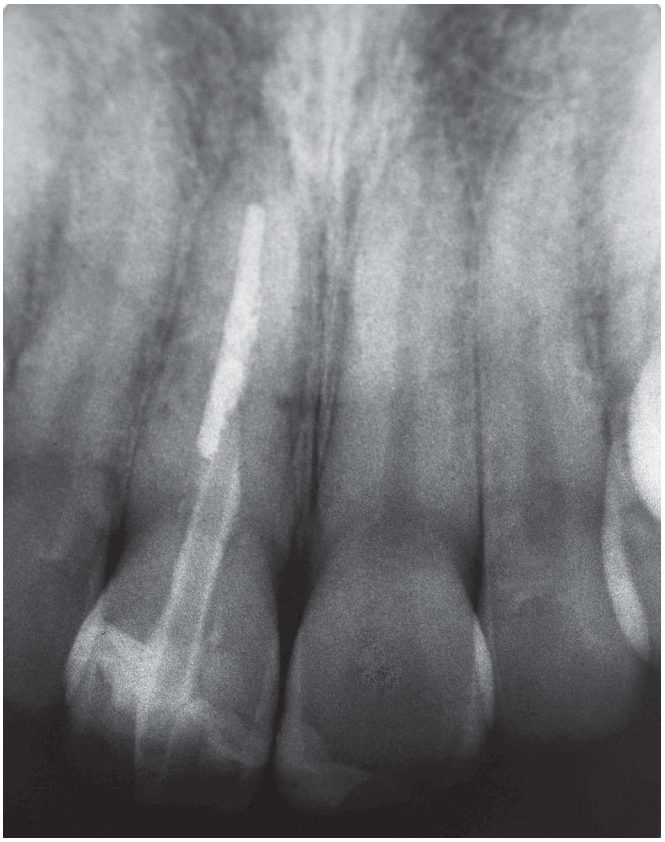


Figure 2. Periapical radiograph shows inadequate root canal filling and a short individual post. The core demanded further prosthetic restorations.

Figure 3. Facial and palatal view after removal of the deficient direct composite restoration on teeth #11 and 21.

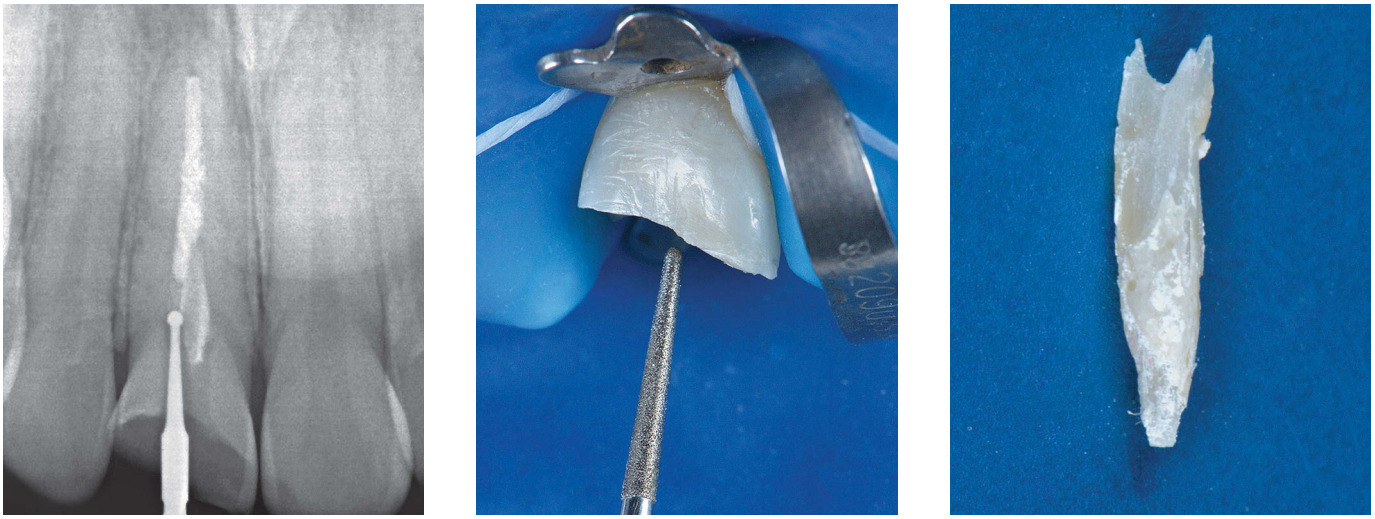
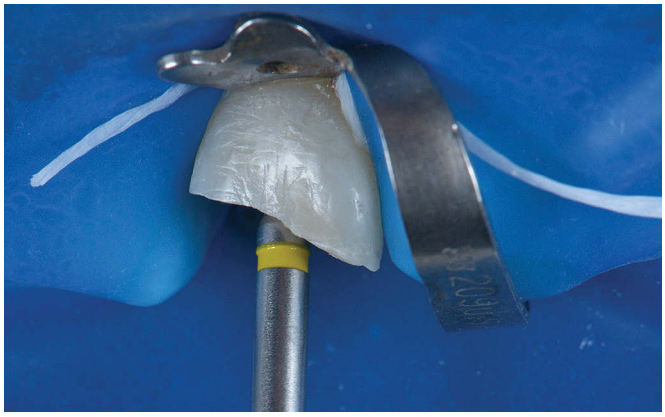
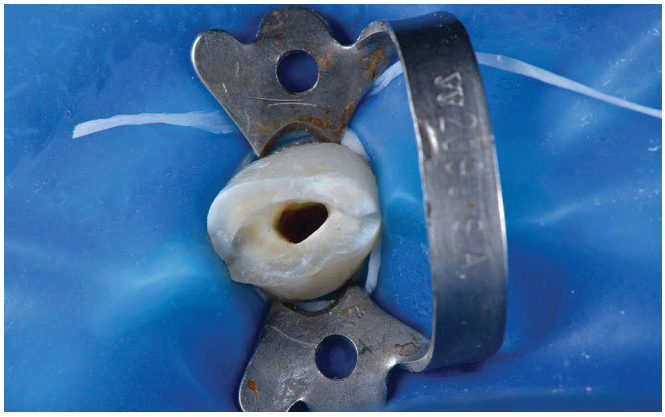


Figure 4. Periapical radiograph and clinical procedure shows removal of the individual cast post from the root canal using a spherical diamond tip and ultrasonic inserts.

After complete removal of gutta-percha, working lengths were determined by applying an electronic apex locator (ProPex II, Dentsply/Maillefer, Switzerland). Cleaning and shaping of the root canal were performed up to K-files #80 with copious irrigation. Calcium hydroxide was kept as intracanal medication for 21 days. Then, root canal filling was performed by means of cold lateral compaction technique (Fig 6).

Control radiography was performed immediately after endodontic retreatment, revealing homogeneity with apical filling levels corresponding to the electronically determined working lengths. Space for installation of a new post was prepared immediately after root canal filling. Gates-Glidden and Largo drills were used to remove gutta-percha from the cervical and middle thirds of the root canal. Figure 7 shows absence of adaptation of the





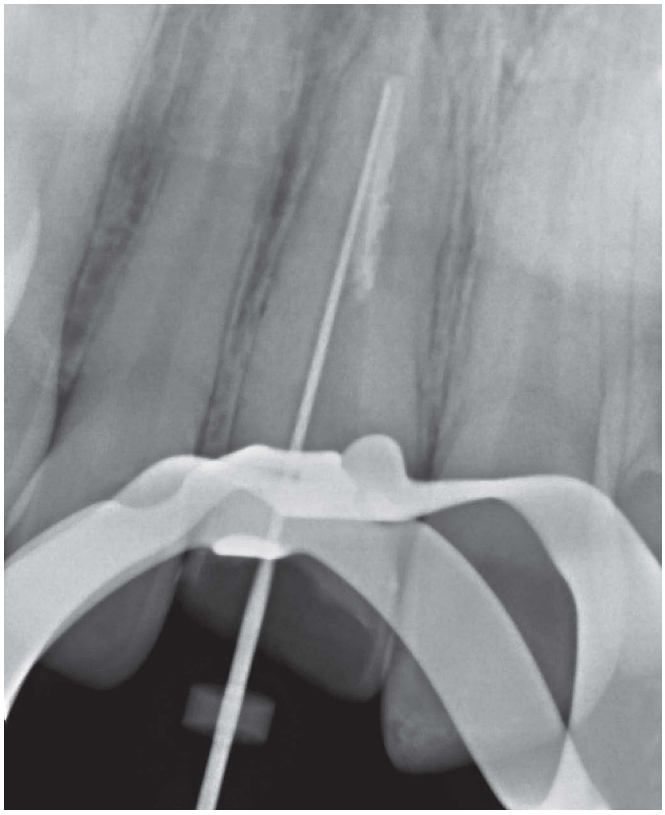


Figure 5. Clinical aspect and periapical radiography showing root canal filling removal.

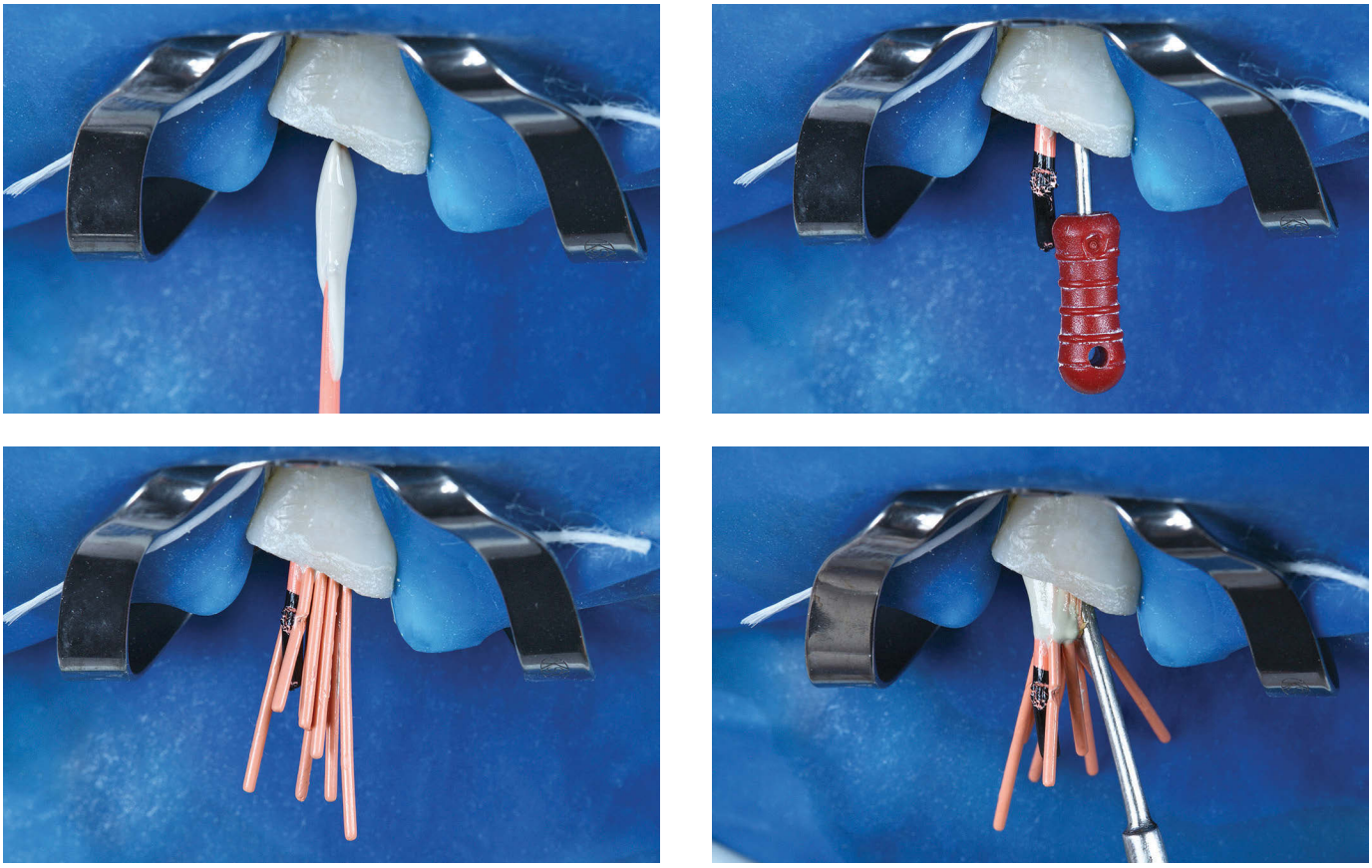


Figure 6. Facial view of endodontic retreatment.

prefabricated post in the radicular canal, indicating the use of an anatomic post.

The pre-fabricated post was immersed in 24% H_2O_2 at room temperature for 1 minute and then rinsed with distilled water and air-dried. A single layer of silane coupling agent was applied to the post surface and gently air-dried after 60 seconds. The adhesive (Scotchbond Multiuse Plus, 3M ESPE, USA) was applied over the post surface and light-cured for 20 seconds. Light activation was performed using a halogen lamp (VIP Jr; Bisco Inc, Schaumburg, IL) with 600-mW/cm2 irradiance (Fig 7).

