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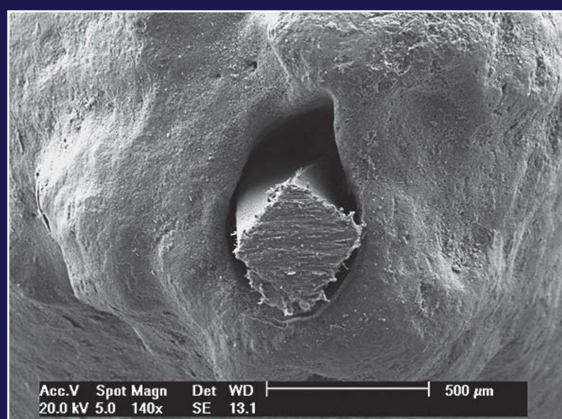

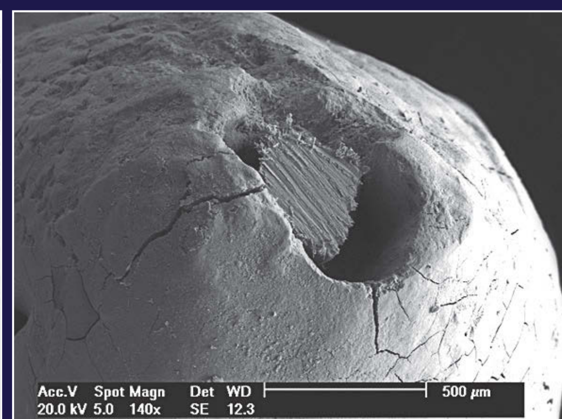

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The modern endodontic therapy

In the second edition of his book Endodontics, Ingle added a photo of the Washington Monument, representing the great integrity that seemed vital to the specialty at that time.

In its third edition, in 1985, the picture was of Mount Rainier, a massive base that rose in a spectacular ridge. Noting that mount, Ingle thought that, when reviewing the mountain of endodontic achievements, one gets impressed with the solid foundation of research and important observations that lead us to the zenith of our progress. Still, he claimed we were being crushed by an avalanche of ideas, techniques and tools, all of them exciting, some threatening and many still not adequately tested. So, for him, the intact splendor of our “mountain” of knowledge was being threatened. He wondered: Could Mount Rainier become another St. Helens, an active volcano in southwest Washington state that in 1980, after 127 years of inactivity, came into violent eruption, followed by a tremor of 5.1 points on the Richter scale, bringing the northern part of the volcano down, decreasing by 400 meters at its height and increasing its width in a mile?

Today, over 25 years later, the threat remains the same. Automated systems are launched first and tested later! The industry has been resolute in the purpose to directly influence the teaching of Endodontics. But only few educational institutions are prepared for the new technologies. And, leaving it to the industry, we face charges that do not correspond to reality. The race to disseminate new systems brings a number of concerns. As stated Spangberg in 2001, the apparent simplicity of the technique using some instruments is an invitation to ignorance. Without a deep knowledge of the anatomy and pathology, instrumentation does not increase the success rate of endodontic therapy. The reality is that the increase in sales of new systems does not necessarily mean its implementation in daily clinical practice.

It is necessary to understand that it is from the constant practice and training that we’ll execute, in automation, all the experience gained from years of manual training. But, wouldn’t the idea be going the other way around now?

Gilson Blitzkow Sydney
Editor-in-Chief

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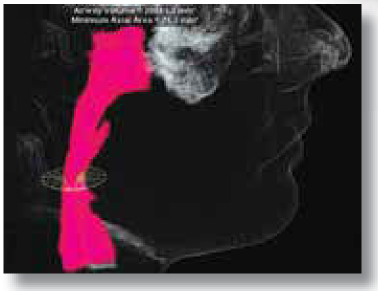

3D airway volume analysis

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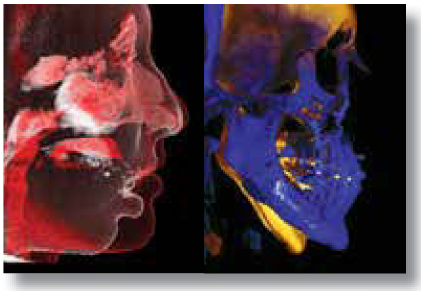

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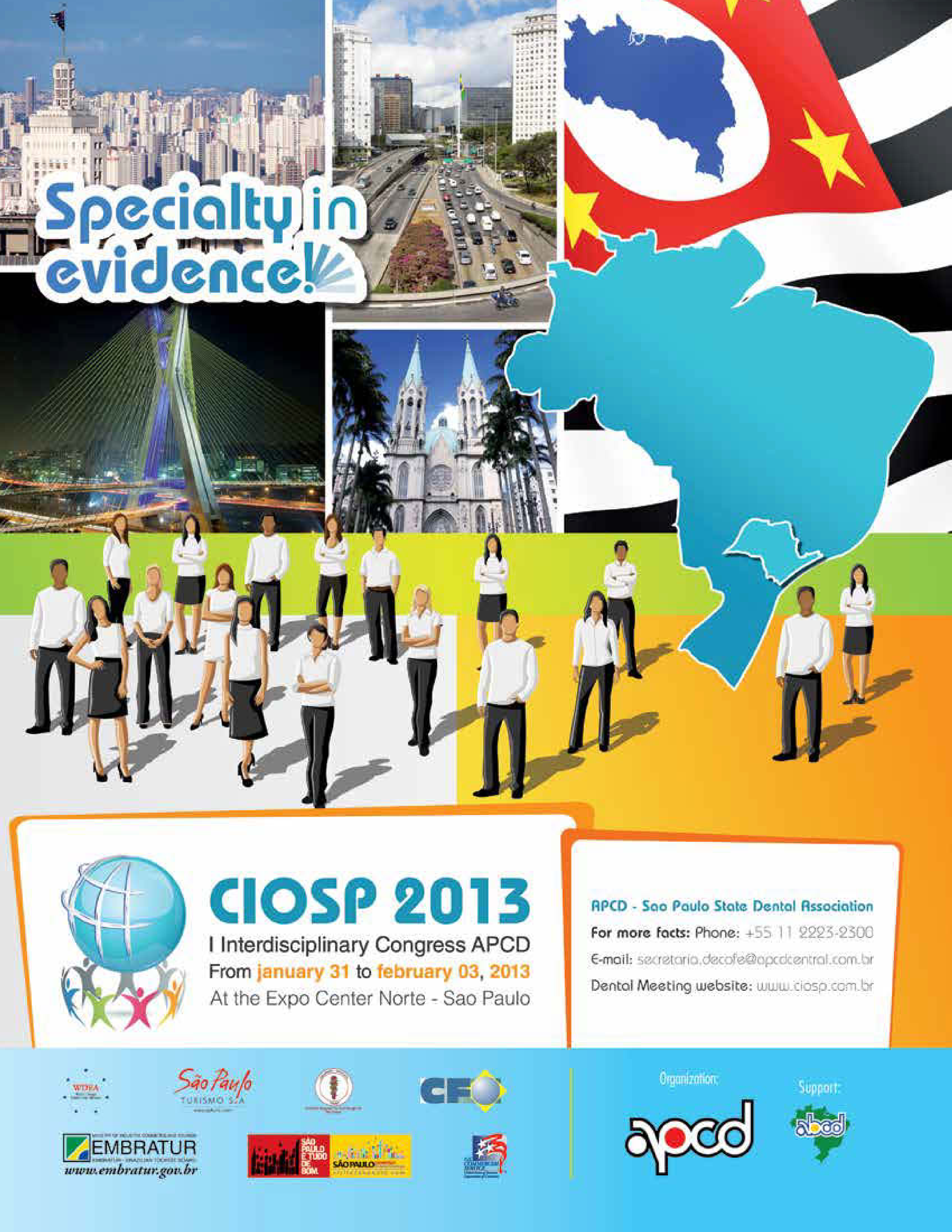
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Clinical and imaginologic diagnosis of occlusal trauma

Alberto **CONSOLARO**[1]

ABSTRACT

A more refined diagnosis tends to be based on subtle signs and symptoms, requiring the specialist to be extremely judicious and knowledgeable. Occlusal trauma should be included in the differential diagnosis of apical periodontitis and dental trauma. Ideally, when a tooth presents with pulp necrosis and signs of occlusal trauma, one should conduct the interview and diagnostic tests in search of a superimposed dental trauma, even in posterior teeth. No scientific rationale is strong enough as to allow one to state that occlusal interference or occlusal overloads produce a necrotic pulp. Interferences and occlusal overloads take months or even years to induce the classic signs and symptoms of occlusal trauma as a clinical entity. It is still common to compare the effects of occlusal trauma to those resulting from orthodontic movement and dental injuries. The mechanisms underlying tissue changes induced by occlusal trauma are in no way comparable to those induced by orthodontic movement or dental trauma. In these three events the primary cause is of a physical nature, but the forces applied to dental tissues exhibit completely different characteristics of intensity, duration, direction, distribution, frequency and form of uptake by periodontal tissues.

Keywords: Occlusal trauma. Occlusion. Gingival recession. Dental trauma. Abfraction.

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The clinical condition that characterizes occlusal trauma and the variables of these clinical and imaging characteristics are greatly undervalued in undergraduate and specialist training programs. Consequently, an accurate diagnosis and its clinical implications end up being ignored in the planning and follow-up of some clinical cases.

Many experts, however, believe that the causes and potential developments of occlusal trauma resemble dental trauma and orthodontic movement, although these are completely distinct conditions. The injuries induced in the tissues by these three situations are considerably diverse.[1]

Orthodontic movement cannot be likened to occlusal trauma.[1] The cellular and tissue changes promoted by occlusal trauma in periodontal tissues are completely different from those induced by orthodontic movement.

In dental trauma, forces are abrupt, intense and short-lived. Damage comprises breakage of periodontal components, with the teeth touching or driving their roots through the alveolar bone structures, causing bleeding and necrosis in support tissues.

The only feature shared by these three conditions – occlusal trauma, orthodontic movement and dental trauma - is the physical nature of their causes translated into forces, but these forces exhibit unique characteristics to such an extent that comparisons between the injuries induced in the tissues are not possible.

The authors sought to publish a series of articles on occlusal trauma in journals geared to the various clinical specialties with a view to contribute to the clarification and understanding - in an applied and specific fashion - of the clinical and imaging signs of occlusal trauma in each area. Given the same topics, many parts of the content, text and figures of these articles inevitably recur.[4,5,6]

Occlusal trauma as a clinical condition or clinical entity

The condition, or clinical entity known as occlusal trauma is synonymous with occlusion trauma, traumatic occlusion, traumatogenic occlusion, periodontal traumatism, occlusal overload, among others.

The name of a given clinical condition seeks to identify the type of injury or set of changes induced in the affected tissues. Terminological precision and standardization facilitate a more comprehensive search for information in databases as well as communication between scholars and researchers.

The term injury means any structural change, irrespective of its nature, which can be transient or permanent. Injuries induced in periodontal tissue, which characterize the clinical condition called occlusal trauma, may be caused by traumatic occlusion or overload of occlusal forces in single or multiple teeth simultaneously, depending on the clinical situation.

The induced injury known as occlusal trauma was classically defined:

1) By Stillman,[10] in 1917, as resulting from a situation in which the act of occluding the jaws damages the supporting tissues of teeth.[11,12]
2) In 1978, the World Health Organization (WHO) described it as periodontium damage induced by pressure on the teeth produced directly or indirectly by antagonist teeth.[11,12]
3) The American Association of Periodontology defines it as an injury in the dental support apparatus, resulting from excessive occlusal force.[8,9]

The three definitions of occlusal trauma given above share the concept that damage is necessarily produced by overload induced by the teeth in occlusion and by antagonist teeth.

Occlusal trauma in one or more teeth may be associated with parafunctional responses such as clenching and bruxism. The causes of occlusal trauma in orthodontic practice may be related to premature contacts arising from the position of teeth, inappropriate occlusal morphology between antagonist teeth, overload on lateral incisors when these teeth are laterally involved in canine guidances, and postoperative periods following orthognathic surgeries.

One should not mistake an occlusal interference, such as premature contact, for occlusal trauma. Occlusal trauma is a clinical entity or a specific condition. Occlusal interference may prove to be the cause, but the term occlusal trauma should be used to identify the clinical entity along with its clinical signs and symptoms. An occlusion may be traumatic, and yet not lead to the injury or disease called occlusal trauma.

Occlusal trauma should not be likened to the effects of orthodontic movement

Human teeth are capable of enduring heavy occlusal loads that produce intrusive movements in the alveoli, mainly during mastication. Injuries to this apparatus are caused by very strong, persistent, or repetitive forces. Even in this situation, the periodontal ligament — with an average thickness of 0.25 mm, or 250 μm - will not allow the teeth to touch the apical alveolar cortical surface. This underscores a structural organization that comprises a perfect physiological apparatus, which enables the insertion of the tooth in the socket.

The periodontal ligament is a delicate membrane overlying the root surface and connecting the latter to the alveolar bone. Fifty percent of its structure is composed of vessels (Fig 1). It is efficient for intrusive forces, but not for lateral forces, so that when one intends to move teeth orthodontically,[1] forces are often lighter, with inclination or bodily movements, and such forces are by far lighter than in occlusal trauma. These forces are delivered slowly and eventually dissipate.

After each period of appliance activation, the periodontal tissues return to normal, allowing new forces to be applied with the same characteristics: Light and in one single moment, while forces dissipate.[1] This differs in almost everything if one tries to compare the effects of orthodontic movement to occlusal trauma, especially in regard to induced cellular and tissue reactions and their consequences.

One of the major objectives of clinical orthodontic practice is to correct occlusion disorders, especially those involved in the relationships between the jaws and dental arches. Professional orthodontic training, however, is usually not thorough enough or suitable for detecting more subtle occlusal interferences. In Brazilian Dentistry, within the scope of clinical specialties, there are professionals who specialize in the examination, diagnosis and correction of occlusion and temporomandibular disorders.

Orthodontic movement induces some occlusal interference, but these are temporary and generally do not last long enough to injure the periodontal support structures significantly. The changes inherent in occlusal trauma require prolonged action by the damaging forces, affecting one and the same site.

At the end of orthodontic treatment, it is not a widespread conduct to perform a thorough occlusal analysis on discharging the patient, thereby allowing a natural "accommodation" to settle over the subsequent months.[3] However, in many cases the patient complains and exhibits changes that are typical of occlusal trauma in specific teeth.

Occlusal trauma and orthodontic movement do not induce pulp necrosis: But dental trauma does!

Occlusal trauma promotes cellular and tissue changes which are totally distinct from phenomena induced by orthodontic movement.[1] Occlusal trauma is characterized by repeated, intense forces, whereas orthodontic forces are much lighter and although applied in one go, are delivered slowly and progressively: Within 3 to 6 days these forces dissipate gradually, fading completely within 7 to 10 days in humans.[1] In both cases the vascular bundle does not undergo breakage or partial injury. Despite the periodontal ligament's average thickness of 0.25 mm or 250 μm, its organization and function do not allow the teeth to touch the apical alveolar cortical surface during heavy chewing, which could damage the vascular bundle at the entrance of the apical foramen (Fig 1).

Abrupt, intense and short-lived forces typical of dental trauma can cause breakage of periodontal components as the teeth touch or drive their roots through the alveolar bone structures, resulting in bleeding and necrosis in the supporting tissues. Sudden displacement by strong, transient forces disrupts the vascular bundle at the entrance of the root canal at the level of the apical foramen. Dental trauma by concussion often occurs without the patient exhibiting clinical signs of discomfort or pain syndrome.

In orthodontic movement forces are much lighter than in dental trauma, as they are applied slowly until dissipation and, despite the fact that the orthodontic appliance is activated periodically in one go. These characteristics of forces delivered in orthodontic treatment have justified the results of many studies about the absence of significant changes in the dental pulp.

There is absolutely no rationale to substantiate claims that orthodontic movement induces pulp necrosis. Moreover, the greater the forces delivered orthodontically, the less effectively these forces are likely to induce tooth displacement, and therefore, the less likely they are to cause pulp necrosis. Similarly, there is no rationale to explain pulp necrosis induced by occlusal trauma. When such suspicious cases are identified, it would be more advisable to blame dental trauma.

In occlusal trauma, forces are repetitive and intense, but nothing comparable to that of dental trauma, where forces occur in one go, suddenly and intensely.

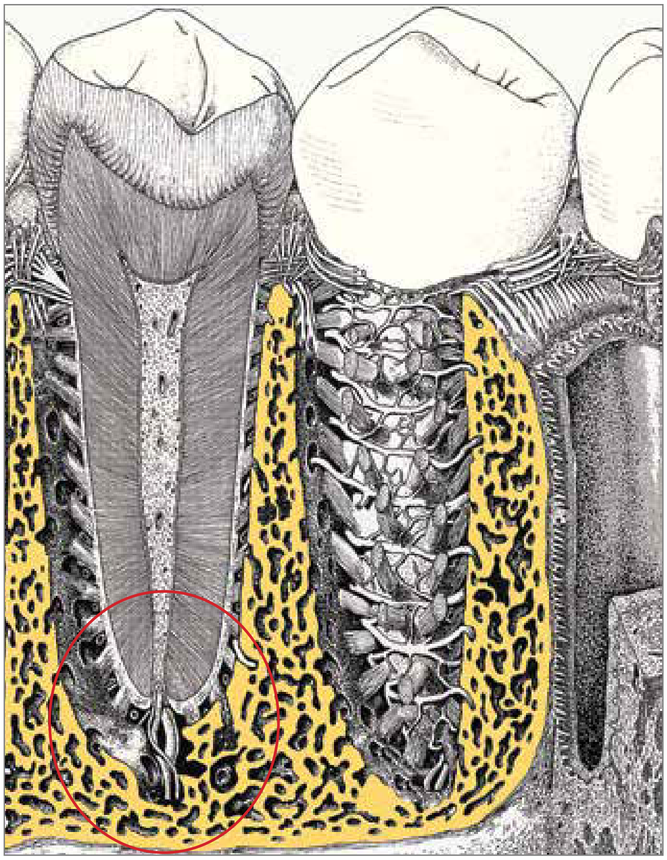

Figure 1. Two and three dimensional aspects of the periodontal ligament and other structures. Note the shape and extreme organization in the distribution of collagen fibrous bundles that prevent, even under overload conditions, the apex from touching the bottom of the socket (modified, from Krstic, RV, 1991).

Occlusal forces, even in overload, cannot put the tooth apex in contact with the bottom of alveolar bone and crush, or otherwise damage the vascular bundle. The human periodontal ligament was designed to absorb and dissipate the intrusive forces that predominate in chewing and swallowing movements.

Occlusal trauma in mineralized structures and abfraction

In areas of occlusal interference, occlusal trauma determines the presence of wear facets produced by friction.[8,9] At the same time, excessive pressure or eccentric forces produce three-dimensional deformations in the mineralized tooth structure. These deformations are called temporary and repetitive deflections.

Deflection is the act or effect of deflecting, a verb that indicates a movement that deviates from a given line in order to follow another direction — this line can be referred to as the long axis of the tooth. A deflection on the tooth, when deviating from the long axis, can create traction on one side and compression of mineralized structures on the other side.

Cementum and dentin are deformable, but enamel is not. Dentine is comprised on average of 60% inorganic component, and 40% organic component, predominantly proteins and water. On the other hand, 50% of the cementum structure consists of organic matter, and 50% inorganic. Dentin and cementum together form a structure with relative flexibility, and not prone to structural changes.

Enamel, with its 96% of mineral component, has a minimum, negligible deflection capacity. On the compression side — during a deflection of the tooth as a whole, by occlusal trauma, for example - the enamel resists its effect, but on the traction side, enamel cannot resist, and presents with early fractures and/or cracks in its delicate cervical portion. This process, if repetitive, can lead to fragmentation and loss of enamel structure, which is medically known as abfraction (Figs 2 and 3). Abfraction is very common, especially in youths and in premolars.[2,4,7]

The cracks cannot be seen in the cervical enamel of premolars experiencing this condition. The patient, however, may complain of intense sensitivity to thermal variations in these “healthy” teeth when eating. If the tooth displays wear facets and V-shaped recession (Figures 2 and 3), one may suspect the presence of abfraction, even if only initial, albeit not observable, which would explain this enhanced sensitivity.

How to spot radiographic signs of occlusal trauma in periodontal tissues

When the periodontal ligament is under compression in primary occlusal trauma a reduction occurs in the diameter of the vessels, with consequent disorganization of fibers and cells. This situation induces cellular stress, with release and greater accumulation of mediators in the periodontal ligament, especially those mediators that can locally influence the constancy rate of bone remodeling.

The local mediators of bone remodeling have a biphasic effect: When accumulated at very high levels, they stimulate bone resorption, while at slightly increased levels they induce new bone formation.

Figure 2. V-shaped gingival recession with a minor crack at its end (arrow), related to occlusal trauma.

Figure 3. V-shaped gingival recession in a tooth with abfraction: Two clinical signs of occlusal trauma.

Forces delivered to the tooth act as a lever with intra-alveolar rotation and the fulcrum located between the apical and middle thirds of the tooth root. In occlusal trauma, forces tend to be well distributed in the periodontal ligament and overload promotes slightly increased levels of bone remodeling mediators.

This tissue dynamic in occlusal trauma allows one to visualize radiographically the thickening of the lamina dura (Figs 4 and 5) by increasing alveolar cortical bone deposition, reinforcing this structure and elongating the collagen fibers. In other words, the periodontal structures will conform better in order to absorb the increased occlusal forces.

In primary occlusal trauma, collagen fibers must be renewed faster, and the longer and the better organized its bundles, the greater their absorption capacity, and the more effectively excessively repetitive forces are suppressed. Radiographically, one can notice an irregular widening of the periodontal space, since the ligament is constantly undergoing structural reorganization (Figs 4, 5, 6 and 7).

In occlusal trauma, forces are excessive and eccentric, but the periodontal tissues adapt by thickening the alveolar cortical bone, increasing the density of adjacent trabeculate, and irregularly widening the periodontal space. This happens throughout the length and width of tooth root and surrounding tissues (Figs 7, 8, and 9).

In the cervical region of periodontal tissues - given the lever effect produced by the tooth - if occlusal trauma grows too intense and persistent it can cause stretching/traction and/or excessive compression of the periodontal ligament. In the cervical region, the accumulation of mediators may rise to the point of stimulating predominantly the activity of bone resorption. The plane parallel to the tooth surface of the lamina dura in this region may undergo some angulation, implying V-shaped bone loss (Figs 4, 7, 9).

The imaging of this V-shaped bone loss shows some vertical bone loss with no periodontal pocket on probing thoroughly and appropriately. By simply removing the primary cause, i.e., the occlusal trauma, one can restore the original bone level.

Occlusal trauma can thus show its first radiographic signs, i.e., vertical cervical V-shaped bone loss, thickening of the lamina dura, irregular widening of periodontal space, and increases in density or apical bone sclerosis, or in the bone crest (Figs 4 and 9). These signs reflect an attempt by the periodontal tissues to adapt to a new functional demand. Much later, areas of inflammatory root resorption may arise (Figs 10 and 11).

Effects of occlusal trauma on the buccal free surface of the periodontal ligament and alveolar cortical bone

The same cellular and tissue phenomena that occlusal trauma can induce in the periodontal surface of the ligament facing the alveolar bone crest when subjected to the same type of load and consequent deflection, can also be induced in the free buccal surface.

However, the structure of the buccal cortical bone tends to be very thin, and any slight resorption in its periodontal surface can lead to decreased cervical

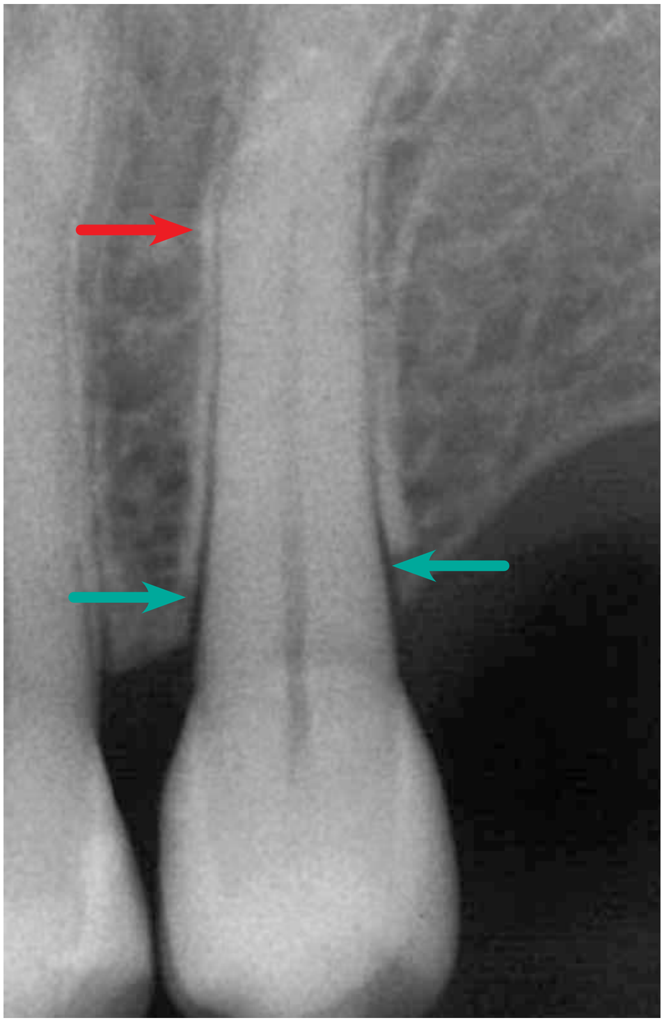

Figure 4. Thickening of the lamina dura and widening of the periodontal space (red arrow). Note the V-shaped bone resorption in the cervical region of the alveolar bone crest (green arrows): Initial aspects of occlusal trauma.