The direct anatomic post was shaped using the method described by Grandini et al.[17] After lubrication of the canal walls with glycerin gel (Fig 8), the fiber post (Reforpost, Angelus, Brazil) was covered with composite resin (Tetric Ceram, Ivoclar Vivadent, Liechtenstein) and inserted into the canal (Fig 8). The composite resin was initially photoactivated for 10 s. Subsequently, the post-composite set was removed from the canal and fully photoactivated for other 60 s (Fig 8).

The anatomic post was rinsed with distilled water and air-dried. A single layer of silane coupling agent was applied to the post surfaces and gently air-dried after 60 s (Fig 9). Root dentin surfaces were irrigated with 10 ml of irrigant NaOCl for 60 s and with 10 ml of physiologic saline for 60 s.

RelyX U200 (3M ESPE, USA), a self-adhesive resin cement, was used for luting. The catalyst and base componentes of the material were mixed and applied in accordance with manufacturer's instructions. The resin cement was placed into the

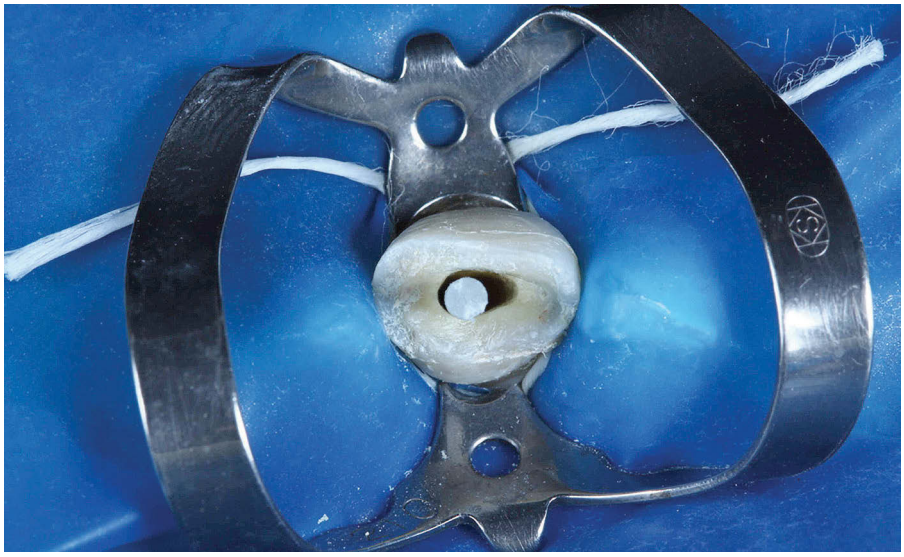


Figure 7. Selection and surface treatment of post.

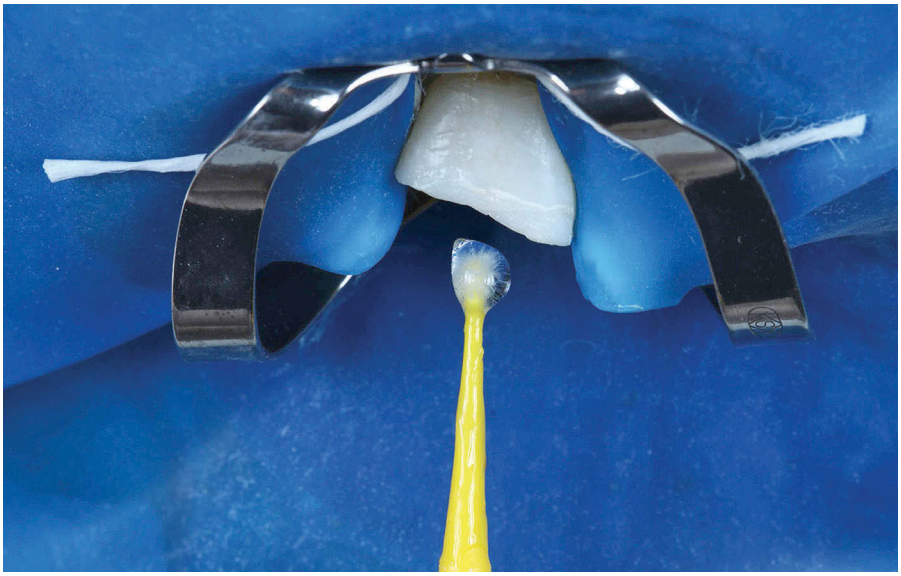
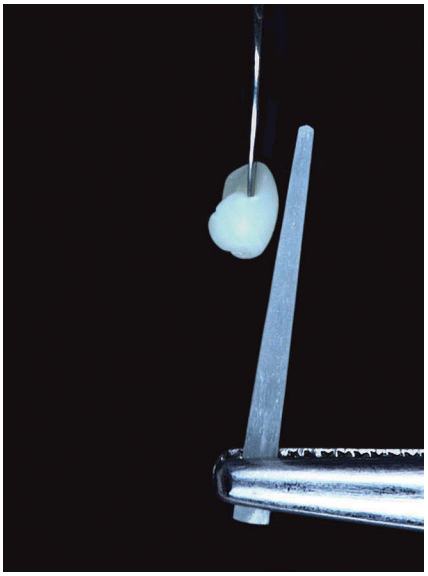
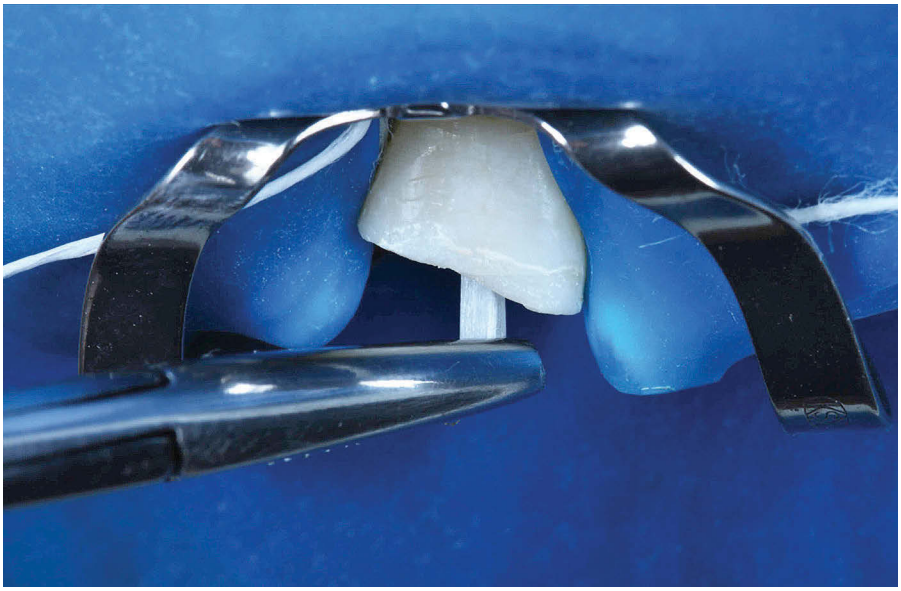
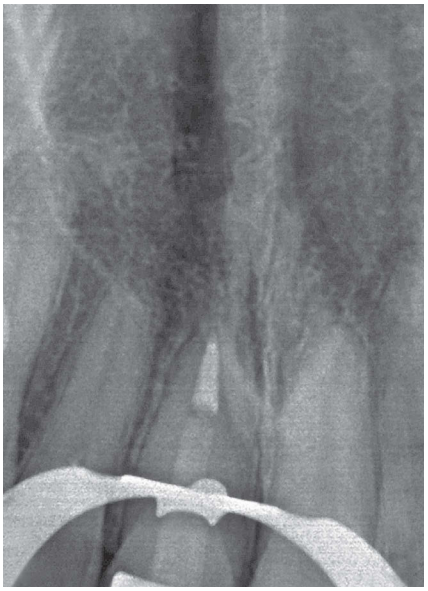





Figure 8. Build of the anatomic post and test.

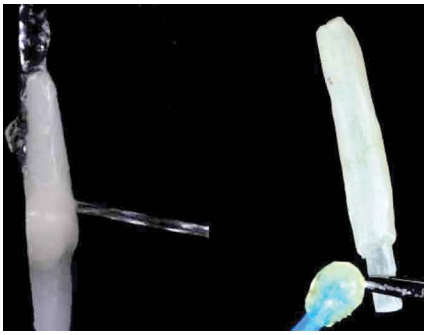
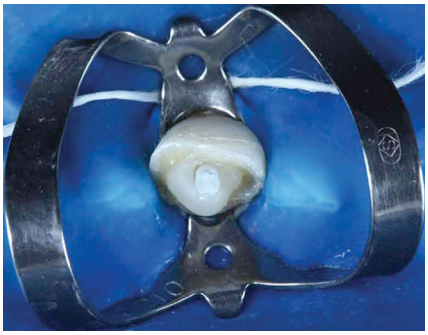




Figure 9. Surface treatment and cementation of anatomic post.

Figure 10. Postoperative photograph.

root canal space, the post was seated and excess material was removed before light-curing for 40 s. Due to patient's young age, the clinician devided to postpone preparation for a prosthetic crown. The anatomic post was therefore simply used as a base for direct composite restoration. The prepared tooth was etched with 37% phosphoric acid (Bisco, USA) applied as recommended by the manufacturer. Restoration was completed with resin composite (Empress Direct, Ivoclar Vivadent, Liechtenstein) (Fig 9). Periapical radiography shows the final outcomes (Fig 9) and postoperative photographs show beautiful and functional results (Fig 10).

Discussion

The ferrule effect greatly influences fracture resistance, especially in decoronated teeth. A ferrule, defined as a circumferential area of axial dentin superior to the preparation bevel, should have a height of 1.5 to 2.5 mm.[13,19,20] Various *in vitro* studies have shown that fracture resistance can be significantly increased by the use of a ferrule; post length or design (either parallel-sided or tapered) are of secondary importance for fracture resistance if a sufficient ferrule can be provided.[13,19,20]

Should deep destruction of teeth render sufficient ferrule impossible, surgical crown lengthening can be performed. This procedure can provide a crown ferrule which results in reduction of static load failure.[20] Bolhuis et al[21] asserts that crown ferrule is more important than a post and core, or a core reconstruction with adhesive filling, only.

The type of fixation used for post also influences its required length. Nissan et al[22] showed that adhesive fixation can compensate for reduced retention due to the use of shorter parallel-sided or tapered posts. Testori et al[23] demonstrated that there is no significant difference in the retention of adhesive fixed posts measuring 5 mm or 8 mm. These results, however, are less reliable because they were ascertained with a very limited number of samples.

Other studies[24,25] assessed remaining root filling after post-space preparation, especially with respect to leakage. They showed that leakage increases with post-space preparation, and a remaining apical filling of less than 3 mm results in unpredictable seal.

Based on some results,[26,27] lower concentration (24%) of H_2O_2 used for only 1 minute are preferable in clinical use. The use of peroxide over the fiber post increased bond strengths. The deleterious effect of peroxide was probably not observed due to the absence of residual oxygen into the post structure. Another important observation was the absence of cohesive failures within the resin composite during microtensile tests. The high flow of resin used in this study probably allowed close contact between the resin and the post, reducing the presence of voids.[28]

Polymerization shrinkage and associated stresses (the C-factor and S-factor) are a major consideration in all bonding/restorative procedures. In this case, C-factor is not higher than it is in post cementation[29] because of the high number of surfaces involved. Even though composite resin core material generally have more filler and, therefore, higher strength than resin cements, polymerization shrinkage stress is higher with 70% filler than that with 10% filler.[30] This may seem counterintuitive to most dentists, but the objective is to employ a technique that compensates for the inherent deficiencies of some types of material and capitalizes on them without becoming clinically cumbersome, time-consuming, or with the integration of outside laboratory fees.

In an earnest attempt to address these factors, Grande et al[31] and Plotino et al[18] described chairside techniques for adapting prefabricated fiber posts to ribbon-like, oval, or ovoid canal spaces by remodeling them. Their results suggest that the volume of cement is minimized, and the retentive surfaces of the post are not compromised.

In order to reduce resin cement layer thickness and its disadvantages, Boudrias et al[32] described the use of an anatomic post. Clavijo et al[33] suggested that anatomic posts seem to be a good alternative for restoring flared root canals. In this technique, the fiber post is reshaped to fit the root canal using composite resin. The enhanced mechanical properties compared to resin cements leads to fracture strength values similar to those of cast metal post-and-core. The technique for fabrication of direct anatomic posts is relatively easy. In addition, by adding only a few more steps to those required to lute a conventional fiber post, it is possible to achieve better fitting quality. Moreover, thickness of the cement layer, in which voids and bubbles are likely to develop, can be minimized.[11,12]

Conclusion

Direct anatomic post technique is relatively easy. It indicates that anatomic posts are a good alternative for restoring flared root canals. In addition, by adding only a few more steps to those required to lute a conventional fiber post, it is possible to achieve better fitting quality.