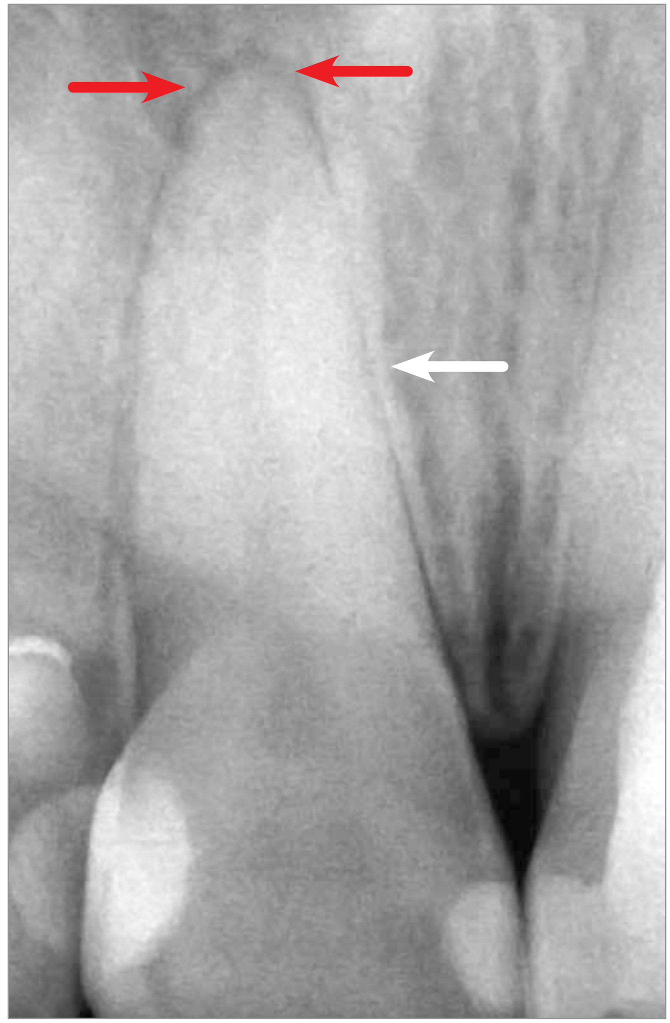

Figure 6. Occlusal Trauma with thickening of the lamina dura (white arrow) and widening of the periodontal space with increased diffuse periodontal bone density (red arrows).

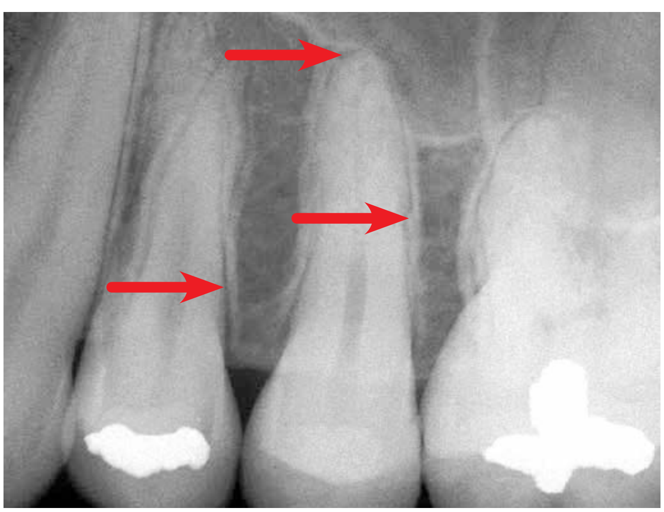

Figure 5. Thickening of the lamina dura and widening of the periodontal space (red arrows). Note a slight increase in the density of the alveolar bone crest.

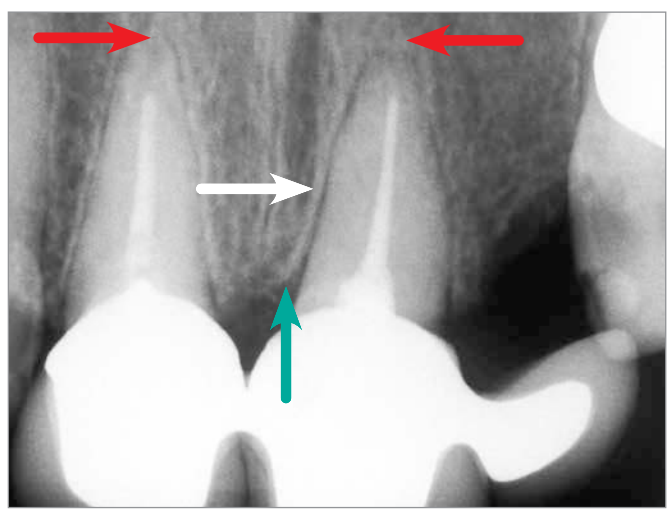

Figure 7. Occlusal Trauma with thickening of the lamina dura (white arrow), widening of the periodontal space, increased diffuse periodontal bone density (red arrows), and vertical bone loss (green arrow).

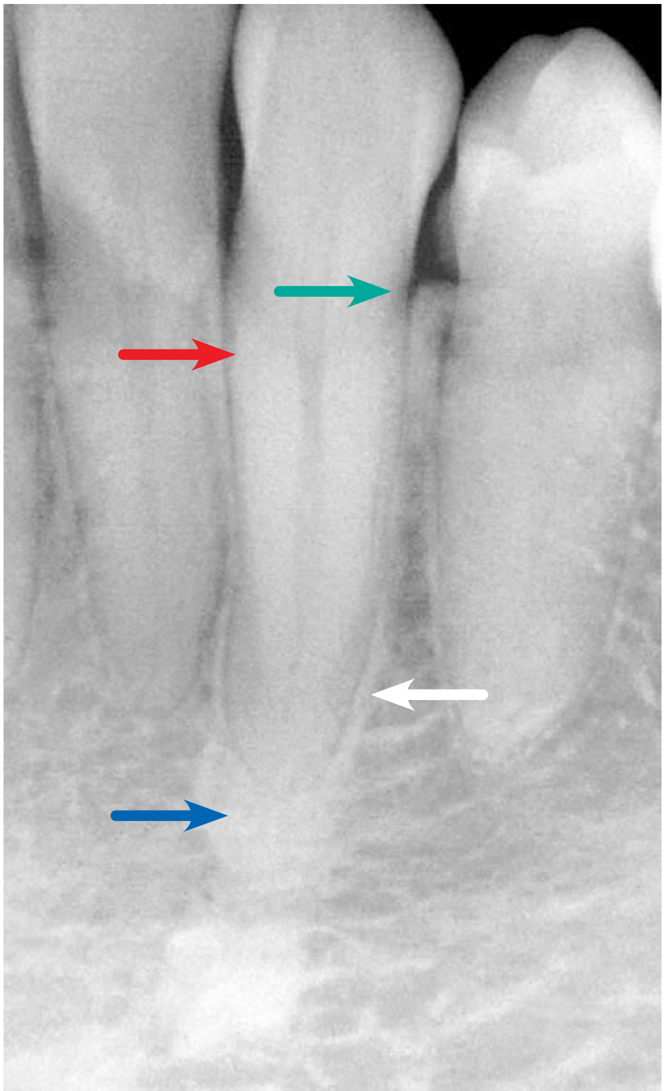

Figure 8. Occlusal Trauma with thickening of the lamina dura (white arrow), widening of the periodontal space (red arrows) with increased diffuse periodontal bone density on the bone crest (blue arrow), and vertical bone loss (green arrow).

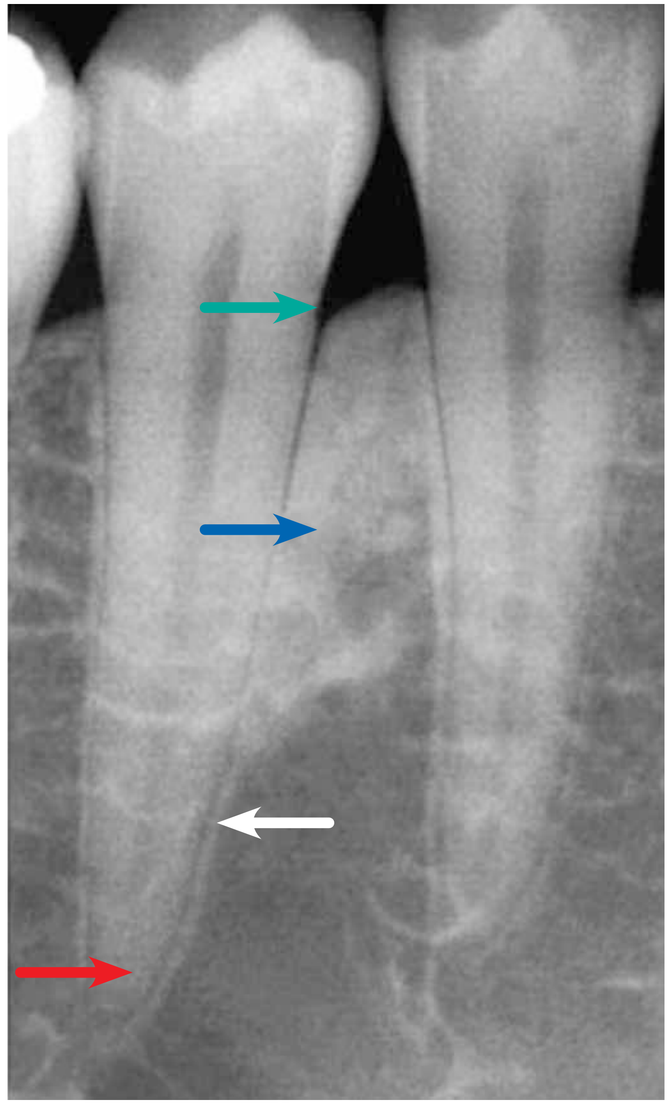

Figure 9. Occlusal Trauma with thickening of the lamina dura (white arrow), widening of the periodontal space (red arrows) with increased periapical periodontal bone density (blue arrow), and V-shaped vertical bone loss (green arrow).

height and V-shaped bone dehiscence on the buccal surface of the affected root (Fig 12).

Buccal bone dehiscences are local and specific, and they grow in size through a gradual and slow process. Detection in imaging can be particularly challenging, although some sophisticated tomographic equipment claim to deliver reliable results. Fenestrations further compound the condition (Fig 12).

Upon the emergence of buccal bone dehiscence, the periosteum initially remains in place for a clinically indefinite period. With no bones to coat it, protect it and nourish it with their vessels, the periosteum tends to settle on the margins of the bone dehiscence, and following these margins while leaving the root surface exposed to gingival and periodontal connective tissue (Fig 12).

V-shaped gingival recession in occlusal trauma and how it develops

Primarily, occlusal trauma can cause gingival recession, especially V-shaped recession. Some scholars, notably in Scandinavia,[8,11] refuse in principle to accept this finding, and believe that in order for gingival recession to occur it should always be associated with an accumulation of bacterial plaque. This stance has sparked much controversy and heated debate.

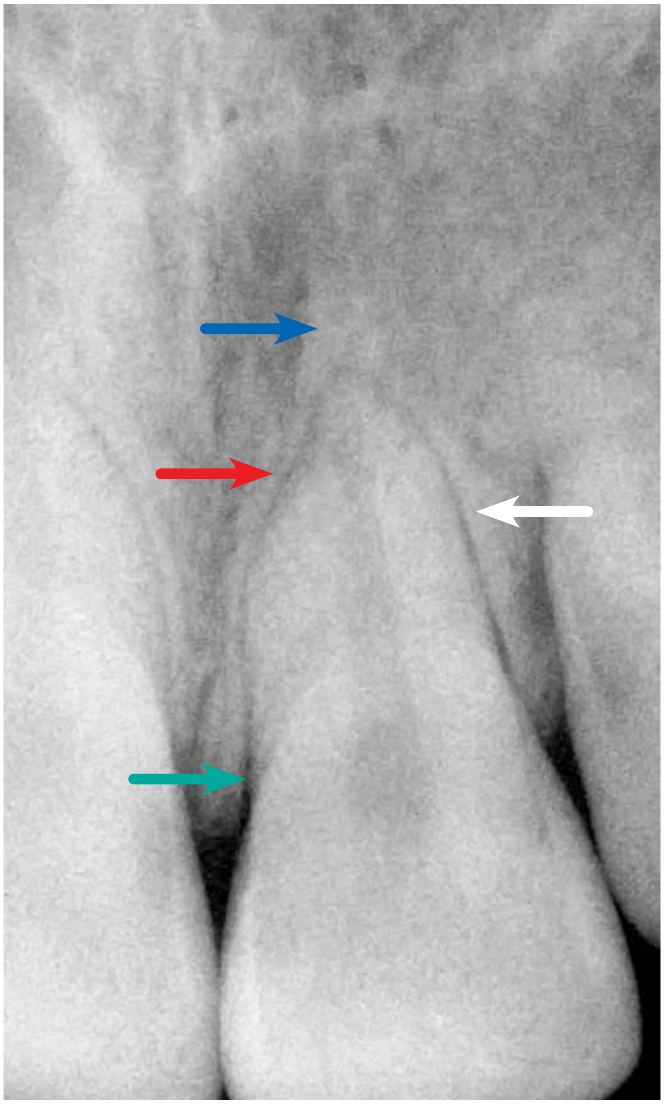

Figure 10. Apical inflammatory root resorption associated with occlusal trauma with thickening of the lamina dura (white arrow), widening of the periodontal space (red arrow) with increased periapical periodontal bone density (blue arrow), and V-shaped vertical bone loss (green arrow).

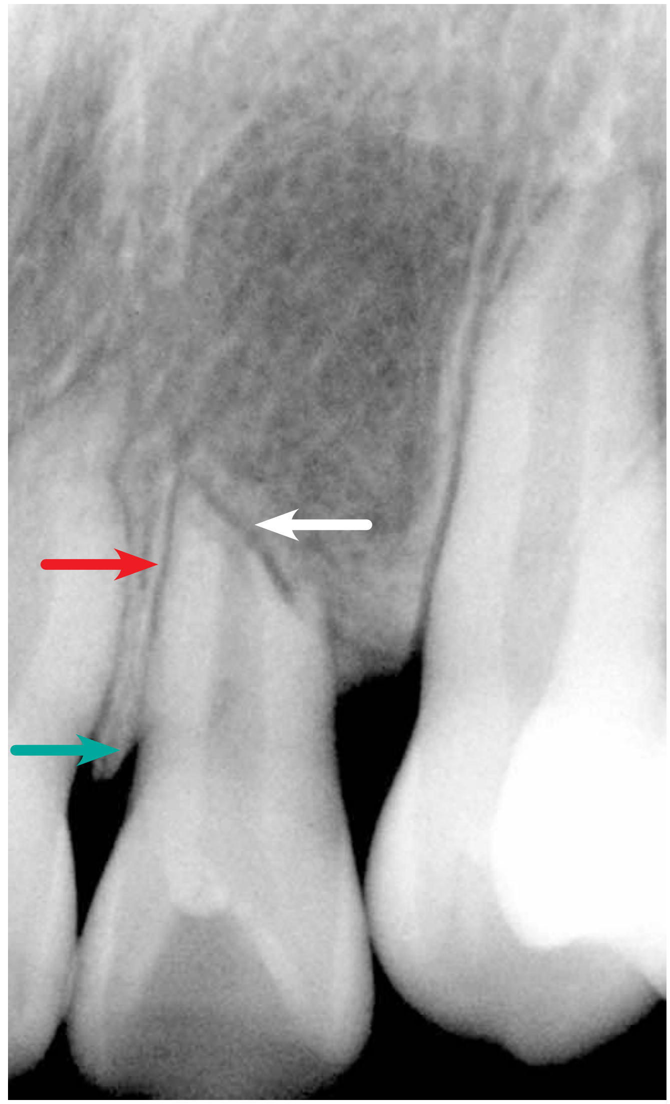

Figure 11. Buccal cortical bone of maxillary canine with dehiscence, also showing a small fenestration in the first premolar (arrow). Note the delicate buccal alveolar cortical bone thickness.

One of the reasons why the Scandinavians claim that bacterial plaque must be present if gingival recession is to develop in occlusal trauma can be explained by the focus of their studies and rationale: They compare occlusal trauma to orthodontic movement, and even call it "orthodontic trauma.[11]"

Gingival recessions can be generalized, compromising several or almost all teeth. Localized recessions can be caused by several factors depending on how they emerge, and are classified as atrophic changes in periodontal tissues.

U-shaped or circular recessions are closely associated with the presence of bacterial plaque and chronic inflammatory periodontal disease, frenular attachments, poor brushing technique, and other less common causes.

V-shaped or angled gingival recessions have a small fissure at their most apical end. This type of recession is directly involved in occlusal trauma[12] commonly associated with abfraction[2,7,10] (Figures 2 and 3). In the majority of early cases, elimination of the occlusal trauma leads to a reduction or regression of this V-shaped recession.[12] In many of these cases one can not determine a direct relationship with accumulation of bacterial plaque.

Buccal bone dehiscences - as seen above - tem-

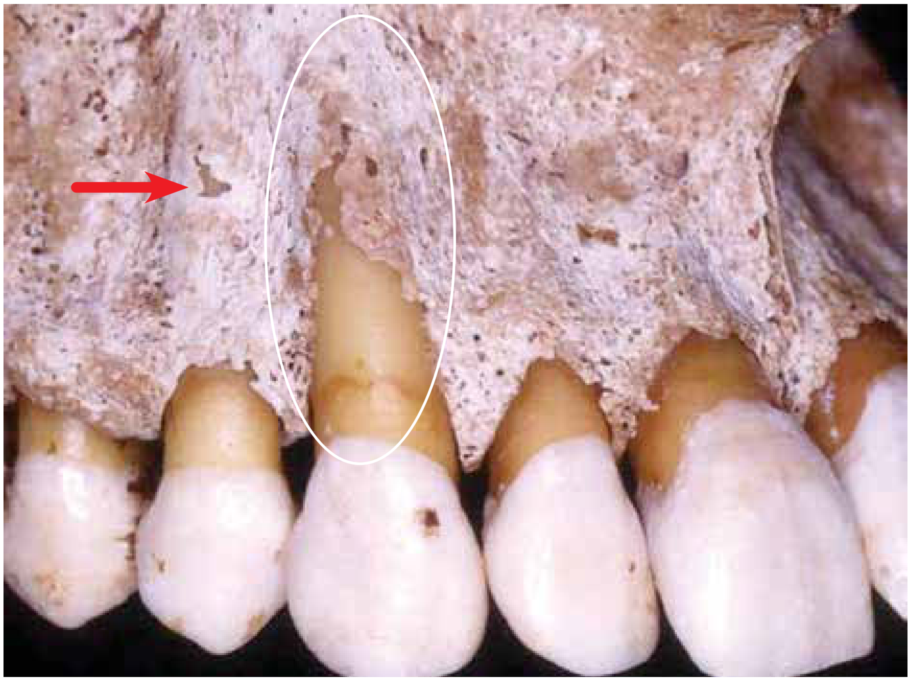

Figure 12. Buccal cortical bone of maxillary canine with dehiscence, also showing a small fenestration in the first premolar (arrow). Note the delicate buccal alveolar cortical bone thickness.

porarily enable the linking of two very similar structures which are ultimately fused and reorganized into one single structure over time. The plate or buccal alveolar cortical bone becomes - sometimes very delicately - interposed between the periosteum and the periodontal ligament.

The periosteum is composed of two distinct layers and continuous fibrous connective tissue. The very fibrous outer layer has few cells and naturally joins the richly cellularized and vascularized inner layer. This inner layer directly interfaces with the periosteum and is intersected by fibers which become strongly attached to the mineralized part of the cortical bone.

In the human skeleton, it is solely in tendon attachments and in alveolar cortical bones that the periosteum coats the bone surface. The periodontal ligament sometimes plays the role of the periosteum on the alveolar surface. It can be said that the periodontal ligament provides another manner in which to organize the periosteum.

When the cortical bone is lost due to resorption and dehiscence on the buccal surface of the tooth experiencing primary occlusal trauma, the two structures usually become juxtaposed, but over time, they should reorganize themselves. With no bone in the region and with the periosteum and periodontal ligament now joined together, the two structures no longer play an active role functionally. The fibrous connective tissue resulting from this condition gradually starts functioning by elongating the connective tissue and attached gingiva, positioned far away from the cervical bone due to the dehiscence.

Bone loss causes the periosteum and ligament to bind together by contiguity or proximity, thereby producing an elongated connective attachment and modified biological distance between the junctional epithelium and cervical bone. If the occlusal trauma persists, there is no way to keep the periodontal fibers functionally attached to the cementum given the lack of anchorage due to the absence of bone.

Gradually, the periodontal fibers that lack anchorage and the neighboring periosteum without bone reorganize themselves as normal gingival connective tissue. The connective attachment is joined by hyperplasia and epithelial migration, with the development of a long junctional epithelium, which can resist and persist keeping the gingival level at a normal height for a certain period of time under the occlusal trauma.

In continuation, the occlusal trauma may ultimately result in the bone dehiscence being accompanied by the gingival tissue in the form of a V-shaped gingival recession.

Recessions are classified among periodontal diseases as atrophic changes. Without function, increased gingival connective tissue - due to bone loss - tends to remodel itself by volume and organization, similarly to what is found in gums of normal teeth, but this results in exposure of the dental root involved in the process.

The decrease in tissue volume seen in gingival recession is due to periodontal tissue accommodating to a new functional situation, since there is no bone in the area of dehiscence. The reduction in volume occurs by means of constant and normal tissue remodeling. This remodeling accomplishes the goal of normalizing the tissue relationship and thus restoring the normal proportions between bone, gingival submucosal connective tissue and mucosal, sulcus and junctional epithelia.

While the gingival level is maintained, despite vertical bone loss - provided there is no periodontal pocket - removal of primary occlusal trauma can reverse the process even in the presence of considerable bone loss. In cases where the root has already been exposed in the mouth, restoring the gingival level usually requires surgical procedures with or without grafting of gingival tissue and bone.

Criteria for diagnosing early occlusal trauma

Primary occlusal trauma can manifest itself clinically (Figs 2 and 3) subtly and incipiently as a triad:[2,7,10]

Wear facets of the areas of interference, abfraction, especially in premolars, and mild V-shaped recession

This triad of signs virtually confirm and reiterate the clinical condition of occlusal trauma, but some cases may display just one or two of these signs. Even before the appearance of V-shaped recession, when only facets and abfraction are present, these signs should indicate to the clinician the need for a thorough analysis. She/he should search for periodontal radiographic signs (Figs 4 to 11) in periapical films, such as:

» Increased thickness of the lamina dura
» Irregular thickening of the periodontal space
» V-shaped vertical bone loss
» Bone sclerosis in the periapical region and/or interdental bone crest
» Inflammatory root resorption, more common in the advanced stages of occlusal trauma

Friction-related wear facets[5,6] and abfraction should be corrected, but not without first correcting the occlusal interference, even when gingival recession is already present.

Early diagnosis considerably improves the prognosis of V-shaped gingival recession, and elimination of occlusal trauma may in many clinical cases lead to spontaneous regression.

On vertical percussion, some soreness is seldom noted. Likewise, patients rarely report the sensation that the tooth is the first to touch the teeth during occlusion. These two signs characterize apical periodontitis induced by dental trauma, and those associated with pulp necrosis due to pulpitis.

Grafts in V-shaped gingival recession associated with occlusal trauma

When gingival recession appears very severe it could mean that the root surface was exposed too long in the mouth under the action of bacterial plaque, thereby irreversibly contaminating the root structure with lipopolysaccharides (LPS).

These surfaces contaminated by LPS, even after relentless scraping and/or treatment with a wide range of acidic and antimicrobial substances will not allow cementoblastic cells to recolonize them to the point of forming new cementum layers. In other words, it will be impossible to reattach periodontal fibers to these surfaces, even after gingival grafts.

In some case reports, the most that can be achieved with surgical procedures — with results being analyzed microscopically at a later date - is the positioning of fibroblasts and collagen fibers parallel to the root surface after scraping and treatment, without reattachment of perpendicular and functional periodontal fibers. This occurs simultaneously and alternately in gum and bone grafting.

The extremely satisfactory outcomes achieved with these surgical procedures using gingival grafts stem from the formation of a long junctional epithelium and the maintenance of post-operative gingival levels indefinitely. Epithelial cells can colonize these tooth surfaces previously exposed in the mouth and contaminated by LPS, after the surfaces have been scraped and treated.