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Detection of vertical root fractures: An investigation on the impact of using orthogonal and dissociated radiographs in conventional and digital systems

Lisangela da **SILVA**[1]
Priscila Fernanda da **SILVEIRA**[2]
Mariana Boessio **VIZZOTTO**[3]
Gabriela Salatino **LIEDKE**[2]
Heraldo Luis Dias da **SILVEIRA**[4]
Heloísa Emília Dias da **SILVEIRA**[5]

ABSTRACT

Introduction: Intraoral radiographs are an important investigative aid in the detection of endodontic injuries, including vertical root fractures (VRF). **Objective:** The objective of this study was to assess the capacity of orthogonal and angulated conventional as well as digital radiographs to detect VRF in teeth under different root conditions. **Methods:** Sixty teeth were divided into three groups according to the canal condition: non-filled, filled with gutta-percha and filled with gutta-percha and metallic post. Ten teeth in each group were artificially fractured, whereas teeth in the control group were not fractured. Orthogonal and horizontally angulated conventional film (Kodak) and digital phosphor plate (VistaScan Dürr Dental) were used. Three blinded and calibrated observers carried out evaluations at four different time intervals. Modal values were used to calculate sensibility, specificity and accuracy. The area under the ROC curve (aucROC) and confidence intervals (CI) was used to compare the performance between radiographic systems, as well as the influence of combined angulated images. **Results:** Angulated radiographs showed larger aucROC for both conventional and digital images. CI revealed statistically significant differences between conventional orthogonal and digital angulated radiographs (CI: 0.403 – 0.697 and 0.767 – 0.967, respectively). Moreover, when only orthogonal incidences were considered, digital radiographs yielded better results than the conventional ones (CI: 0.403 – 0.697 and 0.622 – 0.878, respectively). **Conclusion:** The strong inclination towards yielding better diagnostic test results provided by digital radiographs suggests that the digital system using angulated projections is more appropriate to investigate VRF than the conventional one.

Keywords: Diagnosis. Endodontics. Dental radiography.

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[1]Degree in Dentistry, Federal University of Rio Grande do Sul (UFRGS).
[2]Doctorate student of Clinical Dentistry, Radiology, UFRGS.
[3]Adjunct professor of Radiology, UFRGS.
[4]Adjunct professor of Radiology, UFRGS.
[5]Associate professor of Oral Radiology, UFRGS.

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Contact address: Gabriela Salatino Liedke
Rua Ramiro Barcelos, 2492/503 – CEP: 90035-003 – Porto Alegre/RS — Brazil
Email: gabiliedke@yahoo.com.br

Introduction

Intraoral radiographs are, in the majority of cases, the first investigative aid in the detection of endodontic injuries, including vertical root fractures (VRF).[1,4] In recent decades, digital radiography has replaced the conventional methods.[5] The digital system has some advantages over the conventional one, namely: ease of processing, storing and exchanging data information, as well as the possibility of image post-processing.[5,6] Regardless of the system, the technique plays an important role in precise diagnosis: radiographic imaging shows a radiolucent line when the central X-ray is directed parallel to the fracture line; therefore, it is recommended that different angles be adopted in order to increase the odds of detecting VRF.[7]

Correct diagnosis of VRF is based on clinical and radiographic findings. With regard to radiographic evaluation, the condition of the root canal (filled or non-filled), the system used for image acquisition (conventional or digital), as well as the number of radiographic images acquired are important and may interfere on the diagnosis. Therefore, this study compared the diagnostic accuracy of digital and conventional images using orthogonal and angulated radiographs to diagnose VRF in teeth under different root canal conditions.

Material and Methods

The Federal University of Rio Grande do Sul Institutional Review Board approved this research. Sixty human single-rooted extracted teeth were cut at the cement–enamel junction. The roots were placed in acrylic resin blocks so as to guarantee fragment stability after fracture. In order to simulate resilience of the periodontal ligament, a thin wax layer was used to cover the teeth. The teeth were randomized and divided into three groups (n = 20) according to the root canal condition: non-filled, endodontically filled with gutta-percha, and endodontically filled with gutta-percha and metallic post. Ten teeth of each group were fractured (test group) by means of a chisel positioned inside the root canal, whereas ten teeth were not fractured (control group). Visual inspection under magnification confirmed the presence or absence of VRF and established the gold standard.

Conventional and digital radiographs were obtained by means of an intraoral dental X-ray unit (Dabi Atlante, Spectro 70X — 127 kV, 7.5 mA and 50/60 Hz). Orthogonal (0°) and horizontal angulated (15° shift, mesial and distal) radiographs were taken, thus totalizing 360 images. Conventional radiographs were taken by means of D-Speed Intraoral dental films (0.4 s; Kodak, Rochester, NY, USA) processed in an automatic loader (DENT-X 9000, Elmsford, NY, USA), whereas digital radiographs were taken by means of VistaScan System phosphor plates (0.3 s; Dürr Dental, Bietigheim-Bissingen, Germany).

Conventional radiographs were inspected in a light box equipped with a dark-mask, in a subdued-lighted room. Digital radiographs were stored and viewed in the DBSWIN 5.3.0 software (Dürr Dental, Bietigheim-Bissingen, Germany) which includes some visualization tools and filters for image post-processing. Figure 1 shows the orthogonal and angulated radiographs of three fractured teeth under different root canal conditions.

Three calibrated examiners (Kappa Index ≥ 0.7) scored the imager for presence or absence of VRF by using a dichotomous scale. The process of analyzing the images was conducted in four steps with a 15-day interval in between: (I) conventional orthogonal radiographs; (II) digital orthogonal radiographs; (III) conventional orthogonal and angulated radiographs, and (IV) digital orthogonal and angulated radiographs. Sensitivity, specificity and accuracy assessments were carried out based on the modal value (the most prevalent score among the three examiners). The area under the ROC curve (aucROC) and the confidence interval (CI) was calculated for each condition and used to compare the performance of the radiographic systems as well as verify the effectiveness of angle variation.

Results

Sensitivity, specificity and accuracy values of each radiographic system and each group of root canal condition, together with the mean aucROC and CI values for each radiographic technique, are shown in Table 1. Combined images improved diagnostic accuracy, regardless of the root canal condition, in both conventional and digital systems. However, accuracy was even higher when teeth with non-filled canals were analyzed.

The analysis of the aucROC and respective CIs revealed that combined images yielded similar good results in both conventional and digital systems. Statistical difference was observed between conventional orthogonal radiographs (CI: 0.403–0.697) and

Table 1. Mean sensitivity, specificity and accuracy values for conventional and digital systems in each root canal condition; area under the ROC curve (aucROC) and confidence interval (CI).

	Conventional radiography						Digital radiography					
	Orthogonal			Angled			Orthogonal			Angled		
	NF	Fi	MP	NF	Fi	MP	NF	Fi	MP	NF	Fi	MP
Sensitivity	0.4	0.4	0.4	1	0.6	0.4	0.8	0.6	0.5	1	0.5	0.8
Specificity	0.5	0.7	0.9	0.9	0.9	1	0.9	0.8	1	1	0.9	1
Accuracy	0.45	0.55	0.65	0.95	0.75	0.7	0.85	0.7	0.75	1	0.7	0.9
aucROC (CI)	0.550 (0.403 – 0.697)			0.800 (0.682 – 0.918)			0.750 (0.622 – 0.878)			0.867 (0.767 – 0.967)		

NF = non-filled, Fi = filled with gutta-percha, MP = filled with gutta-percha and metallic post.

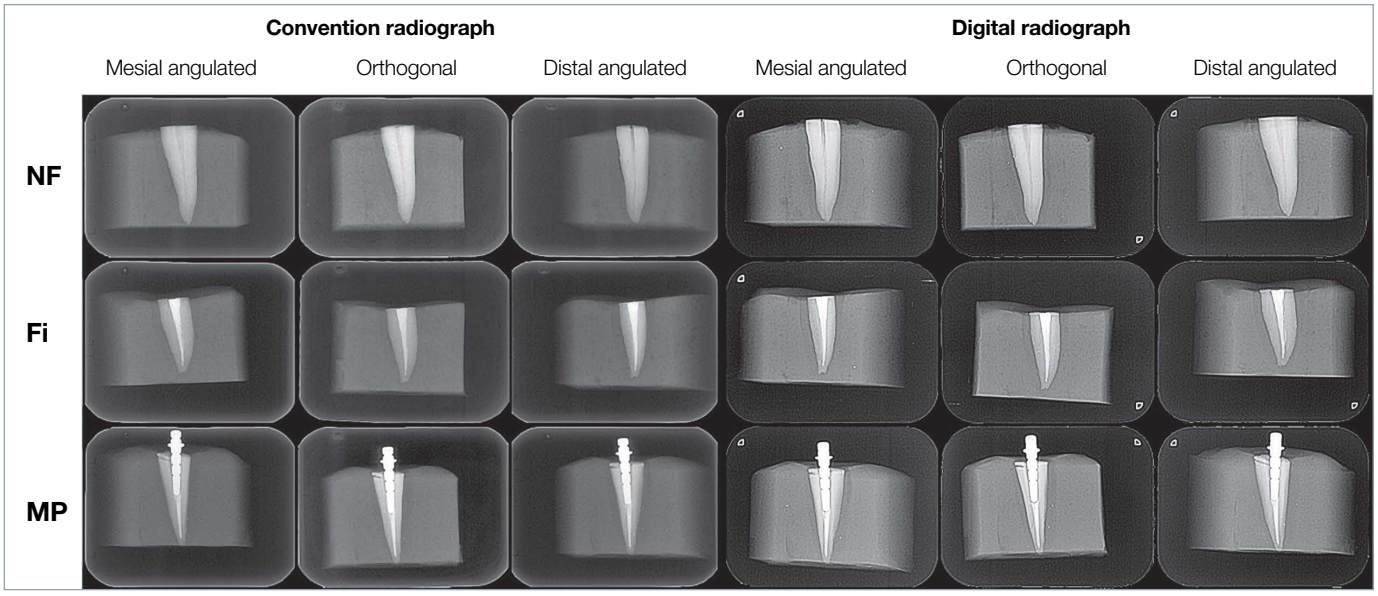

Figure 1. Conventional and digital radiography (orthogonal and angulated) of three teeth with VRF under different root canal conditions. NF = non-filled, Fi = filled with gutta-percha, MP = filled with gutta-percha and metallic post.

combined digital orthogonal and angulated radiographs (CI: 0.767–0.967). Moreover, a strong inclination towards better results produced by the digital images was observed when only orthogonal radiographs were analyzed (CI for conventional radiographs: 0.403–0.697; CI for digital radiographs: 0.622–0.878).

Discussion

This study assessed two radiographic systems used to detect VRF in teeth under different root canal conditions. Despite the limitation of *in vitro* studies, characterized by the impossibility of assessing the clinical conditions that help to achieve correct diagnosis, the methodology used herein aimed at reproducing the circumstances observed in clinical dental alveoli. Thus, the resilience of the periodontal ligament, the vertical fractures randomly oriented and the stability of tooth fragments were observed. Additionally, image assessment was performed in a stepwise sequence: first, orthogonal and then the combined images; thus reproducing what should be performed in daily practice. Therefore, the benefit of adding images could be estimated.

The literature cannot yet reach an agreement on the diagnostic ability of digital images in comparison to the conventional system among different tasks in Dentistry.[8-11] When post-processing tools for digital image processing are analyzed, some studies have suggested that the accuracy of digital systems for some diagnostic tasks may be improved.[9,12-14] This study showed higher values of specificity, sensitivity and accuracy when digital radiographs were used, although without statistic difference, regardless of the root canal condition. The best results produced by the digital system may be related to image post-processing, since the examiners were allowed to use the available tools as they wished. Nevertheless, other studies comparing digital and conventional images used to detect VRF found similar results.[15-17]

It is known that endodontic materials or metallic post may affect the correct diagnosis of VRF, since they may simulate or hide the fracture line.[17] Higher sensitivity was observed in teeth with non-filled root canals, which corroborates other studies.[18,19] Specificity was similar among the analyzed systems, regardless of the root canal condition. These facts suggest that, when in doubt, examiners tend to give a negative diagnosis, therefore increasing specificity values.

The values of aucROC and CI suggest that combined radiographs better diagnose VRF, regardless of the radiographic system. An *in vivo* study investigating the diagnosis of VRF found a mean sensitivity of 0.23 — a considerably low value.[20] For this reason, it is possible to deduce that this might have occurred because the authors used only one radiographic incidence for the diagnosis. In an attempt to increase the diagnostic capacity of intraoral images, other studies also performed three intraoral incidences.[15,17,18] Kambungton et al[15] compared the scores obtained with orthogonal and combined radiographs. However, in their study, all three images were viewed at the same time, what may have increased the accuracy for the orthogonal projection. The present study also compared the performance in assessing one or three images at a time, but with a stepwise approach, which is believed to be more consistent with what is supposed to happen in the dental clinic. Therefore, if a radiographic image does not show the fracture line, giving no conclusive diagnosis, a second one (mesially or distally angulated) should be carried out. Moreover, if the doubt persists, a third radiographic image must be taken from the opposite angle in order to fully explore the radiographic method.