Unfortunately, consistent evidence to confirm these clinically obtained results is still lacking, mainly due to methodological difficulties in clinical and experimental work. As for the reattachment of fibers to surfaces previously exposed for long periods in the mouth, under the agency of bacterial plaque, no sound, methodological evidence is available as yet.

Conclusions

In endodontic practice, diagnoses tend to be based on subtle signs and symptoms, requiring great care and prior knowledge by the specialist. Occlusal trauma should be included in the differential diagnosis of apical periodontitis and dental trauma.

Increased periapical bone density of the periapical sclerosing osteitis type, associated with tooth pulp vitality, may favor a diagnosis of occlusal trauma, even in the presence of inflammatory root resorption.

Perhaps ideally, when a tooth presents with pulp necrosis and signs of occlusal trauma, one should try to establish - based on patient history and diagnostic tests - a diagnosis of superimposed dental trauma, even in posterior teeth. Here are some situations likely to cause dental injuries such as concussion in posterior teeth leading to pulp necrosis:

» Anchoring surgical levers on neighboring teeth during extractions
» Accidentally bumping instruments like forceps during surgical procedures
» Allowing instruments to slip on probing during gastroesophageal examinations
» Moving laryngoscopes during general anesthesia procedures
» Presence of sweets and other food in the mouth during sporting and leisure activities, and during sudden movements performed when riding on a motorcycle or roller coaster, for example.

Occlusal interferences and overloads take months or years to induce the classic signs and symptoms of occlusal trauma as a clinical entity. Correction of these occlusal overloads and interferences will typically avert these signs and symptoms. The presence of occlusal interferences and overloads does not necessarily indicate that the signs and symptoms of the clinical entity called occlusal trauma are present: They may take many months before emerging in the clinical context and in different imaging methods.

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Biocompatibility and setting time of gray Portland cement clinker with or without calcium sulfate

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ABSTRACT

Objective: To evaluate the biocompatibility of Grey Portland Cement Clinker without and with 2% and 5% calcium sulfate. **Methods:** Twenty-four mice received subcutaneously polyethylene tubes filled with grey Portland Cement Clinker without or with 2% or 5% calcium sulfate. After 15, 30 and 60 days of implantation, the animals were killed and specimens were prepared for microscopic analysis. Setting times of each material were also evaluated according to the ASTM specification # C266-08. ANOVA and Tukey's test for setting time and Kruskal Wallis and Dum test for biocompatity at 5% significance level were used. **Results:** Histologic observation showed no statistical difference among the materials in the subcutaneous tissues. **Conclusion:** Clinker without calcium sulfate showed 5 min for initial setting time and 55 min for final setting time, followed by clinker with 2% sulfate calcium (8/95 min) and clinker with 5% sulfate calcium (10/110 min).

Keywords: Mineral Trioxide Aggregate. Clinker. Portland cement.

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Introduction

Mineral Trioxide Aggregate (MTA) is currently used for endodontic therapy such as root-end filling, perforation repair, resorptive defect repair, pulpotomy and apexification,[5] due to its good marginal adaptation, sealing ability, antimicrobial activity and biocompatibility.[6-10] MTA is basically Portland cement type 1 with bismuth oxide added for radiopacity.[6,11,12] Portland cement is manufactured by a clinkering process of these unprocessed materials. The components of Portland cement produce calcium hydroxide and a silicate hydrate gel during hydration responsible of the biocompatibility of the cement.[13-15] The biocompatibility of MTA and Portland cement has previously been tested in implantation tests,[8,16,17] human cells test[9] and in human and animal direct pulp capping procedures.[4,18] These studies showed similar results for Portland cement and MTA.

In cement industry, the gypsum is added to the Portland cement in amounts of 3-6% to retard the setting time and this was confirmed by Camilieri[15] that showed decrease of the setting time of Portland cement excluding the gypsum in the final stage of manufacturing. Significant reduction in setting time is helpful during clinical procedures because of MTA exhibits a longer setting time.[19-26] Clinker cement is the main component of Portland cement and has an adequate setting time, alkaline pH and calcium release.

In 2003, in Argentina, was launched Endo CPM sealer, the first root canal filling material MTA-based.

The aim of this study was to evaluate the subcutaneous tissue response to implantation of polyethylene tubes containing grey Portland cement clinker without /with 2% and 5% calcium sulfate and Endo CPM sealer. Setting times of each material were also evaluated.

Material and methods

The research protocol was approved by the Ethics Committee for Research on Animals # 02/2006. The materials used in this study were: grey Portland cement clinker without calcium sulfate (Fancesa, Sucre, Bolivia), grey Portland cement clinker with 2% or 5% calcium sulfate (Carlo Erba Reagents, Italia) and Endo CPM sealer (EGEO SRL, Argentina). Grey Portland cement clinker was served under laboratory conditions to a particle size of 0.062 mm (Bronzinox, Brasil).

Twenty four adult male Wistar albinos rats (Rattus norvegicus albinos), weighing between 200-250 grams were used for this experiments. Animals were anesthetized by intramuscular dose of 25 mg/kg cloridrate of ketamine and 10 mg/kg cloridrate of xylazine. In each animal, two anterior and two posterior incisions were made through the dorsal skin using a nº 15 scalpel blade. A blunt dissecting instrument was used to create a 20 mm deep pocket in the subcutaneous tissue to receive the implants. Polyethylene tubes (1 mm diameter and 10 mm length) were filled either with Portland cement clinker without calcium sulfate, Portland cement clinker with 2% of calcium sulfate, Portland cement clinker with 5% of calcium sulfate and Endo CPM sealer in power/liquid ratio 3:1. Other side of the tube was sealed with gutta-percha and served as control. Each animal received four implants. The wounds were sutured, with removal of sutures after 7 days.

After 15, 30 and 60 days of implantation, the animals were killed by overdose of Ketamine. The connective tissue containing the implant were excised and kept in 10% formalin. A section parallel to the long axis of the tube was made with 5 µm-thick and stained with hematoxylin and eosin. The tissue reactions at the end of the tubes in direct contact with the cements were evaluated and scored as: 0 – without inflammation cells (no reaction); 1:<25 inflammatory cells (mild reaction); 2:25-125 inflammatory cells (moderate reaction); 3:>125 inflammatory cells (severe reaction). A Kruskal-Wallis test was carried out to determine the significant difference for the inflammatory response of the test materials ($p < 0.05$).

The setting time of the cements tested were carried out under controlled temperature and humidity (37+/-1°C and 95+/-5% relative humidity) according to the International Stands Organization (ISO) 6876 specification and the ASTM C266-03 standard test. The material were mixed and inserted in metallic ring mold (10 mm in diameter and 2 mm thickness). Three specimens were fabricated for each cement. After 180 seconds, each specimen was indented with the 113.4g Gilmore needle for determining initial setting time. After the initial setting time a 456.5g Gilmore needle was used to determine the final setting time. The data were submitted to statistical analysis using the ANOVA and Tukey test for multiple comparisons ($p < 0.05$).

Results

Microscopic analysis

In the period of 15 days was observed a fibrous capsule formation outlining the polyethylene tube. The capsule was thicker, with collagen fibers arranged around the cement and a large number of fibroblasts, showing high synthetic activity. This area also presented small blood vessels and few inflammatory cells. Endo-CPM showed a greater inflammatory response with statistical significant differences among the materials ($p < 0.05$). Clincker with 2%, 5% and without calcium sulfate showed similar results, with no statistical significant difference among the materials ($p < 0.05$) (Fig 1).

In 30 days the tissue response was similar to the 15 days period. However, more organized capsule was found with collagen fibers disposed parallel to the cement containing few fibroblasts and inflammatory cells; predominantly, macrophages. Collagen fibers, in this period were thicker, blood vessels less numerous and there were smaller empty spaces than the 15 day period indicating a larger degree of tissue organization. There was no statistical significant difference among the materials ($p < 0.05$) (Fig 2).

In 60 days the tissue showed a thick fiber structure parallel positioned to the cement surface. There were few fibroblasts, little visualization of other structures,

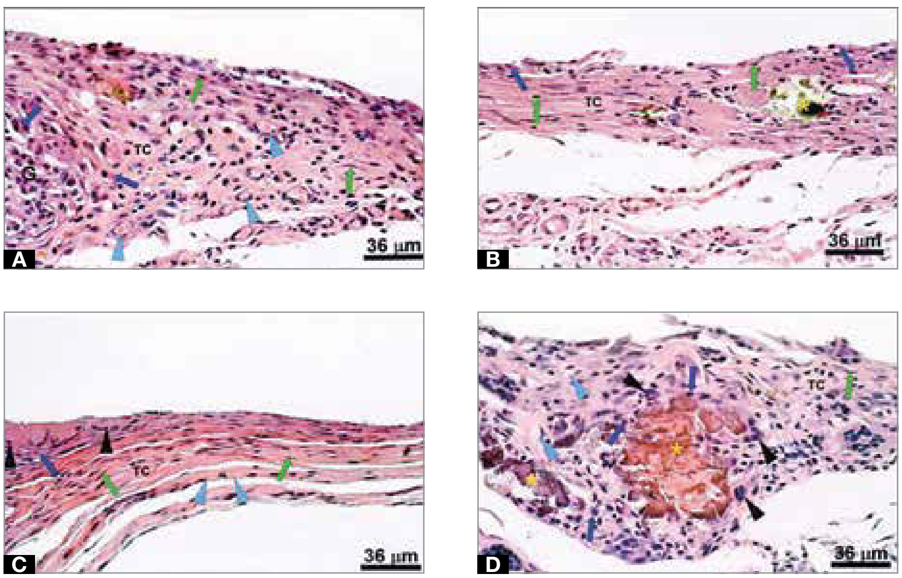

Figure 1. 15 days: **A**) Clincker without calcium sulfate; **B**) Clicker with 2% calcium sulfate; **C**) Clincker with 5% calcium sulfate; **D**) CPM sealer.(blue arrow: macrophage; blue arrow head: blood vessels; black arrow head: giant cells; CT: connective tissue; green arrow: fibroblasts; asterisk: extruded material). HE 40x

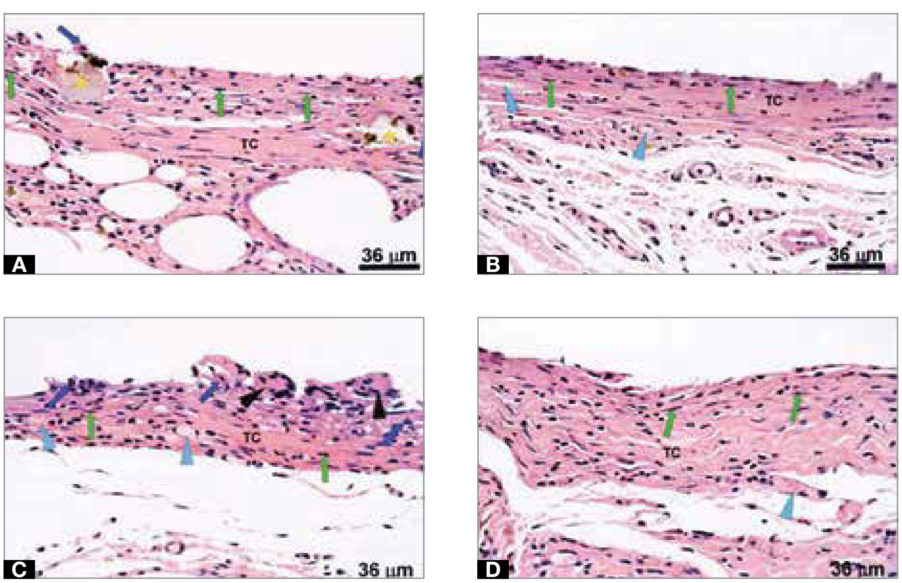

Figure 2. 30 days: **A**) Clincker without calcium sulfate; **B**) Clicker with 2% calcium sulfate; **C**) Clincker with 5% calcium sulfate; **D**) CPM sealer. (blue arrow: macrophage; blue arrow head: blood vessels; black arrow head: giant cells; CT: connective tissue; green arrow: fibloblasts; asterisk-extruded material). HE 40x

decreasing in quantity. There were few blood vessels and absence of inflammatory cells, with no statistical significant difference among materials ($p < 0.05$) (Fig 3).

In the three experimental periods the clinker without calcium sulfate showed very little inflammatory response.

In control (gutta-percha) the tissue response was similar to the 15, 30 and 60 days period, showed a thick fiber structure parallel positioned to the material. There was no statistical significant difference among the different periods ($p < 0.05$) (Fig 4).

Figure 1 to 4 shows tissue response for grey Portland cement clinker without calcium sulfate, grey Portland cement clinkler with 2% or 5% calcium sulfate, Endo CPM sealer and control.