In an attempt to overcome the drawbacks imposed by radiography, especially with regard to the overlapping of structures, the development of cone beam computed tomography (CBCT) substantially increased the request for tridimensional images, including cases of VRF diagnosis. Some *in vitro* studies reported better values of sensitivity for CBCT assessment of teeth with unfilled root canals,[15,18,21-23] which is rare in the case of gutta-percha or metallic post-filled teeth.[18,21] When specificity values are analyzed, the results among methods proved to be similar.[15,23] In addition to that, it is important to have in mind that as important as the diagnosis of the pathology per se, is how the other type of exam will change the treatment plan for the patient,[24,25] especially when there is a significant increase in the radiation dose received by this patient.[26,27] This attitude reinforces the radiographic indication for VRF searching and shows that the technique must not be limited to orthogonal radiography, thus revealing the importance of horizontally angulated incidences as a diagnostic tool. Furthermore, when digital and conventional systems are compared, the lower radiation dose obtained with the digital method should be seen as an important advantage.[28,29]

Conclusion

Digital radiograph using orthogonal and horizontally angulated projections proved to be suitable to diagnose VRF, given that it provides higher values of accuracy in comparison to the conventional system.

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Influence of menopause on endodontic treatment

João Eduardo **GOMES-FILHO**[1]
Christine Men **MARTINS**[2]
Gustavo **SIVIERI-ARAUJO**[3]
Ludmilla Mota da Silva **SANTOS**[2]
Índia Olinta de Azevedo **QUEIROZ**[3]
Marcelo Tadahiro **WAYAMA**[4]
Guilherme Hiroshi **YAMANARI**[5]
Eloi **DEZAN-JÚNIOR**[1]
Luciano Tavares Angelo **CINTRA**[6]

ABSTRACT

Menopause is one of the physiological changes characterized by the end of menstrual and ovulatory cycles occuring in women in their fourth and fifth decade of life. Thereat, production of estrogen, an important hormone that acts in many physiological process of the individual such as the regulation of skeletal system, decreases. The decline in estrogen levels results in loss of bone mineral density, increased fracture risk, as well as bone diseases such as osteoporosis, a pathological process in which there is increased resorption of cavities that are not completely filled by newly formed bone. Furthermore, estrogen deficiency can cause many changes in an individual's oral health. In the presence of bacterial infection of pulp tissue, this deficiency can aggravate apical periodontitis. Several drugs have been studied as potential therapeutic agents to compensate for deficiency of estrogen. These drugs aim to reduce the likelihood of fractures and prevent bone loss as well as cardiovascular and mental disorders resulting from postmenopausal hormone disabilities. Raloxifene (RLX) is one of the most studied drugs therapies and proves to prevent bone loss. Even though raloxifene is indicated for and produces benefits to bone metabolism and maintenance of bone density, additional studies are warranted to further investigate the role of raloxifene in endodontic infection of osteopenic organisms.

Keywords: Endodontics. Systemic diseases. Menopause.

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[1]Full professor in Endodontics, School of Dentistry — State University of São Paulo (UNESP) / Araçatuba.
[2]PhD resident in Dental Sciences, School of Dentistry — UNESP / Araçatuba.
[3]Postdoc in Endodontics, School of Dentistry — UNESP / Araçatuba.
[4]Masters student in Endodontics, School of Dentistry — UNESP / Araçatuba.
[5]MSc in Endodontics, University of Marília (UNIMAR).
[6]Postdoc in Endodontics, State University of Maringá (UEM).

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Contact address: João Eduardo Gomes-Filho
Faculdade de Odontologia de Araçatuba, UNESP-Araçatuba.
Rua José Bonifácio, 1193 – CEP: 16015-050 – Araçatuba/SP —Brazil
E-mail: joao@foa.unesp.br

Introduction

The growing number of older people has been increasingly evident and, for this reason, has raised health concern over this age group mainly due to physiological changes and increased susceptibility to diseases.

Menopause is one of the physiological changes that occur during women fourth and fifth decade. It characterizes the physiological end of menstruation[1] and decline in the level of estrogen, which results in loss of bone mineral density, increased fracture risk and bone diseases such as osteoporosis.[2]

Estrogen is key to the physiological processes of the individual, including cell growth and development, as well as regulation of reproductive, neuronal, immune, cardiovascular and skeletal systems.[3,4] Furthermore, estradiol plays an important role in inflammatory diseases, which can interfere in the proliferation of cytokines.[5,6]

Deficiency in estrogen level can affect ones body, including oral health.[7] Estrogen is capable of recruiting immune and skeletal cells modulating the progression of pathological tissue.[6,8]

Bacterial infection of pulp tissue can cause periapical lesion, in which case inflammatory cells are stimulated to produce factors that increase the activity of osteoclasts and, as a result, lead to alveolar bone resorption.[9] Since estrogen plays an important role in the process of alveolar resorption, its deficiency can aggravate apical periodontitis.[10]

Several drugs have been studied as potential therapeutic agents to compensate for estrogen deficiency. Among these, we highlight the selective estrogen receptor modulator (SERM). It is a class of non-hormonal molecules that, depending on the estrogen receptor that it binds to, may produce agonist or antagonist effects on estrogen in different target tissues.[11] Raloxifene hydrochloride (RLX), a second generation of SERM, mimics the beneficial effects of estrogen without stimulating breast and endometrium tissues.[12] SERM molecular mechanism of action involves high binding affinity with estrogen receptor, causing a conformational change in the structure of the receptor, as well as its dimerization and association with specific DNA response elements for RLX.[13] Studies reveal that raloxifene treatment results in increased bone mineral density, thereby significantly reducing the incidence of fractures.[14,15,16]

Osteoporosis

The increase in worldwide life expectancy is causing the proportion of elderly people to grow faster than any other age group.[17] The elderly have higher vulnerability and incidence of pathological processes, such as osteoporosis. These conditions affect quality of life and increased mortality, representing an important issue for the health of people in this age group.[18,19] In this context, there is great concern about the health of the elderly and prevention of diseases resulting from the aging process,[20] which leads to further studies that can improve the quality of life of these individuals.

The elderly presents several physiological changes that predispose them to pathological conditions typical of aging.[21] Osteoporosis is a pathological process resulting from the decline in estrogen that occurs in menopausal women.[22] These changes result in increased resorption cavities not completely filled by newly formed bone, causing bone density loss and thereby increasing the risk of fracture.[23,24]

Estrogen

Adult skeleton is maintained due to regeneration that occurs by the process of bone remodeling: the continuous process of resorption and bone formation.[25] Bone metabolism is regulated mainly by estrogen an essential hormone that acts on the cells involved in bone remodeling, such as osteocytes, osteoblasts and osteoclasts[26] which, in turn, can be influenced by systemic and local factors.[27]

Estrogen has beneficial effects on skeletal tissue, minimizing bone resorption and acting directly or indirectly on cells of bone metabolism. Estradiol can also act in the expression of osteoprotegerin (OPG) and as receptor activator of nuclear factor kappa-β ligand (RANKL). Furthermore, this hormone stimulates secretion of OPG and inhibits RANKL, thereby promoting bone formation.[28]

Osteoporosis X Periapical lesions

Bone changes caused by decreased production of estrogen may impair maxillary regions, specially the alveolar process, thereby resulting in the loss of bone in this region.[29] This is proved by some authors who suggest that lack of this hormone promotes intense resorption of the alveolar process in female rats.[8]

Therefore, the same signs and symptoms that occur in long bones as a result of decreased estrogen (fractures, pain and loss of function) may also affect maxillary bones, causing abscesses, mobility and tooth loss.[30]

Estrogen also acts in inflammatory sites, as it is the case of chronic inflammatory and degenerative diseases.[5] Estrogen deficiency may therefore influence periapical and periodontal disease, increasing the intensity of bone resorption.[10] These disease processes involve different cells such as osteoblasts and osteoclasts of which function determines the development of bone loss.[31] Periapical diseases do not involve bone cells only, but also include cytokines such as IL-1 and TNF-alpha, also observed in osteoporosis. Thus, the cellular and molecular mechanisms leading to bone loss are similar between inflammatory processes and osteoporosis.[32]

Periapical lesion is common in pulp inflammatory processes, necrosis and contamination. Bacterial growth reaches the root canal system, recruiting inflammatory cells, inducing cell bone metabolism and causing bone resorption in the periapical region.[33,34,35] Systemic factors such as osteoporosis may interact with local factors, (for instance, apical periodontitis) and aggravate bone loss.[36] Given that estrogen influences the process of bone resorption, deficiency of this hormone can worsen the condition of apical periodontitis.[10]

Osteoporosis and apical periodontitis are both involved with bone resorption; however, osteoporosis is not the primary cause of apical periodontitis, a systemic disease that can contribute to the progress of the lesion. Studies conducted with mice report that decreased concentration of estrogen aggravates alveolar bone resorption, which can be reduced with estrogen infusion.[37,38]

Hormone replacement therapies

Several therapies are available in the market to treat and prevent diseases arising as a result of menopause. Hormone replacement therapy with bisphosphonates, raloxifene and calcitonin is one example.[39] These drugs aim to reduce the risk of fracture, in addition to preventing bone loss as well as cardiovascular and mental disorders resulting from postmenopausal hormone defficiency.[20] However, depending on the medium, some important side effects should be considered before using these drugs, given that some medications may have effects on patient's breast and uterus causing tumors.[40] Estrogen hormone replacement is an example of these side effects, in which case women also complain or discontinue treatment due to swelling and tenderness after replacement.[41] Therefore, raloxifene is an alternative drug therapy in the treatment of osteoporosis in postmenopausal women.[42]

Raloxifene (RLX) is one of the drug therapies widely studied and discussed nowadays. After approval, its indication for prevention and treatment of osteoporosis in postmenopausal women increased.[14] Studies reveal that raloxifene also prevents bone loss and secondarily suppresses its formation, thereby resulting in decreased bone remodeling in ovariectomized rats.[43] Moreover, it acts on bone tissue without stimulating other tissues, such as breast and endometrium, due to its different action that depends on the receptor.[11]

Raloxifene is classified as SERM (selective estrogen receptor modulator) with different effects depending on the tissue target of estrogen action.[44] Due to its different mechanisms of interaction with different estrogen receptors, it selects the tissues it acts upon. Thus, depending on the target organ, it produces antagonistic effects (as in breast and uterus) and does not stimulate estrogenic processes;[45] or agonist effects, in which case it exerts its antiresorptive function.[46] Raloxifene is recommended for patients with a family history of breast and/or endometrial cancer, or in cases in which classic hormonal replacement is contraindicated.[20]

Even though the indication, performance and benefits of the drug on bone metabolism and maintenance of bone density are well-known, there are no studies focusing on its action over apical periodontitis in osteopenic organisms treated with raloxifene. To date, the literature comprises studies that assess the effect of raloxifene in case of fracture, alveolar repair after tooth extraction, bone mineral density in postmenopausal women and osteoclastogenesis.

Bone metabolism is influenced by several mechanisms in which bone cells participate. These cells are modulated by factors such as the presence of proteins rank/rankl/opg.[47] Differentiation and activation of osteoclasts are mediated by a member of the TNF family and TNF-receptor in conjunction with other factors, such as hormone levels and the presence of inflammatory cells.[48] OPG is produced by osteoblast

lineage and binds to RANK receptor present in osteoclasts, thereby preventing RANKL from binding to its receptor and, as a result, inhibiting the activity of osteoclasts. Therefore, OPG is essential for bone metabolism, since it is closely related to bone resorption.[49] A study assessing the effect of raloxifene and estradiol on alveolar repair of ovariectomized rats demonstrated that raloxifene treatment yielded more satisfactory results than estradiol treatment. Additionally, the alveolar repair of rats treated with raloxifene is stabilized faster than in the group treated with estradiol, given that the serum levels of OPG increased while RANKL decreased.[27]

In addition to OPG, RANKL also participates in osteoclastogenesis as a cytokine present in osteoblasts of which function is essentially related to bone metabolism. When RANKL binds to RANK, osteoclasts are activated, thereby increasing bone resorption.[50] Therefore, studies aiming to assess bone remodeling and disease are commonly performed by measuring the levels of RANKL. A study investigating the role of raloxifene in women with osteoporosis demonstrated that treatment with raloxifene had a negative effect on the levels of RANKL, significantly decreasing their number and increasing bone mineral density. For these reasons, it supported the hypothesis that raloxifene may reduce the activity of osteoclasts.[51]

Other studies show that the use of raloxifene in postmenopausal women increases bone density by producing agonist effects on tissue and inhibiting the action of osteoclasts.[11,14,52] There is also another study assessing the effect of raloxifene and resedronate on tibia of ovariectomized rats. This study reveals that both drugs, used alone or in combination, decreased the number of osteoclasts.[53] Furthermore, the authors noted that rats treated with these drugs had increased activity of alkaline phosphatase and calcium in plasma. Alkaline phosphatase is considered a marker of osteoblast and affects bone mineralization.[45,54] Some authors suggest that raloxifene increases calcium absorption in the gastrointestinal tract, thereby indirectly benefiting bone tissue.[55,56,57]

Another method used to assess the activity of bone remodeling is by tartrate-resistant acid phosphatase (TRAP), a marker of osteoclasts which is directly related to bone resorption. One study[58] assessing the effect of raloxifene on osteoclastogenesis revealed significant decrease in the number of osteoclasts in the presence of the drug. in addition to increased enzymatic activity of alkaline phosphatase and osteoblastic activity.

In addition to having antiresorptive activity, raloxifene action on the differentiation of osteoblasts is evident.[59,60] These cells are influenced by the presence of alkaline phosphatase.[54] Based on this information, it is reasonable to conclude that raloxifene increases alkaline phosphatase activity.[61]

Conclusion

Raloxifene is widely discussed as an alternative hormone replacement therapy for postmenopausal women. With agonist or antagonist effects, depending on the target organ, raloxifene has proved effective in improving the quality and quantity of bone without causing malignant effects on breast and uterus. Despite the indications and benefits of raloxifene, additional studies are warranted to further investigate the role of raloxifene in endodontic infection of osteopenic organisms.

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Prevalence of pulp stones in cone beam computed tomography

Vanessa **RODRIGUES**[1]
Isabella **SCAMARDI**[2]
Cezar Fioravanti **SCHACHT JUNIOR**[2]
Milena **BORTOLOTTO**[3]
Luiz Roberto **MANHÃES JUNIOR**[4]
Luiz Fernando **TOMAZINHO**[1]
Sheila **BOSCHINI**[5]

ABSTRACT

Introduction: Calcifications of the pulp chamber, known as pulp stones, are common and may be adhered or not to dentin. These changes are detected during routine radiographic evaluations as single or multiple circular or ovoid radiopaque images measuring more than 200 µm. Used in Endodontics, cone-beam computed tomography (CBCT) may demonstrate root and coronary anatomy and detect calcifications, which may help to make an accurate diagnosis. **Objective:** This study assessed the prevalence of pulp stone on CBCT scans retrieved from the collection of the Radiology Center of the School of Dentistry — São Leopoldo Mandic. **Methods:** A total of 181 images were analyzed by means of multiplanar reconstructions. Results were subjected to biostatistics. **Results:** The prevalence of pulp stones was 55%. Prevalence was highest in the 31-40 year age group (89.7%) and in the group of teeth that had been restored (61%). Teeth #16 was the most affected, at a prevalence of 12.8 %, followed by #17 (10.3%). **Conclusion:** The prevalence of patients with pulp stones was 55%. Pulp stones were not associated with aging. Most teeth with pulp stones were maxillary permanent molars, and tooth restoration may be the cause of stone formation.

Keywords: Dental pulp diseases. Dental pulp calcification. Cone-beam computed tomography.

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[1]Professor, School of Dentistry, Paranaense University (UNIPAR).
[2]Undergraduate student, School of Dentistry, UNIPAR.
[3]Professor, School of Dentistry, São Leopoldo Mandic.
[4]PhD in Radiology and Assistant Professor, State University of São Paulo (UNESP).
[5]Master's student in Dental Radiology, São Leopoldo Mandic.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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Contact address: Vanessa Rodrigues
Rua Inajá 3560, Apto. 42 – Umuarama/PR – Brazil — CEP: 87.501-160.
E-mail: vanessanascimento@unipar.br

Introduction

Calcifications of the pulp chamber, known as pulp stones, are common lesions that may be adhered or not to dentin. Their size may range from microscopic to large masses that obliterate almost the entire pulp chamber.[1-5] The causes and process of stone formation have not been fully clarified, but stones seem to be associated with several factors: patient's age, low-intensity stimuli, caries, occlusal trauma, orthodontic movement, periodontal problems, epithelial rests, dental abnormalities and systemic disorders.[4,6,7]

Pulp stones, detected during routine radiographic examinations, are seen as single or multiple circular or ovoid radiopaque images. The prevalence of pulp stones ranges from 8% to 90%, and only lesions greater than 200 μm are detectable.[8-12]

The use of cone-beam computed tomography (CBCT) in Dentistry has made it possible to obtain different planar views of a region of interest and to identify anatomic details without superimpositions. Therefore, this method has greater specificity and accuracy in comparison to conventional radiographs and are indicated for preoperative planning. They have become essential in endodontic treatment because accurate images of root and coronary anatomy, as well as of calcifications, increases treatment success.[13,14,15]

This study assessed the presence of pulp stones on CBCT scans retrieved from the collection of the Radiology Center of the School of Dentistry — São Leopoldo Mandic in Campinas, Brazil, in 2012.

Material and methods

This study was conducted in the Radiology Center of the School of Dentistry — São Leopoldo Mandic. A total of 181 CBCT scans were retrieved and assessed in 2012 (March 2012 to December 2012).

Male and female patients of all ages were included, whereas edentulous patients were excluded. The sample included restored, carious, impacted and healthy teeth.

CBCT scans were obtained by means of an I-CAT scanner (Imaging Sciences International, Inc, Hatfield, PA) set at standardized parameters: 40 s exposure, 13 cm fov, 0.25 mm voxel, 120 kV and 36.15 mAs. All cases included treatment plan with implant placement or surgeries in maxilla or mandible. Images were assessed in a dimly lit room by two examiners (radiologists) using a specific computer and monitor

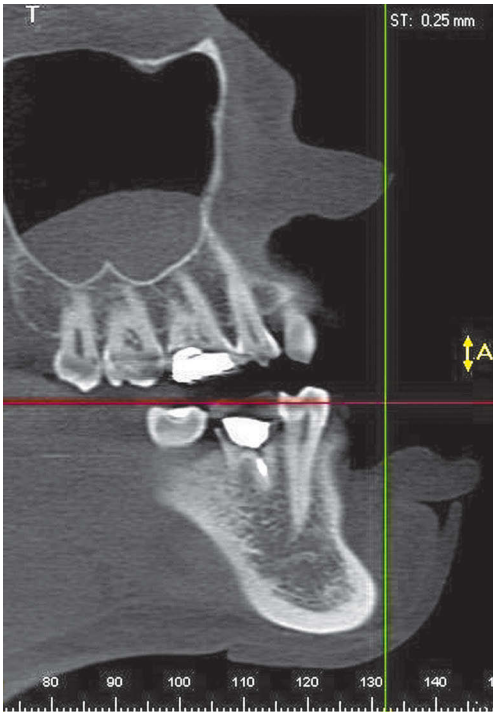

Figure 1. Computed tomography multiplanar reconstructions evincing pulp stone in tooth #17. Sagittal view.

Figure 2. Computed tomography multiplanar reconstructions evincing pulp stone in tooth #46. Sagittal view.

Figure 3. Computed tomography multiplanar reconstructions evincing pulp stone in tooth #27. Sagittal view.

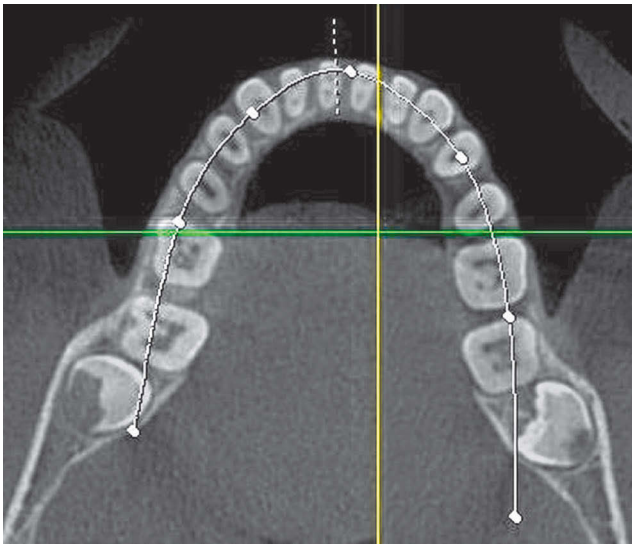

Figure 4. Computed tomography multiplanar reconstructions evincing pulp stone in teetg #36, 37,46 and 47. Axial view.

Figure 5. Computed tomography multiplanar reconstructions evincing pulp stone in teeth #26 and 27 (unerupted), #37 (recently erupted). Sagittal view.

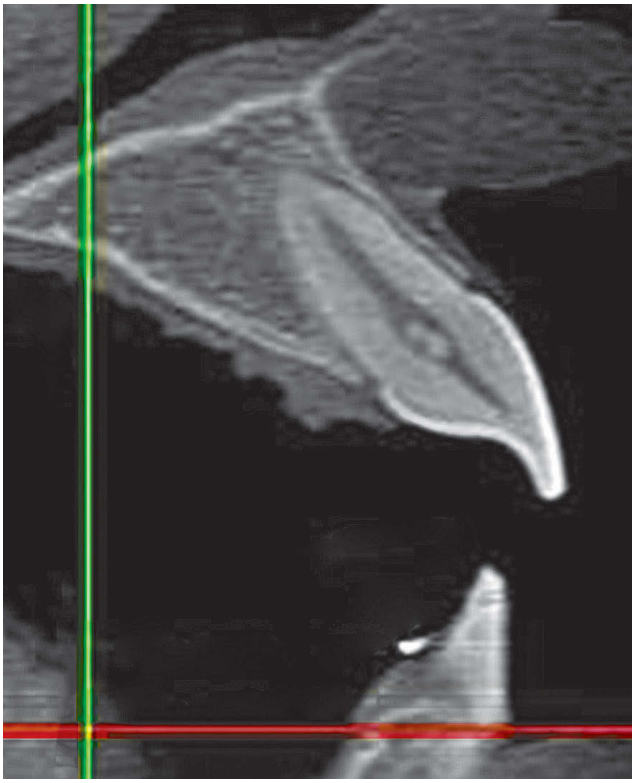

Figure 6. Computed tomography multiplanar reconstructions evincing pulp stone in tooth #21. Sagittal view.

and who were calibrated before the beginning of the study. The scans were assessed using multiplanar reconstruction of 1-mm cross-sectional slices in the Xoran software (Xoran Technologies, Ann Harbor, MI) and its zoom tool when necessary.

Opaque masses in the pulp chamber and inside the root were diagnosed as pulp stones.

Data were organized in Excel spreadsheets and analyzed statistically.

Results

This study assessed the prevalence of pulp stones on CT scans of 122 patients (67.5% women) (Fig 7). Patients' age ranged from 10 to 76 years with mean age (± standard deviation) of 42.74 ± 16.72 years.

CT scans revealed that 55% of patients had pulp stones. The highest prevalence (89.7%) was found in the 31-40 year age group, followed by 88.3% in the 41-50 year group and 85% in the 21-30 year group. Table 1 shows the prevalence of pulp stones according to patients' age.

The greatest prevalence was found for teeth with restorations. However, in the 10-20-year-old group, pulp stones were diagnosed in 63.5% of healthy teeth. This was the only group in which healthy teeth had the highest prevalence of pulp stones (Table 2).

Moreover, out of all teeth with stones, tooth #16 was most frequently affected (12.8%), followed by tooth #17 (10.3%) (Table 1).

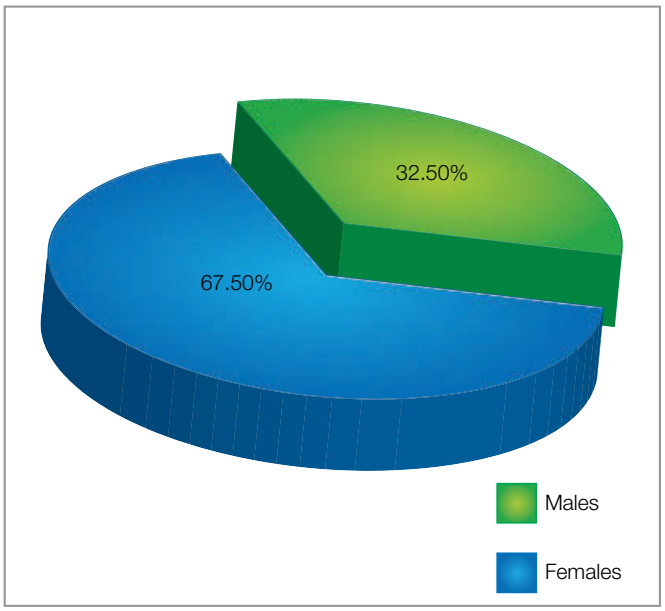

Figure 7. Patients distribution according to sex.

Discussion

Pulp stones are detected by means of conventional or digital imaging techniques such as bitewing, panoramic and bisecting angle techniques. However, they are only detactable when lesions are greater than 200 µm. The prevalence of pulp stones ranges from 8% to 90% probably due to the different techniques used in different studies.[4,8,16,17,18]

To overcome radiographic limitations, such as superimposition of structures and poor resolution or accuracy, CBCT has been included the armamentarium for endodontic diagnoses. CBCT was used in this study and revealed greater prevalence (55%) of pulp stones in comparison to other studies using conventional imaging methods (Hamasha and Darwazeh,[4] Baghdady et al,[8] Tamse et al,[16] and Ranjitkar et al.[17]

The etiology of pulp stones has been intensively discussed, and different authors have found associations with low-intensity local irritants (carious lesions and restorations). Our biostatistics results revealed a prevalence of 61% in restored teeth. In contrast, the prevalence in healthy teeth was 63.5% in the 10-20 year age group, thereby confirming the controversy about the origin of these stones. This is in agreement with findings by Hamasha and Darwazeh,[4] Edds et al,[6] and Nayak et al,[7] who assigned the presence of stones to other factors and systemic disorders.

The age group with the highest prevalence of pulp stones was the 31-40-year-old group, in which 89.7% of teeth had stones. This finding is in disagreement with the studies conducted by Gulsahi et al,[10] Tamse et al,[16] Shafer[19] and Seltzer and Bender,[20] who found an association between age and calcifications. Conversely, it confirms findings reported by Hamasha and Darwazeh[4] who reported no association with age.