Table 1 show mean scores attributed to the inflammatory cells, adjacent to implanted material surface at 15, 30 and 60 days.

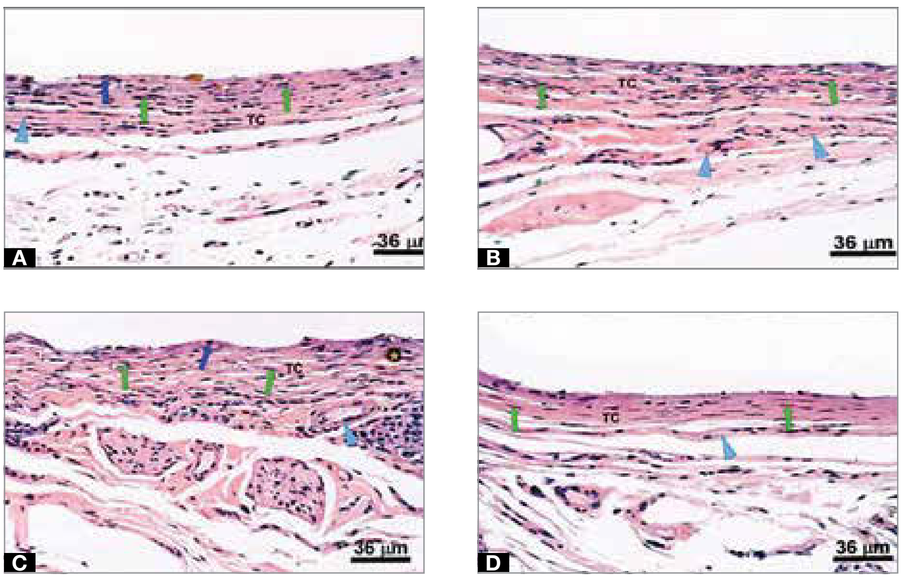

Figure 3. 60 days: **A**) Clincker without calcium sulfate; **B**) Clicker with 2% calcium sulfate; **C**) Clincker with 5% calcium sulfate; **D**) CPM sealer.(blue arrow: macrophage; blue arrow head: blood vessels; CT: connective tissue; green arrow: fibroblasts). HE 40x

Figure 4. Control: gutta-percha **A**) 15 days; **B**) 30 days; **C**) 60 days. (blue arrow: macrophage; blue arrow head: blood vessels; CT: connective tissue; green arrow: fibroblasts). HE 40x

Table 1. Mean scores attributed to the inflammatory cells, adjacent to implanted material surface at 15, 30 and 60 days period.

	15 d	30 d	60 d
Endo CPM Sealer	2	1	1
Clinker	0	0	0
Clinker + 2% $CaSO_4$	1	1	1
Clinker + 5% $CaSO_4$	1	2	1

Scores: 0 – no reaction, 1– mild reaction, 2 – moderate reaction, 3 – severe reaction.

Table 2. Mean of initial and final setting times (values expressed in minutes).

Material	Initial setting Time	Final setting Time
Endo CPM Sealer	6	22
Clinker	5	55
Clinker + 2% $CaSO_4$	8	95
Clinker + 5% $CaSO_4$	10	110

Setting time

The initial and final setting time for all material are shown in Table 2. Endo CPM sealer show shortened initial and final setting times (6/22 min); Clinker without calcium sulfate show initial setting time 5 min and final setting time 55 min, followed by clinker with 2% sulfate calcium (8/95 min), clinker with 5% sulfate calcium (10/110 min).

Discussion

Several studies examined the similarities in the physical, biologic and microbiologic aspect of MTA and Portland cement.[4,6,7,9,10,12,18,24]

The present study shows that all the tested materials presented a similar behavior with small differences regarding to the evaluated periods. During the literature review, there were no found *in vivo* biocompatibility studies about the gray Portland cement clinker. Consequently, a comparison among the materials was performed since they have the same composition of Portland cement clinker. The good biocompatibility of MTA and Portland cement was verified in several studies and is basically attributed to calcium hydroxide formation after hydration.[4,13,14]

In 15 days period, Portland cement clinker without calcium sulfate exhibited the smallest amount of inflammatory cells in comparison to another cement without statistical significant differences. Few specimens showed overfilled cement. Collagen fibers density, in 30 and 60 days periods, increased providing a more organized and dense fibrous capsule with decrease of the fibroblast number and blood vessels decreased when compared to shorter periods, demonstrating a better organization and tissue maturation with time. A thin fibrous capsule, with few chronic inflammatory cells (macrophages, lymphocytes, and multinucleated giant cells) circumscribed the material, in the 15 days period. These cells diminished in the 30 and 60 days periods.

Regarding to materials setting time studies show an initial setting time of 40 minutes for MTA ProRoot and 12 minutes for MTA-Angelus[11,20,25] MTA final setting times reported are 140-170[11,20,24] and Portland cement initial and final setting times have been 70 minutes and 170 minutes [20,25] respectively. In our study we observed that clinker Portland cement without calcium sulfate exhibited the smallest initial setting time (6.18 minutes), followed by Portland cement clinker with 2% calcium sulfate (9.22 minutes), and Portland cement clinker with 5% calcium sulfate (10.06 minutes). The results of setting time of Portland cement clinker are similar to the results reported by Camilleri[15] that reported initial and final setting times of 6 and 12 minutes.

Conclusion

The inflammatory response of grey clinker Portland cement without or with 2% or 5% calcium sulfate is similar when they were implanted in mice's subcutaneous tissue for 15, 30, and 60 days. Endo CPM sealer show the smallest initial and final setting time following by grey clinker Portland cement without calcium sulfate, grey clinker Portland cement with 2% and 5% calcium sulfate. Calcium sulfate delayed the grey Portland cement clinker setting time.

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In vitro evaluation of two techniques to determine working length with an electronic apex locator

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ABSTRACT

Objective: To verify *in vitro* whether an electronic apical location using a non-foramen by-pass technique influences the accuracy of the procedure. **Methods:** Fifteen incisors and canines human teeth with complete apical formation were used. Teeth were fixed to a resin-based model and embeded into alginate to serve as a conduction medium for the eletronical readings. Using a K-flexofile #20 coupled to the apical locator device (Root ZX II, J Morita, Kyoto, Japan), root canals were electronically measured at two different time-points. Firstly, it has been registered before passing through the apical foramen (alternative technique) and, thereafter with the file bypassing the apical foramen (recomended technique). On both techniques the readings were performed whenever the display was stabilized at level 0.5. After each electronic determination, the tooth was radiographed with the file in position. To measure the agreement between the two techniques, the interclass correlation statistical procedure was used. **Results:** The difference between the two techniques at the radiographic evaluation was 0.118 mm (± 0.170) and for the electronic reading 0.086 mm (± 0.398). The two techniques were significantly correlated both for the electronic reading and for the radiographic evaluation (ICC = 0.98; $p < 0.001$, ICC = 0.97; $p < 0.001$, respectively). **Conclusion:** The alternative technique for electronic apical location, without passing the foramen, has shown similar accuracy as the standard technique, sugested by the manufacturer.

Keywods: Endodontics. Tooth Apex. Odontometry.

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Introduction

Odontometry is an indispensable step in endodontic therapy, in which the objective is to determine with the greatest possible accuracy, the working length (WL). However, the ideal WL for treatment of root canals has always been a much discussed and controversial topic. Sjogren et al[1] in an epidemiological study found that when the apical limit of obturation was at 2 mm from the radiographic apex, endodontic treatment had a better prognosis. These results were best explained by Ricucci and Langeland,[2] which in a histological study found the best repair conditions when the instrumentation and obturation remained near the apical constriction, and when there was cement or gutta percha extrusion a severe inflammation was evidenced. Thus, the instrumentation and obturation must remain, preferably, in the narrower part of the root canal, i.e., the apical constriction, for the preparation in this point provides a smaller diameter wound, providing better conditions for repair.[2]

The most popular method for establishing the working length is the radiographic method, which is based on the premise that the apical constriction is located between 0.5 and 1 mm from the radiographic apex.[3,4] However, this radiographic estimate can lead to over- or under-instrumentation/obturation. Moreover, the determination by radiographic means has several limitations such as distortion, shortening and lengthening of the image, interpretation variability, besides representing an image in three dimensional structures in two dimensions.

Currently, the odontometry method considered more accurate is the electronic one, using electronic apex locators (EAL).[5] The desire to establish the limit of electronic instrumentation is quite old. Suzuki[6] proved that the electrical resistance between an instrument inside the canal and an electrode present in the oral mucosa showed consistent values. Sunada[7] considering this information made a clinical application, developing a device that indicated constant electrical resistance when the tip of an instrument inserted into the root canal reached the periodontal membrane, through the apical foramen. Later, Ushiyama et al[8] reported that the lowest intensity of the electrical impedance was obtained when the electrode reached the apical constriction, changing the foramen location concept (location of periodontal membrane) from biological to physical, ie, in dependence of determining the apical constriction.

In recent years, the EALs have become popular, however, according to the manufacturers, in order to ensure that the narrowest point in the root canal detected by the locator is in fact the apical constriction, it is necessary to surpass the apical foramen and regress the instrument to the point of constriction. However, this standard method recommended by the manufacturer can possibly cause injuries to the apical tissues, in cases of teeth with vital pulp, and in cases with necrotic pulp result in extrusion of necrotic material. Thus, from a biological standpoint, during the electronic measurement of the WL, ideally, the instrument should not exceed the apical foramen, reaching the periapical tissues. However, the use of this alternative approach without passing through the apical foramen may result in lower accuracy or inaccuracy in apical location. Still, this hypothesis has not been tested yet.

Thus, this *in vitro* study was designed with the objective of determining whether the technique of electron odontometry not exceeding the apical foramen influences the accuracy of the measurement. The null hypothesis tested is that the measurements obtained with the alternative technique does not correlate with the standard technique.

Materials and methods

Selection and preparation of samples

This study was approved by the Research Ethics Committee of the University CEUMA (protocol number 00519/11). Fifteen human extracted teeth, upper and lower, single rooted (incisors, canines, and premolars) and with completely formed apices were selected. The teeth were stored in sodium hypochlorite 2.5% for six hours and then stored in sterile saline solution. The crowns of the teeth were horizontally sectioned at the cementoenamel junction in order to simplify the access to the root canal and get an occlusal reference point reliable and stable. Gates-Glidden drills 4 and 3 were used to expand the coronary third. The canals were irrigated with saline solution and patency was assessed with the aid of a file #10 (Flexofile).

The teeth were fixed in a resin model and soaked up to 2 mm below the cementoenamel junction in alginate molding (Jeltrate II, Dentply, Petrópolis Brazil)[9] which was used as a conducting medium for electronic apical locations. The alginate was prepared according to the recommendations of the manufacturer. A steel wire, 0.5 mm thickness, was set in the resin model to serve as a dimensional reference for the measurements performed on radiographs.

Electronic and Radiographic Odontometry

For electronic measuring the root canals were put in a sodium hypochlorite 1% solution and labial connector of the appliance remained immersed in wet alginate. A Flexofile #20 was attached to the connector on the device Root ZX II (J Morita, Kyoto, Japan).

The root canal of each tooth was measured by two techniques which presuppose or not the file passing by the apical foramen to perform the measurements. In the first measurement, named alternative technique, the file was gently introduced into the root canal watching on the device display the progress that occurred until the value 0.5 remained stable. At this time, the course of silicone was adjusted in the reference and a radiographic technique of parallelism was performed using a digital X-ray sensor (Schick Technologies, Inc., Long Island City, NY) and X-ray Seletronic model (Dabi Atlante, Ind. Dental Medicine, Ribeirão Preto) set to 70kV and 8 mA. After radiography, the file was removed from the root canal and the distance from the tip of the instrument until the cursor was recorded using an electronic caliper with zoom at 0.01mm (Mitutoyo Digimatic).

In the second measurement, performed by the standard technique recommended by the manufacturer, the file was again gently inserted into the root canal until the buzzer emitting a continuous beep and the word “APEX” flashed on the LCD screen of the device. Then the file was retracted to the position indicated on the display stabilized at 0.5. The cursor was again adjusted and another radiograph was performed under the same conditions of the first. The file was removed from the root canal and the distance from the tip of the cursor to the file was recorded with a digital caliper.

All measurements were performed at an interval of 1 hour, remaining the alginate sufficiently wet during this time. Measurements were performed after the canals were irrigated with 2 mL of sodium hypochlorite (Biodynamics, São Paulo, Brazil). A single experienced operator in the use of electronic apex locator conducted electronic and radiographic measurements.

Radiographic images reading, data tabulation and statistical analysis

Radiographs obtained after each electronic measurement technique were analyzed by an independent evaluator, with the aid of the computer program Image J (National Institute of Health. USA). The distances were measured between the tip of the instrument and the radiographic apex taking as dimensional reference the 0.5 mm steel wire image incorporated in the resin model and visible on radiographs.