As in most studies (Hamasha and Darwazeh,[4] Baghdady,[8] Tamse,[16] and Ranjitkar[17]), molars were the teeth most often affected, with 12.8% of the total prevalence.

The presence of free stones or stones adhered to dentin does not greatly affect patient's teeth, but the high prevalence found in our study suggests that their detection using CBCT imaging studies may aid endodontic treatment planning.

Table 1. Prevalence of pulp stones according to patients' age.

Tooth	10 - 20 years	21 - 30 years	31 - 40 years	41 - 50 years	51 - 60 years	61 - 70 years	71 years up	Total
11	1	0	0	0	0	0	0	1 (0.4%)
13	0	0	2	2	1	0	0	5 (2%)
16	6	8	9	9	2	1	0	35 (12.8%)
17	3	5	8	7	3	2	0	28 (10.3%)
18	0	2	2	2	5	1	1	13 (4.8%)
21	1	0	0	0	0	1	0	2 (0.7%)
22	1	0	0	0	0	0	0	1 (0.4%)
23	0	0	1	1	0	0	0	2 (0.8%)
26	7	5	2	2	3	0	1	20 (7.1%)
27	3	2	4	4	3	4	0	20 (7.3%)
28	0	1	3	3	0	2	0	9 (3.3%)
31	1	0	0	0	0	0	0	1 (0.4%)
32	1	0	0	0	0	0	0	1 (0.4%)
33	1	0	3	3	2	0	0	9 (3.3%)
34	1	1	1	1	0	1	0	5 (2%)
35	1	0	3	3	1	0	0	8 (2.9%)
36	3	2	2	2	6	0	0	15 (5.5%)
37	1	2	6	5	9	1	0	24 (8.8%)
38	0	0	3	3	1	1	0	8 (2.9%)
41	1	0	1	1	0	0	0	3 (1.1%)
42	1	0	1	1	0	0	0	3 (1.1%)
43	1	0	1	1	2	0	0	5 (2%)
44	0	0	2	2	0	0	0	4 (1.5%)
45	1	0	4	4	0	0	0	9 (3.3%)
46	3	1	3	3	2	0	0	12 (4.4%)
47	3	2	5	5	3	0	0	18 (6.6%)
48	0	3	4	4	0	0	0	11 (4%)
Total	41	34	70	68	43	14	2	272 (100%)

Table 2. Status of teeth with pulp stones. Presence of pulp stones according to age.

	10 - 20 years (n = 41)	21 - 30 years (n = 34)	31 - 40 years (n = 70)	41 - 50 years (n = 68)	51 - 60 years (n = 43)	61 - 70 years (n = 14)	71 years up (n = 2)	Total (n = 272)
Healthy	26 (63.5%)	15 (44.1%)	29 (41.4%)	16 (23.5%)	10 (23.2%)	2 (14.3%)	0 (0%)	98 (36%)
Restoration	12 (29.3%)	18 (52.9%)	40 (57.1%)	51 (75%)	31 (72.2%)	12 (85.7%)	2 (100%)	166 (61%)
Caries	1 (2.4%)	0 (0%)	1 (1.4%)	0 (0%)	1 (2.3%)	0 (0%)	0 (0%)	3 (1.1%)
Unerupted	2 (4.8%)	1 (3%)	0 (0%)	1 (1.5%)	1 (2.3%)	0 (0%)	0 (0%)	5 (1.9%)

Conclusion

In this study, the prevalence of pulp stones was 55%. The presence of pulp stones was not associated with aging. Maxillary permanent molars were the teeth most frequently affected. Most teeth with stones had restorations; however, given that the cause of restoration was not identified, a causal relation between restorations and stones could not be established.

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Horizontal root fracture: A case report

Sérgio Henrique Staut **BRUNINI**[1]
Élio Gomes da **SILVA JUNIOR**[2]
Iago de Melo **TRIDA**[2]

ABSTRACT

Introduction: Root fracture normally occurs in anterior teeth and is a condition oftentimes found in school children. It is commonly caused by horizontal trauma mistakenly subjected to extraction by unprepared and unskilled clinicians. Although trauma involves several different structures, traumatized teeth may be kept in the oral cavity. **Methods:** This study reports a case of horizontal root fracture in the middle third of tooth #13 treated by conventional endodontic treatment performed in the coronal segment. **Results:** One year after root canal filling, radiographic exams revealed complete fracture repair with bone tissue between fragments. **Conclusion:** Tooth with horizontal root fracture may be successfully kept in the oral cavity and exert its normal functions after conventional endodontic treatment is properly performed.

Keywords: Oral surgery. Root canal treatment. Tooth fracture.

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[1]Adjunct professor, Department of Dentistry, UNIPAR.
[2]Undergraduate student of Dentistry, UNIPAR.

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Contact address: Sérgio Henrique Staut Brunini
Rua Bartira, 2745 – Jardim São Marcos – Umuarama/PR — Brazil
CEP: 87.501-440 – E-mail: brunini@unipar.br

Introduction

Dental trauma is relatively common. It usually causes coronal lesion, particularly in school children. On the other hand, root fracture are reasonably uncommon and account for 0.5 to 7% of lesions caused by dental trauma.[1,2,3]

Diagnosis of root fracture is based on tooth mobility, coronal fragment displacement, sensitivity to root palpation and radiographic exams. The condition is most prevalent in upper incisors with closed apex, given that completely formed roots are strongly supported by bone and periodontium.[4] Therefore, the injury affects the pulp, periodontal ligament, dentin and cementum at the same time, thereby hindering healing.[5]

Proper diagnosis and treatment planning require the case to be fully investigated, with emphasis on when, where and why the injury occurred. Once the clinician finds out when it occurred, proper treatment can be determined. Additionally, once the site of injury is identified, one can estimate the risk of contamination. Knowing how it occurred allows potential lesions to be identified.[5]

Root fracture results from labiolingual tooth displacement caused by a horizontal impact that, in turn, results from traumatic lesions caused by sports, car accidents or fights. Such an impact will also cause coronal fragment displacement, which results in pulp and periodontal ligament lesions.[5] It is worth noting that lesions occur in a directly proportional relationship, in other words, the worse the trauma caused to supporting tissues and the greater the distance between fragments, the worse the damage caused to the dental pulp and the less the possibility of repair by means of mineralized tissue deposition. Healing also depends on the stage of root development and bacterial contamination near the fracture line, both of which may lead to unfavorable prognosis.[6,7] Furthermore, the condition of the dental pulp strongly influences treatment and prognosis. Andreasen and Andreasen[5] explain that the pulp may strain or break at the level of the fracture, causing the coronal portion of the pulp to lose vascularization. Revascularization is possible through a process that has not yet been fully understood. It is believed that pulp cells comprising the apical fragment or the periodontal ligament enter into the pulp and restore vascularization. Periodontal ligament cells unite the fragments with hard tissue or interposition of connective tissue. Pulp cells comprising the apical fragment establish revascularization.

At first, in case of horizontal root fracture, treatment should promote repositioning of the fragment and provide immediate retention orthodontically performed through adjacent teeth support[8] and kept for at least 12 weeks, as recommended.[7,9,10]

Final treatment depends on several factors such as the type of trauma, prognosis of the traumatized tooth, patient's age, the conditions of the dentition, patient's expectations and financial resources.[1]

Although the rates of repair of horizontal root fractures, achieved by healing through calcified tissue, connective tissue or bone tissue,[4] are of 80%, tooth extraction is often mistakenly recommended by unprepared and unskilled clinicians.[9] For this reason, the aim of this article is to demonstrate by means of a case report that, although trauma involves several different structures, traumatized teeth may be kept in the oral cavity, thus preventing patients from undergoing prosthetic rehabilitation.

Case report

A 23-year-old male patient arrived at the dental clinic of Paranaense University (UNIPAR) seeking endodontic treatment of teeth #11, 12 and 13. Treatment had been started by another clinician. Clinical examination revealed a provisional restoration sealing the endodontic cavity. Retention of teeth #11, 12 and 13 was also identified.According to the patient, treatment had begun a year before as a result of an accident. He admitted not going back to the clinician's office for additional procedures (removing the retainer and finishing the endodontic treatment).Radiographic exams revealed minor resorption in the root apex of tooth #11, periapical lesion of tooth #12 and horizontal fracture in the middle third of tooth #13 (Fig 1).

After removing the retainer, the clinician identified absence of tooth mobility and sensitivity at percussion. For this reason, he opted for endodontic treatment of teeth #11, 12 and 13.

Due to horizontal fracture in the middle third, tooth #13 was endodontically treated in its coronal portion, only. Odontometry (Fig 2) and biomechanical preparation were carried out. The latter was manually performed with the aid of a Kerr #70 file at the fracture

line and 1% sodium hypochlorite irrigation solution. The root canal was dried with paper cones and filled with calcium hydroxide paste associated with propylene glycol + iodoform used as vehicle so as to provide radiopacity to the mixture and ensure that the root canal was completely filled. Radiographic exams were taken to confirm the results.

After 76 days, root canal filling was performed by means of the lateral condensation technique with Sealer 26 (Fig 3). One year after root canal filling, radiographic exams revealed complete fracture repair with bone tissue between fragments (Fig 4).

Discussion

Root fractures may be successfully treated when appropriate procedures are carried out. Should there be no contamination, treatment consists of reducing the fracture and stabilizing it with adjacent teeth as

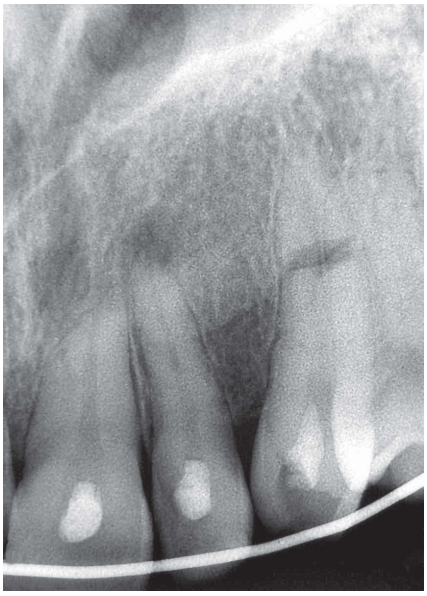

Figure 1. Initial radiographic exam of teeth #11,12 and 13.

Figure 2. Odontometry of the coronal portion of tooth #13.

Figure 3. Radiographic image of tooth #13 taken immediately after root canal filling.

Figure 4. Control radiographic exam taken 12 months after treatment conclusion.

support. These procedures eliminate the need for other types of treatment.[11]

Similarly to traumas in general, root fractures often affects upper incisors (70%) and males in their twenties.[12]

The consequences of fracture lesions are of multifactorial etiology. For this reason, knowing the possibilities of healing is essential. Four types of tissue repair may occur:

» Fusion of fragments by means of hard tissue formation;
» Interposition of connective tissue and bone tissue between fragments;
» Healing through the formation of connective tissue;
» "Fake union" due to the presence of chronic inflammatory tissue between fragments.[3]

Clinical or radiographic evidence revealing the development of pulp necrosis are occasionally found in 20 to 40% of root fracture cases[2] in which chemomechanical preparation significantly reduces the amount of bacteria. However, microorganisms are inevitably present in inaccessible areas.[10]

According to Irala et al,[10] these cases require intervention in both root portions, coronal and apical, so as to avoid necrotic debris, especially in the second canal fragment that certainly hinders case prognosis.

The use of antimicrobial intracanal dressing, such as calcium hydroxide, has been suggested with a view to reversing intraosseous necrosis at the fracture line. According to Diangelis and Bakland,[9] this type of medication prevents infection, decisively contributes to total reduction of microbes and favors apexification, thereby allowing the root canal to be properly filled and, as a consequence, ensuring treatment success.[10] It is worth noting that keeping the intracanal dressing with calcium hydroxide paste for 76 days corresponded to the period necessary for carrying out the endodontic treatment of the other traumatized teeth.

In the case reported herein, endodontic treatment was exclusively carried out in the coronal portion, given that the apical portion usually remains with vital pulp tissue of which removal is not necessary. Furthermore, access to the apical segment is hindered by coronal fragment displacement in relation to the apical fragment.

Conclusion

Based on the results of this study it is reasonable to conclude that tooth with horizontal root fracture may be successfully kept in the oral cavity and exert its normal functions after conventional endodontic treatment is properly performed.

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Reimplantation of two incisors avulsed by trauma. A 10-year follow-up

Antonio Henrique **BRAITT**[1]
Maria Adelaide Bastos Bacelar **COSTA**[2]
Ernani da Costa **ABAD**[3]
Evaldo Almeida **RODRIGUES**[4]
Carlos Eduardo da Silveira **BUENO**[5]

ABSTRACT

Introduction: Approximately 50% of young people younger than 15 years old are victims of some type of traumatic injury in the orofacial region. Dentoalveolar traumas are among the biggest problems described in the dental literature. The indexes of violence in modern society, traffic accidents and extreme sports contribute to this type of injury. These traumatic episodes occurring in childhood or adolescence may lead to major issues such as psychosomatic disorders in patients, parents or guardians. **Objective:** To report the clinical history of a 9-year-old patient who sought dental service due to trauma caused to teeth #21 and 22 at hhr home. **Methods:** The patient was examined and subjected to periapical radiograph, confirming the avulsions. After anesthesia, the area was cleaned with saline solution and the alveolar clots removed. A gauze humidened in saline was used. Teeth were reimplanted and splint with polyester strips attatched with light-curing resin removed after 30 days. Endodontic treatment was conducted with change of calcium hydroxide for 90 days, after which the channels were closed. **Results:** The patient was clinically and radiographically monitored for 10 years with follow-up radiographs showing the teeth in the alveoli without root resorption. **Conclusion:** Dental reiplantation is an alternative treatment that should be done whenever possible, even if the prognosis is bad due to the time between the accident and treatment onset.