The results (in mm) obtained were tabulated for both methods, radiographic and electronic. The intraclass correlation coefficient (ICC) was used to measure the degree of agreement between the two techniques (standard and alternative) for each of the methods (electronic and radiographic).

In all tests the significance level was 0.05 and the statistical program used was SPSS version 17.00 (SPSS Inc. Chicago, IL, USA).

Results

The data obtained in electronic and radiographic measurements for standard and alternative techniques are shown in Table 1.

The result of the intraclass correlation to the measurements obtained in electronic measurement was highly significant (ICC = 0.97, $p < 0.001$), indicating high concordance between the two techniques.

For the radiographic method, the intraclass correlation was also significant (ICC = 0.98, $p < 0.001$), indicating a good agreement between the two radiographic techniques observed.

Table 1. Mean and standard deviation of measurements by standard and alternative techniques of WL and the difference [modulus] between techniques in each method assessed.

Eletronic Measurement (mm)			Radiographic Measurement (mm)		
Standard	Alternative	Difference Standard / Alternative	Standard	Alternative	Difference Standard / Alternative
14,328 ± 1,582	14,414 ± 1,540	0,086 ± 0,398	0,604 ± 0,471	0,722 ± 0,531	0,118 ± 0,170

Discussion

To establish WL using the EALs it is recommended to use the apical indentation technique, which consists in the introduction of the file to the foramen (where the locators indicates 0.0 or APEX) and shortly after is carried the retreat to the electronic location of the apical constriction. With this method it is possible to identify the first constriction in the crown-apex direction. However, such a procedure, specially in teeth with pulp necrosis may eventually force the extrusion of necrotic material to the periapical region with the possibility of originating a bacteremia as shown by Debelian et al.[10] In this study it was tested the hypothesis of no difference between this standard technique and an alternative one in which the reading is performed when the AL indicates the point of apical constriction, crown-apex direction, without the need to go through the apical foramen.

The results observed with the alternative technique significantly correlated with the data from the standard technique, indicating that not going through the apical foramen did not alter the apical electronic localization accuracy of the device used (Fig 1). This correlation between the two techniques was also confirmed in radiographic evaluation (Fig 2). Thus, the null hypothesis suggested in this work was rejected.

The Root ZX device uses the "ratio method" to locate the apical constriction5 measuring impedance using two frequencies simultaneously. This device has demonstrated, in *in vivo* and *in vitro* studies, when used according to the manufacturer's recommendations and with apical transposition, an accuracy ranging from 85% to 97.37%.[11-14] In the present study, the alternative technique was used before the standard technique, once it was aimed in the alternative technique to determine the first apical constriction without any prior foramen transposition. It is also known that the pre-expansion of root canals increases the accuracy of the apical location with the Root ZX,[15,16] and therefore Gates Glidden drills were used in the cervical preparation of root canals.

Tinaz et al[17] and Meares and Steiman[18] showed that different concentrations of sodium hypochlorite solution did not influence the reading of EALs. Due to hypochlorite being used as irrigant in clinical situations, it was used hypochlorite 1% during the reading of WL in this study.

In vitro studies of EAL should use material allowing the simulation of the periodontal ligament and it must conduct electricity.The most commonly used materials for this purpose are agar,[19] gelatine,[20] saline solution[18] and alginate,[21] however, a study conducted by Baldi et al[9] showed that the alginate was the way providing more consistent results with the real working length,and for this reason it has been used as a means of electrical conduction in this research. During this study, measures andradiographs were performed only when the display of the device indicated, without any

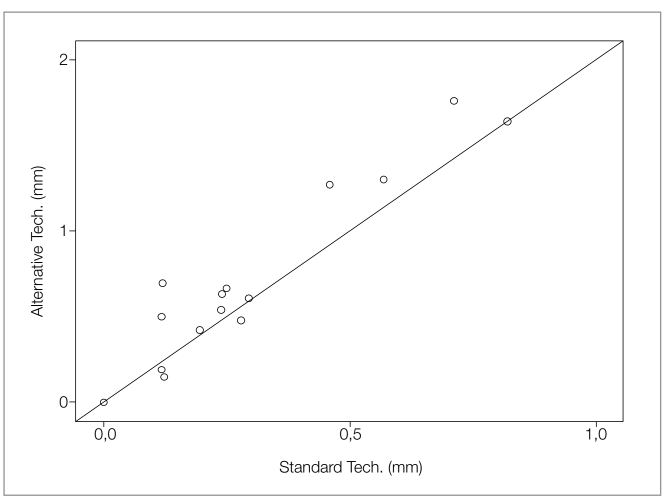

Figure 1. Correlation between the measurements obtained by the standard technique and alternative one, evaluated byradiographic method (ICC = 0,97, IC95% = 0,912-0,990, p < 0,001).

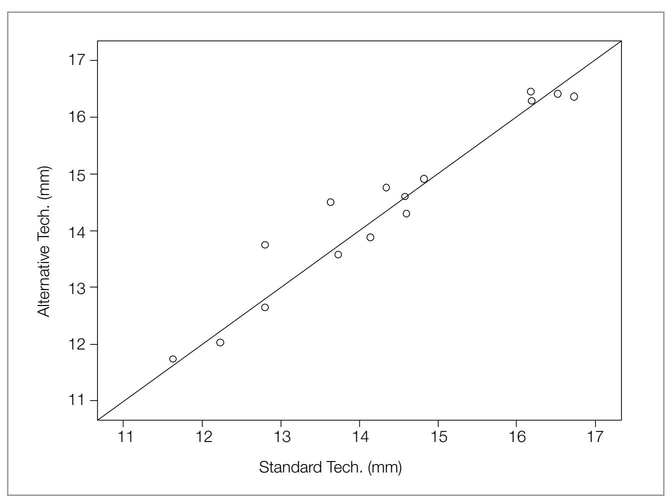

Figure 2. Correlation between the measurements obtained by the standard technique and alternative one, evaluated by clinical method (ICC = 0,983, IC 95%= 0,951-0,994, p < 0,001).

oscillation, the position 0.5. According to the manufacturer, this data indicates that the file tip is positioned exactly at the apical constriction or very close to it.

Considering that the objective of the study was to determine the accuracy of the alternative method of locating the apical constriction with and without apical transposition, the 0.5 indicator was used as reference in this study. This data was also used in other studies.[22,23]

The result of this *in vitro* study suggests that the AL technique using alternative method as described in this study haveaccuracy similar to the technique recommended by the manufacturer. However, there it is necessary further studies usingother EALs and other dental groups to prove that this principle applies regardless of these other variables, as well as *in vivo* trials to determine the same pattern observed in this *in vitro* study.

Conclusion

The alternative technique without exceeding the apical foramen showed similar accuracy to the standard technique withforamen transposition, both in radiographic and electronically measurements obtained.

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Influence of the curved root canal segments length on the fatigue fracture of rotatory NiTi instruments

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ABSTRACT

Introduction: The aim of this study was to evaluate the influence of the curved root canal segments length on the number of cycles needed to induce fatigue fracture of a rotatory nickel-titanium (NiTi) instrument. **Methods:** The instruments used in this study were Mtwo with 0.35 mm D_0 diameter, 0.02 mm/mm taper and 25 mm length. The instruments were used in two artificial metallic root canals with curved segments under 300 rpm speed. The curvatures were located in the root canals extremities and had different curved segments lengths. The device used in the rotating bending test of the selected endodontic instruments was described previously by Lopes et al.[1] **Results:** The number of cycles needed to cause fatigue fracture was influenced by the artificial root canal curved segments length. **Conclusion:** The number of cycles needed to induce fatigue fracture on the instruments used at rotating bending in artificial root canals of same radius sizes decreased with the curved segments length increasing.

Keywords: Curved segments length. Fatigue. Fracture.

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Introduction

A substantial concern when rotatory nickel-titanium (NiTi) instruments are used in curved root canals is the fatigue fracture. When used in curved root canals, these instruments undergo a rotating bending loading, which induce an alternating compressive and tensile stresses. The repetition of these stresses promotes microstructural cumulative changes that induce fatigue fracture of the endodontic instrument.[2-4]

The rotating bending test allows to identify the number of cycles that an endodontic instrument is able to resist until the fatigue fracture at a established loading condition.[2,5-7]

The number of cycles until fatigue fracture of an endodontic instrument is related to the curved root canals geometry (radius length, curved segments length and curved segments position along the root canal).

The aim of this study was to evaluate the influence of the curved root canals segments lengths of same radius on the number of cycles needed to induce fatigue fracture of a rotatory nickel-titanium (NiTi) instrument.

Material and methods

Twenty rotatory NiTi instruments Mtwo (VDW, Munich, Germany) of 0.35 mm D_0 diameter, 0.04 mm/mm taper and 25 mm length were selected.

Artificial grooves simulating two artificial canals measuring 1.5 mm in width, 20 mm in length, 3.5 in depth with U-shaped bottom and curved segments on the tips with a curvature radius of 6.0 mm were machined into AISI-316L stainless steel blocks by computer-assisted milling. The curved segments of the first canal (A) measured 9.42 mm (90-degree angle), whereas the second canal (B) measured 12.56 mm (120-degree angle). A 1 mm-thick metal plate was manufactured and screwed in front of each simulated canal. The curvature radius of the artificial canal was measured taking into consideration the concave surface of the interior of the canal (Figs 1 and 2).

The apparatus used in the fatigue test (rotating-bending) was described previously.[1] Ten instruments were subjected to clockwise rotation at 300 rpm inside each artificial canal until fracture. The time of fracture was recorded by the same operator using digital stopwatch (Technos, Manaus, Brazil) and was established when there was visual observation of the instrument fracture. The number of cycles to fracture (NCF) was obtained by multiplying the rotational speed by the time (in seconds) until fracture occurred. During the test, the artificial canal was filled with glycerin to reduce the friction of the instrument against the canal wall and to minimize the release of heat. Data relative to the number of cycles until the instruments fractured because of curved canal segments length with the same radius were obtained and statistically analyzed by the Student's *t* test at the 5% significance level.

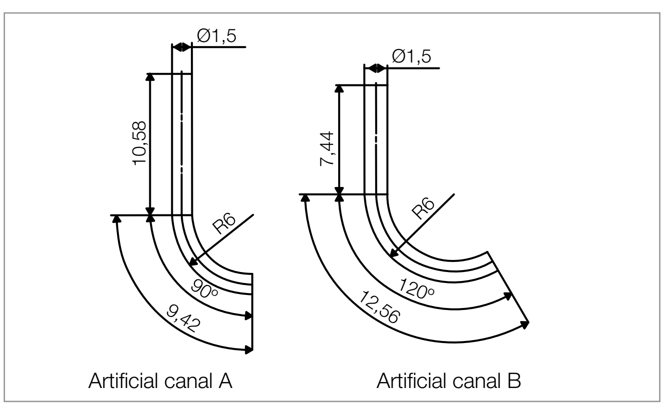

Figure 1. Schematic representation of artificial canals A and B used in the cyclic fatigue tests.

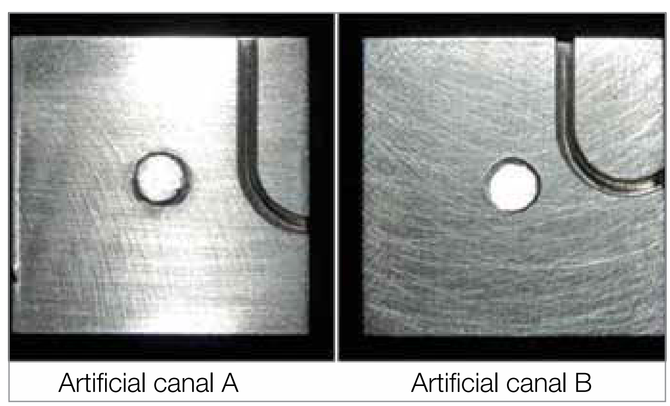

Figure 2. Artificial canals A and B used in the cyclic fatigue tests.

Results

The average and the standard deviation of the time and the number of cycles until the instrument fracture occurred are shown in Table 1.

The statistical analysis using t test showed that there was a significant difference in the number of cycles of the tested instruments in relation to the canal curved segments lengths with the same curvature radius ($p < 0.0001$).

The results showed that the Mtwo instruments tested in the canal with a 12.56 mm long curved segments (120 degrees-angle) fractured at a lower average number of cycles than those used in canals with a 9.42 mm curved segments (90 degrees-angle).

Discussion

The geometry of artificial root canals must be standardized for radius and curved segments lengths parameters to evaluate the fatigue resistance of rotatory NiTi endodontic instruments submitted to the rotating bending test. Thus, it is clear that to test the influence of the curved segments on the resistance to fatigue fracture of an endodontic instrument the other parameters must be necessarily equal.