Keywords: Tooth avulsion. Endodontics. Traumatology.

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[1]MSc in Endodontics, School of Dentistry — São Leopoldo Mandic. Professor, Specialization program in Endodontics, FUNORTE.

[2]Degree in Dentistry, State University of Feira de Santana.

[3]PhD in Endodontics, Federal University of Rio de Janeiro (UFRJ). Adjunct professor, Estácio de Sá University.

[4]MSc in Endodontics, Federal University of Bahia (UFBA). Professor, Specialization program in Endodontics, FUNORTE.

[5]Postdoc in Endodontics, State University of Campinas (UNICAMP). Full Professor, School of Dentistry — São Leopoldo Mandic.

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Contact address: Antonio Henrique Braitt
Av. Aziz Aron, 1117, Sala 703 – Jardim União – Itabuna/BA — Brazil
CEP: 45.605-415 – E-mail: henrique_braitt@hotmail.com

Introduction

Approximately 50% of young people younger than 15 years old are victims of some kind of traumatic injury in the orofacial region. Dentoalveolar trauma, as well as tooth decay and oral cancer, are among the major problems described in the dental literature worldwide. The levels of violence in modern society, traffic accidents and sports contribute to this kind of injury.[11] These traumatic episodes occurring in childhood or adolescence can lead to major issues and psychosomatic disorders in patients, parents or guardians.[2]

In studies conducted by Raphael and Gregory,[9] the degree of awareness of a lay person regarding tooth avulsion was analyzed. The authors found that 33% of parents were unaware of how to behave in a case of avulsion. A total of 90% said they had never received any instruction on how to store an avulsed tooth. Their study concluded that a higher number of better educational campaigns are necessary to inform the population about prevention means and procedures in case of injury. Successful reimplantation depends not only on appropriate first aid procedures, but also on correct treatment in the dental clinics afterwards.

Among the various types of traumatic injuries, tooth avulsion figures as one of the most prevalent. It corresponds to the forcible separation or detachment of a tooth from its socket due to an accidental or surgical procedure.[3,13] Prognosis depends on the stage of root development; tooth storage time, whether wet or dry; and proper storage, handling and retention of the avulsed tooth. The tooth should be rinsed in clean water and reimplanted. Subsequently, a semi-rigid retention should be kept for 7 to 10 days. If reimplantation is not immediately possible, the tooth should be stored in Hank's solution, milk or saline solution.[7] Successful prognosis is related to the time the tooth was left out of the alveolus and the environment where it was stored. Prognosis worsens after the first hour, for this reason, it is always best that reimplantation occur between 15 and 30 minutes after avulsion due to failure of periodontal fibers attached to the cement and of those in the alveolar wall.[6,12]

The protocol for diagnosis and treatment of avulsed teeth recommends the following:[1,6,7] The affected area should be examined for potential sequelae in soft tissues; CT scan and X-ray should be carried out to check potential bone fractures or damage to adjacent teeth. The area should be anesthetized, cleaned with water, saline solution or chlorhexidine. All necessary sutures should be made in soft tissues. The socket should be slightly and carefully cleaned with gauze and saline solution so as to remove the clot. The tooth should be held by the crown, washed in saline solution and repositioned in the socket in its original position and splinted with a semi-rigid material that should be kept for about two weeks.[8] Painkillers, antibiotics and tetanus vaccine should be prescribed to the patient, together with daily mouthwash with 1% chlorhexidine. After removing the splints, pulp vitality test should be conducted with cold (Endo Ice) and hot (gutta-percha) material. Should this test yield negative results, which may occur in most cases, endodontic treatment is indicated. It should be performed within two to three sessions using calcium hydroxide as intra-canal dressing at intervals of 30 days before endodontic filling. Treatment should be monitored every six months for a minimum period of two years, by radiography and tomography.[10]

The consequences of dental trauma with tooth avulsed from its socket comprise crown darkening, mobility, pulp necrosis and root resorption.[5] Being the latter the most probable.

Case report

A 9-year-old female patient attended the clinic at around 21:00 pm on 16th of October, 2000 accompanied by her parents. They sought dental service due to trauma caused to patient's teeth #21 and 22 at her home. The patient was examined and a periapical radiography was performed, thereby confirming toeeth avulsion (Fig 1). As the avulsed teeth had not been brought with them, it was necessary to go back to their house to pick them up. Teeth were placed in a container with saline solution and brought to the clinic. Meanwhile, the patient was anesthetized, the area was cleaned with saline solution and clots were removed from the alveoli which were kept humid with a gauze humidened in saline. Teeth were reimplanted and Splinter strips were bonded with self-curing polyester resin nearly two hours after the accident. The Splinter strips were removed after 30 days. Painkillers, amoxicillin and tetanus vaccine were prescribed .

On the 28th of October, 2000 endodontic treatment began. Cleaning and shaping of root canals were performed with 0.04 ProFile rotary system to their working length with #70 files and irrigated with sodium hypochlorite 2.5% (Fig 2). Calcium hydroxide was placed in

association with polyethylene glycol vehicle for 30 days. After this period, calcium hydroxide was removed with 17% EDTA in passive ultrasonic irrigation, final irrigation with 2.5% sodium hypochlorite, drying and replacement of calcium hydroxide. Two other sessions were performed, one after 30 days and another on the 21st of February, 2001 during which canals were filled with thermoplasticized gutta-percha and cement (Fig 3). The patient was clinically monitored with x-rays taken every two months for 10 years. On the 28th of September, 2010 the radiographies revealed teeth placed in the alveoli without root resorption.

Discussion

Since reimplantation of avulsed teeth is widely studied, the literature has already reached a consensus regarding the best treatment methods and the main shortcomings and difficulties. Moreover, it is common

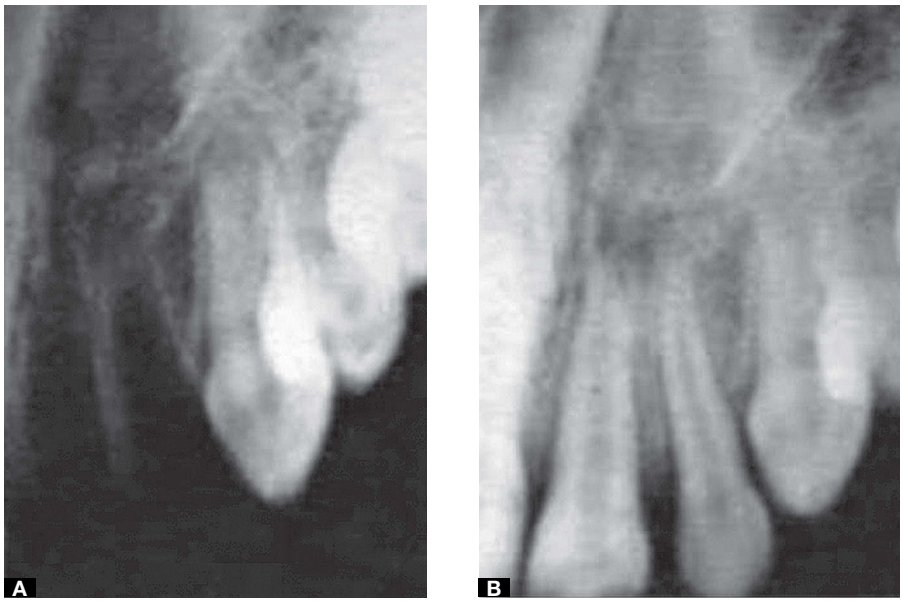

Figure 1. Alveolar socket without teeth (**A**) and with reimplanted teeth (**B**).

Figure 2. First endodontic treatment session. Calcium hydroxide used as intra-canal dressing.

Figure 3. Filled root canal.

Figure 4. 10-year follow-up.

to find some differences in treatment approach, mainly throughout history and in the evolution of treatments.[4] For this reason, additional research should be developed in order to retrieve an even greater number of case reports and elucidate this topic.

Prognosis depends on the time the tooth was left out of the alveolus as well as on proper manipulation of the avulsed tooth. With a view to yielding good results, it is essential that the tooth remains out of the alveolus the shortest possible time and that it be stored in a humid environment without contamination. When reimplantation is performed within the first 15 to 30 minutes after avulsion, the percentage of success is very high; however periods longer than 2 hours usually result in extensive root resorption due to necrosis of the periodontal ligament and the dental element, as well as contamination of trauma on the root surface.[12]

The following were of paramount important to achieve treatment success of the case reported herein: patient's prompt availability; storage of teeth in a humid environment; procedures that prevented alveolar cavities from drying out; and proper endodontic treatment.

Conclusion

This literature review[4] and case report led us to conclude that:

• Dental reimplantation is an alternative treatment that should be performed whenever possible;

• Treatment will have a better prognosis when reimplantation is performed within 15 and 30 minutes after avulsion;

• Should immediate reimplantation be impossible, the avulsed tooth should be kept in a humid environment. The best storage solution is Hank's solution, followed by milk or saline solution;

• Calcium hydroxide proved to be the best intra-canal dressing used in the attempt to delay or prevent cementum and root dentin resorption of reimplanted teeth;

• Campaigns to inform and raise awareness regarding teeth avulsion prove to be effective, but are not widely spread.

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Suggesting a new therapeutic protocol for traumatized permanent teeth: Case report

Jefferson J. C. **MARION**[1]
Laiza Vicente **MARTELOSSO**[2]
Juliana Yuri **NAGATA**[3]
Thiago Farias R. **LIMA**[4]
Adriana de Jesus **SOARES**[5]

ABSTRACT

Introduction: The case reported herein consists of two teeth of one single patient, initially immobilized with a semi-rigid retainer used for 15 days without endodontic intervention. **Objective:** The aim of this article is to report a case of two teeth with extrusive luxation treated with a filling paste of calcium hydroxide, 2% chlorhexidine gel and zinc oxide. **Methods:** After a one-month follow-up, patient's teeth did not present evidence of pulp vitality. Radiographic examination revealed signs of external resorption. Endodontic treatment was carried out in association with a new treatment protocol using intracanal dressing applied in one single session and remaining in the root canal for four years. **Results:** The filling paste remained in the root canal for 24 months without being replaced. The case presented improvements in periapical lesions without inflammatory resorption. **Conclusion:** The filling paste proves to be successful and effective in treating traumatized teeth with root resorption.

Keywords: Endodontics. Calcium hydroxide. Tooth socket. Extrusive luxation. Dental trauma. Chlorhexidine gel. Zinc oxide.

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[1]PhD in Clinical Dentistry/Endodontics, State University of Campinas (UNICAMP).Professor, Department of Endodontics, Brazilian Dental Association (ABO), Maringá. Assistant professor, Ingá College.

[2]Degree in Dentistry, Ingá College.

[3] PhD in Clinical Dentistry/Endodontics, UNICAMP.Assistant professor, Department of Endodontics, Federal University of Sergipe (UFS).

[4] PhD in Clinical Dentistry/Endodontics, State University of Campinas (UNICAMP).

[5] PhD in Clinical Dentistry/Endodontics, State University of Campinas (UNICAMP).Visiting professor, Dental Trauma Service, UNICAMP.

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Contact address: Jefferson J. C. Marion
Rua Néo Alves Martins, 3176 – 6º andar – Sala 64 – Centro
CEP: 87-013.060 – Maringá/PR – Brazil —E-mail: jefferson@jmarion.com.br

Introduction

There is a high incidence of dental trauma in the general population. It may occur in adults and children, but it is more common among children and young adults. Dental trauma is mainly caused by fall, collision, bicycle or car accidents and sports practice, all of which may lead to a wide variety of dental trauma.[1-4] A total of 85.39% of incisor trauma occurs probably due to their positioning in the arch.[5,6]

Traumatic injury is classified under a variety of names, among which luxation is the most common. It includes trauma of tooth displaced from its original position, in which case it is classified according to the direction in which the tooth has been displaced, namely: concussion, subluxation, extrusive luxation, lateral luxation, intrusive luxation and avulsion.[7,8] Damages caused by trauma not only affect hard tissues and dental pulp, but also affect supporting tissues alone or in combination. In extreme cases, trauma may lead to tooth loss.[6] Extrusive luxation is the partial displacement of a tooth, causing it to come out of the socket. According to Andreasen et al,[9,10] it accounts for 64% of dental trauma cases. Complications arising from this type of trauma may occur weeks or years after the accident.[11]

Calcification, pulp necrosis and root resorption are the most common sequelae of trauma.[7,12] The latter has the worst prognosis[13,14] and, according to the American Association of Endodontics,[15] it is associated with physiological and pathological processes that result in dentin, cementum and alveolar bone loss. Additionally, it may be classified as inflammatory or replacement resorption.[16]

Several authors[17-20] assert that extrusive luxation may be treated by repositioning extruded incisors and using a semi-rigid immobilization, both of which do not interfere in occlusion or function. Immobilization must be kept for approximately 15 days, according to the individual characteristics of each case. Retention is performed with orthodontic wire and light-cured resin and it aims at regenerating periodontal fibers. Also, it is extremely important that the clinician perform patient's clinical as well as radiographic follow-up, as cases of pulp necrosis and inflammatory root resorption require endodontic therapy.

Endodontic treatment of reimplanted teeth require the use of intracanal dressing to supplement disinfection and restrain or ease the inflammatory process of resorption. The procedure most commonly used before root canal filling is the use of calcium hydroxide periodically changed and associated with different vehicles. This intracanal dressing is used for having excellent antimicrobial activity and inhibiting the action of cells involved in root resorption.[21-31]

A new therapy associating calcium hydroxide, 2% chlorhexidine gel and zinc oxide has been recently proposed for treatment of avulsed teeth.[32,33,34] The combination of these substances results in a provisional filling paste that remains in the root canal for a long period of time, thereby eliminating the need for restorative procedures and yielding satisfactory results,[32,35,36] except for cases of replacement resorption which are a continuous process.[32] This filling paste provides the patient with comfort, requires less visits to the dentist, and proves less expensive as it does not need to be replaced. In cases of incomplete root formation, it promotes apical closure and relieves clinical signs and symptoms of traumatized teeth for a period of 9 months.[33] Furthermore, it promotes periapical repair in teeth with inflammatory root resorption.[33] Such properties are explained by its high capacity of diffusing throughout the root dentin, inhibiting bacterial growth in the outer root surfaces[37,38] and, therefore, yielding satisfactory results.

Thus, the aim of this article is to report a case of two teeth with extrusive luxation treated with a filling paste of calcium hydroxide, 2% chlorhexidine gel and zinc oxide.

A case report

A 17-year-old male patient sought the Service of Dental Trauma at the School of Dentistry, Piracicaba (FOP-UNICAMP) with dental history of trauma in teeth #11 and #21. Emergency assistance was provided at the Santa Casa hospital of Limeira/SP where extrusive luxation of teeth #11 and #21 was diagnosed. Dental trauma occurred as a result of sports practice. A semi-rigid retainer was installed and kept for 15 days. Subsequently, the patient was referred to FOP-UNICAMP for further treatment.

He sought the services of FOP-UNICAMP a month after the trauma had occurred. His initial clinical and radiographic exams revealed teeth #11 and #21 with no pulp vitality, pain at vertical/horizontal percussion or palpation. Periapical radiograph (Fig 1) revealed complete root formation, external root resorption and

periapical lesion of traumatized teeth. Since it was a case of pulp necrosis, endodontic treatment was recommended and carried out with a putty paste made of calcium hydroxide associated with 2% chlorhexidine gel and zinc oxide (2:1:2).

After crown opening and complete isolation, the septic-toxic medication was neutralized and biomechanical preparation of the crown-apex was carried out with Gates Gliden bur #5,4,3 (Dentsply/Maillefer, Ballaigues, Switzerland) with a view to decontaminating the cervical and middle third of teeth #11 and #21. Odontometry was performed with an electronic apical locator (Novapex, Forum Technologies, RishonLeZion, Israel). Root canals underwent manual instrumentation to their working length with #45 files (Dentsply/Maillefer, Ballaigues, Switzerland). During the instrumentation procedure, 2% chlorhexidine gel (Endogel, Essencial Pharma, Itapetininga/MG, Brazil) was inserted into the root canal at each change of instrument, followed by irrigation with 5 ml of saline solution.

Smear layer was removed by irrigation with 3 ml of 17% EDTA for 3 minutes, followed by final irrigation with saline solution. Root canals were dried with absorbent paper points (Konne Indústria e Comércio de Materiais Odontológicos Ltda., Belo Horizonte/MG, Brazil) and filled with a paste of calcium hydroxide P.A. (Biodinâmica Quim. e Farm. Ltda., Ibiporã/PR, Brazil) associated with 2% chlorhexidine gel (Endogel, Essencial Pharma, Itapetininga/MG, Brazil) and zinc oxide (S.S. White Artigos Dentários, Ltda., Rio de Janeiro/RJ, Brazil). The paste was coltosol or putty-consistent and was prepared in a 2:1:2 ratio. It was inserted by increments with medium and fine medium vertical condenser (KonneIndústria e Comércio de Materiais Odontológicos Ltda., Brazil) throughout the entire root canal. Afterwards, a periapical radiograph was taken to ensure that the filling procedure had been properly performed. Root canals were then sealed with coltosol (Vigodent S/A Indústria e Comércio, Rio de Janeiro/RJ, Brazil) and composite resin (Filtek Z350, 3M Dental Products, Saint Paul, USA) (Fig 2).

Every 3 months, the patient went back to the university for clinical and radiographic follow-up sessions that revealed the presence of intracanal medication/paste completely filling the canal, thus eliminating the need for removal. After 12 months of treatment, the clinician observed remission of periapical lesion (Fig 3A). After 24 months of follow-up, exams revealed the intracanal medication filling the entire root canal, thus eliminating the need for removal. Periapical lesion a remission and interruption of inflammatory resorption were observed (Fig 3B).

Discussion

Endodontic treatment is a predictable way of preserving a tooth in cases of dental trauma. Treatment success and high-quality immediate restoration aim at restoring patient's esthetics and function for years. Thus, endodontic treatment is considered a safe and feasible option.[39]

Cases in need of endodontic treatment due to trauma have led to different therapeutic protocols used to minimize potential sequelae. The use of sodium hydroxide,[40] polymyxin B-Otosporin,[41] Lysozymes,[42] formocresol,[43] chlorhexidine[44,45,46] and calcium hydroxide, in different associations[47,48], has been reported.

Figure 1. Initial radiograph 30 days after trauma and after removal of semi-rigid retainer.

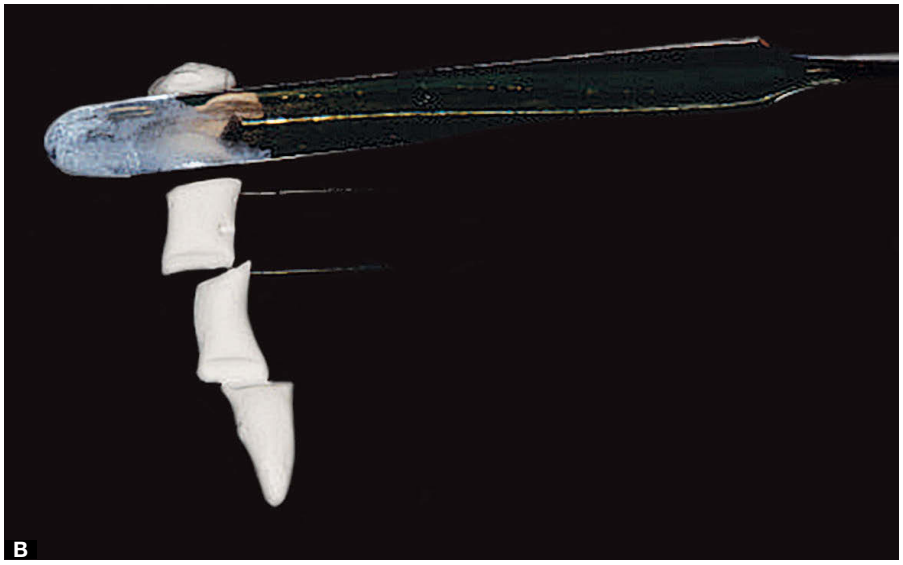

Figure 2. A) Calcium hydroxide P.A; 2% chlorhexidine gel (Endogel) and zinc oxide used as intracanal dressing in a 2:1:2 ratio. **B**) Final consistency. **C**) Final radiograph revealing the quality of insertion of the intracanal dressing. **D**) Vertical condenser used to insert the intracanal dressing.

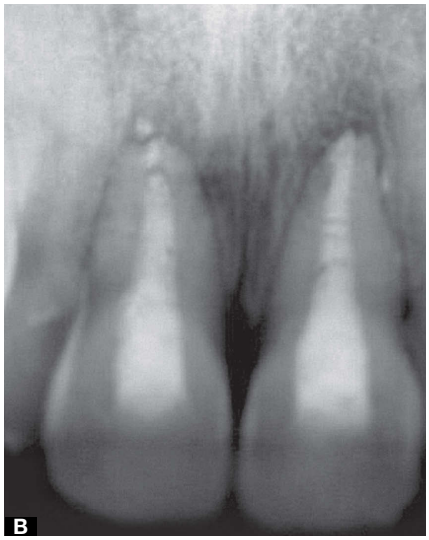

Figure 3. A) 12-month follow-up radiograph. **B**) 24-month follow-up radiograph.

Some authors[24,49,50] recommend that calcium hydroxide be used as intracanal dressing applied with periodic changes and at different time intervals, given that it is considered the most effective intracanal medication of all.[51,52,53] According to Pacios et al,[54] calcium hydroxide yields satisfactory clinical results and may be used in association with different vehicles, for instance, distilled water, chlorhexidine, propylene glycol, anaesthetic solution, PMCC and PMCC + propylene glycol. However, this case report did not implement periodic changes and, for this reason, disagrees with the aforementioned studies. Conversely, it corroborates Felippe et al[35] who asserts that there is no need for applying calcium hydroxide past with periodic changes in teeth with incomplete root formation and incomplete root canal systems.

Even though calcium hydroxide is the most used intracanal medication, it cannot be considered as universal, given that it is not effective against all types of bacteria present in root canal systems.[55] Since chlorhexidine presents highly satisfactory antimicrobial properties, it is important that it be used in association with calcium hydroxide. Calcium hydroxide associated with chlorhexidine aims at enhancing the antimicrobial properties of the former, keeping its biological characteristics as well as its mechanisms of physical barrier.[47] Zinc oxide is a yellowish, white, thin, odorless, amorphous, insoluble in water or ethanol, radiopaque and slightly antiseptic powder[56] that may be present in endodontic cement[57] and gutta-percha cones.[58]

Based on the aforementioned benefits, this case report aimed at assessing the results yielded by a therapeutic protocol using the three elements together: calcium hydroxide, 2% chlorhexidine gel and zinc oxide mixed together to form a coltosol-consistent paste that did not dissolve and could be applied in one single session, thus eliminating the need for periodic changes during trimestrial control. The outcomes of this research corroborate those of previous studies.[32,33,59,60,61]

Due to the fact that the intracanal paste used during the procedure did not dissolve, as revealed by radiographic exams, it is suggested that complete root canal filling was guaranteed by zinc oxide, since calcium hydroxide and chlorhexidine gel had already been dissolved.[32,59] Similar results were yielded by our study in which a 24-month follow-up was performed. During this period, the intracanal dressing did not have to be periodically changed; periapical repair was achieved and root resorption was stabilized, thereby proving the effectiveness of the medication in the long run and eliminating the need for replacement inside the root canal. Gomes et al[31] and Souza-Filho et al[62] also conducted studies in which the intracanal dressing was not periodically replaced. The authors observed that during the follow-up phase, zinc oxide possibly functions as an inert material that provides root canal sealing and, as a consequence, prevents contamination and allows periapical repair. In addition to that, they concluded that the medication can remain inside the root canal for a period not greater than 4 years. Those results disagree with the studies by Moorer and Genet[63] who suggested that additional researches be conducted to further investigate the biological properties of zinc oxide, given that these authors do not consider it as an inert material.

The association of calcium hydroxide, 2% chlorhexidine gel and zinc oxide (2:1:2 ratio) was previously studied.[37,38,47,62,64,65] These *in vitro* studies demonstrated the antimicrobial action of the mixture, as well as its capacity of keeping an alkaline pH and its proper consistency when inserted into the root canal. Furthermore, the association of calcium hydroxide, 2% chlorhexidine gel and zinc oxide proves to have a high diffusion capacity in the root dentin, thus causing inhibition of bacterial growth in outer root surfaces — as previously mentioned — which may have favored root resorption control.

Conclusion

Based on the results of this study and the findings of the literature, it is reasonable to conclude that:

- The filling paste of calcium hydroxide, 2% chlorhexidine gel and zinc oxide (2:1:2 ratio) proves effective in treating traumatized permanent teeth with complete root formation and extrusive luxation. This intracanal dressing stimulates periapical lesion repair and interruption of inflammatory resorption.
- The technique allows treatment to be performed within one single session, as the intracanal medication remains active afterwards. Additionally, it proves advantageous for the patient due to being inexpensive and having shorter chair time.
- Due to having a cortisol-consistency, the provisional filling paste of calcium hydroxide, 2% chlorhexidine gel and zinc oxide (2:1:2 ratio) is easily inserted into the root canal. Additionally, it favors radiographic visualization.

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Dr. Luiz Teixeira Mendes, 2.712, Zona 5
Zip Code: 87.015-001, Maringá/PR
Phone. (44) 3031-9818
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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;
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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,

Carlos Estrela
Editor-in-Chief of Dental Press Endodontics
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E-mail: estrela3@terra.com.br