Most studies in the literature evaluated the influence of curvature angle, not the curved segment length, on the resistance to fatigue fracture of an endodontic instrument submitted to rotating bending test.[2,6,8-12] The curvature angle is quantified in degrees, while the curved segment length is measured in millimeters. As the curvature angle is not synonymous of the curved segment length, the use of the curvature angle is doubtful, once equal curvature angle may present different radius and curvature segments with different lengths.

Table 1. Average (± SD) of the time and the number of cycles for fatigue fracture to occur in instruments based on the curved segments lengths of the artificial canals.

Curved segments (mm)	Time (seconds)	NCF
9.42	95 (13.21)	475 (66.04)
12.56	57.2 (10.17)	286 (50.87)

The curvature angle has been established by the Schneider method.[13] This method is flawed, once it does not determine the radius length, nor the curved segment length, which are decisive parameters to the resistance to fatigue fracture of endodontic instruments submitted to rotating bending test.

However, this method and the curvature fracture frequently have been applied in the evaluation of the mechanic behavior and resistance to fatigue fracture of endodontic instruments.[2,6,8-16] It is important to emphasize that the curvature angle is not quantified by the angle, but by the radius and curved segment length. The curved segment length (L) can be calculated by the curvature angle and the radius length (R), using the equation:

$$L = \frac{2\pi R \text{ x curvature angle}}{360}$$

The obtained results allows to assert the higher the curved segment length, the lower the number of cycles needed to occurrence of rotating bending fracture of a rotatory Niti endodontic instrument. The longest curved segments resulted in lower NCF values, since the location of the critical stress concentration point varies in relation to the curved segments length. Therefore, in canals with longer curved segments, the maximum stress concentration point is located where the instrument's helical shaft presents larger diameter in comparison with canals presenting shorter curved segments lengths. These results corroborate earlier studies[4,15,17] which demonstrate that the greater the diameter of the shaft at the critical stress concentration point, the lower the NCF of a given instrument.

There was significant statistical difference in the instruments NCF when compared the curved segments lengths of the artificial canals applied in this study. The results achieved agree with the described by other authors.[7,18]

Conclusion

The number of cycles necessary to induce fatigue fracture in Mtwo instruments used in rotating-bending in artificial canals with the same curvature radius decreases as the curved segments lengths increase.

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In vitro diffusion of hydroxyl ions from medicaments pastes based on calcium hydroxide

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ABSTRACT

Objective: Analyzing, *in vitro*, the pH of six endodontic pastes based on calcium hydroxide [Ca (OH) 2]. **Methods:** Six groups were formed (n = 5 pastes/group) and a control group (distilled water): GI – $Ca(OH)_2$, propylene glycol 400 (PEG 400) and camphorated paramonochlorophenol (PMCC); GII - $Ca(OH)_2$, iodoform 1:1, PEG 400 and PMCC; GIII – $Ca(OH)_2$, iodoform 4:1, PEG 400 and PMCC; GIV - $Ca(OH)_2$ and Otosporim®; GV – $Ca(OH)_2$ and olive oil; GVI - $Ca(OH)_2$ and chlorhexidine gel 2%. The pastes were previously placed in distilled water and stored at 37° C, and the pH of each sample was measured at seven different time intervals. The assay was performed in two steps, whereas in the second stage the distilled water was replaced after each reading. **Results:** In both phases, there was no statistically significant difference between the pH values of GI, GII, GIII and GIV ($p > 0.05$) in the 7 time intervals evaluated. All groups showed higher pH compared to the GV and the control group ($p < 0.05$), which were statistically similar to each other ($p > 0.05$). **Conclusion:** The pastes presented alkaline pH, with variations according to their composition, having a greater dissociation when a viscous substance was present in the composition.

Keywords: Diffusion. Endodontics. Calcium hydroxide.

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Introduction

The prevention and control of pulpal and periapical infections are crucial in endodontic treatments. The results of the endodontic therapy depend on the reduction or elimination of microorganisms and pathogenicities from periapical lesions and, therefore, the chemomechanical preparation is considered a major step in the disinfection of the root canal system. However, the elimination of bacterial strains involved in the infection process is difficult to perform and thus the intracanal medication between clinic sessions plays a fundamental role in the control of pulpal diseases.[1,2]

Calcium hydroxide [$Ca(OH)_2$] has been used in Endodontics since 1920, when Hermann employed it for the first time on direct pulp capping, and later as intracanal[1] medication. Since then, it has been widely used in clinical dentistry due to its therapeutic properties, both on its own and in the composition of cement and medicinal pastes. The success of $Ca(OH)_2$ as medication is mainly due to its ionic effect, caused by the chemical dissociation in calcium ions and hydroxyl.[3]

The hydroxyl ions diffuse through the dentin, raising the pH of the media and producing an alkaline environment, which is unfavorable for bacterial growth since it favors the lysis of the cell membranes and the inactivation of the enzymes present in the microorganisms. Such mechanisms may explain the antimicrobial activity of the $Ca(OH)_2$.[3,4] Furthermore, the hydroxyl ions activate the alkaline phosphatase, an essential enzyme in the bone repair process. Now calcium ions allow the reduction in the permeability of new capillaries present in the granulation tissue of devitalized teeth, reducing the amount of intercellular fluid and triggering the pyrophosphatase acceleration, which plays a role in the mineralization.[2,5,6]

Different substances have been used together with $Ca(OH)_2$ in intracanal medications, being that the ideal substances are those which modify as little as possible its original alkalinity.[7] Among the substances in those combinations, we have camphorated paramonochlorophenol (PMCC), propylene glycol (PEG), iodoform, olive oil and chlorhexidine, which can circulate and enhance the beneficial effects of calcium hydroxide on periradicular tissues.[1] The aqueous, soluble vehicles and the viscous, water soluble vehicles have the ability to raise the pH to an ideal alkaline value. The only difference lies in the fact that the aqueous vehicles provide a faster hydroxyl ion dissociation and diffusion than the viscous vehicles.[6]

Given the above, the objective of this study was to analyze the ionic dissociation of medicinal pastes based on $Ca(OH)_2$, in combination with different substances routinely used in clinical endodontics, and check the alkalinity of the medium, so important for the success of endodontic treatments.

Material and methods

Six types of medicinal pastes used in the treatment of various clinical situations in endodontics were manipulated, $Ca(OH)_2$ being the most common component to all of them. PEG 400 and 2% chlorhexidine gel were manipulated at Cavallieri compounding pharmacy (Juiz de Fora, state of Minas Gerais, Brazil). The other components were commercially obtained: $Ca(OH)_2$ P.A., iodoform and PMCC (Biodinâmica, Ibiporã, state of Paraná, Brazil); Otosporim® – each mL containing: polymyxin B sulfate 10,000 IU, 5 mg neomycin sulfate and 10 mg hydrocortisone (Farmoquímica, Rio de Janeiro, state of Rio de Janeiro, Brazil); and the L&C paste, composed of $Ca(OH)_2$ and olive oil (Dentsply, Petrópolis, state of Rio de Janeiro, Brazil).

Six experimental groups were formed, each group consisting of five samples of the same paste, namely: Group I – $Ca(OH)_2$, PEG 400 and PMCC; Group II – $Ca(OH)_2$ + iodoform 1:1, PEG 400 and PMCC; Group III – $Ca(OH)_2$ + iodoform 4:1, PEG 400 and PMCC; Group IV – $Ca(OH)_2$ and Otosporim®; Group V – $Ca(OH)_2$ and olive oil; Group VI – $Ca(OH)_2$ and 2% chlorhexidine gel.

The thick, toothpaste-like consistency type of medicinal paste is often recommended by professionals, being that the powder/liquid ratio varies widely.[3,7] In order to determine the proportions of each component, the amount equivalent to a measuring spoon was used, whose volume corresponds to 0.13 cm^3 to measure powdered substances. For liquid substances, the approximate measure of the volume of one drop (0.05 ml) was used. Five manipulations were performed, based on the desired consistency (toothpaste), and, at the end, the proportion of each substance used in the experimental manipulation was established.

Each of the five pastes in each group was manipulated and the amount equivalent to a measuring spoon – 0.13 cm^3 – was separately placed in containers holding 15 ml of distilled and deionized water. One of the containers did not receive the paste, remaining with only 15 ml of distilled and deionized water, working as negative control. The samples were duly stored in closed flasks and kept at 37° C in order to remove the effects of the environment until all measurements were performed.[2]

In the first stage of the experiment, the pastes analyzed remained immersed in distilled water during all the periods of the analysis, and the readings were called GIA, GIIA, GIIIA, GIVA, GVA and GVIA for the respective groups. In the second stage of the assay, exchanges were performed between each reading of the distilled water in which the pastes were immersed, and the readings were called GIB, GIIB, GIIIB, GIVB, GVIB and GVB for the respective groups.[8] For the analysis of the ionic dissociation of the medicinal pastes for each group, a digital pH meter (Model PH 710, state of São Paulo, Brazil) was used, being duly calibrated with standard buffer solutions with pH 7.0. ± 0.02 and pH 4.0 ± .02. Such apparatus consists of a glass electrode (EPC 70) connected to a digital display which allows reading the pH value. For the measurements, the calibrated microelectrode was kept in contact with the solution for about 45 seconds until the pH reading was established.[9]

The measurements were done with 15 and 30 minutes, 1.24 and 48 hours, and 7 and 14 days after manipulation. The pH values found in function of the time intervals were duly entered in a Microsoft Excel® spreadsheet program, through which the average of the five pastes of each group was calculated. The data were analyzed by using the statistical program SPSS 15.0 for Windows (Chicago, USA). The variance analysis (ANOVA) was performed, followed by the Scheffé post-hoc test for comparisons between groups of medicinal pastes. The significance level was set at 5%.

Results

In the first stage of the experiment, the average value of GIA at t = 15' was pH = 10.40; with exponential growth until t = 24 h (pH = 12.16) and stabilization at t = 14 days (pH = 12, 31). Statistically similar pH readings ($p > .05$) occurred in the other groups analyzed: GIIA 15 '(pH = 0.33), 24 h (pH = 12.17) and 14 days (pH = 12.24); GIIIA 15' (pH = 10.46), 24 h (pH = 12,21) and 14 days (pH = 12.32); GIVA 15' (pH = 10.62), 24h (pH = 12.21) and 14 days (pH = 12.31); GVIA 15' (pH = 9.62), 24h (pH = 12.24) and 14 days (pH = 12.33). GVA and control groups presented similar behavior ($p > 0.05$), with pH values lower than those found for the other groups ($p < 0.05$ for all the comparisons): GVA 15' (9.17), 24h (8.98) and 14 days (8.53) and the control group 15' (9.26), 24 h (9.09) and 14 days (8.77) (Fig 1).

In the second stage of the experiment, GIB showed, at t =15', a pH = 10.38, with an increase up to t=24h (pH = 12.14) occurring, as in the first stage of the experiment, a stabilization at t=14 days (pH = 12.23). The other groups analyzed showed similar behavior: GIIB 15' (pH = 10.28), 24h (pH = 12.18) and 14 days (pH = 12.26); GIIIB 15' (pH = 10.42), 24h (pH = 12.18) and 14 days (pH = 12.26); GIVB 15' (pH = 10.56), 24h (pH = 12,20) and 14 days (pH = 12.30). GVIB showed pH = 9.63 at t=15', with a growth at t=30' (pH = 10.42) and stabilized until t=14 days (pH = 10.58). GVB and control groups showed pH values lower than the other groups ($p < 0.05$ for all the comparisons): GVB 15' (pH = 9.16), 24h (pH = 8.92) and 14 days (pH = 8.55) and control group 15' (pH = .17), 24h (pH = 9.21) and 14 days (pH = 9,18) (Fig 2).

In both phases of the experiment, there was no statistically significant difference between the pH values of GI, GII, GIII and GIV ($p > 0.05$ for all the comparisons). All groups showed higher pH compared to the GV and the control groups ($p < 0.05$ for all the comparisons), which were statistically similar to each other ($p > 0.05$ for all the comparisons). The control group remained with no significant changes in pH throughout all the periods.

GVI showed a particular behavior, with an initial pH statistically lower than the GI, GII, GIII, GIV and higher than the GV and the control groups ($p < 0.05$ for all the comparisons). In the first stage, when there was no water exchange, the pH values for GVIA showed initially to be lower but with exponential growth, following the behavior of the groups GIA, GIIA, GIIIA and GIVA. In the second stage of the experiment, in which medium water exchange was carried out , GVIB showed an alkaline pH, but with lower values throughout the periods compared to groups GIB, GIIB, and GIIIB GIVB ($p < 0.05$ for all comparisons).

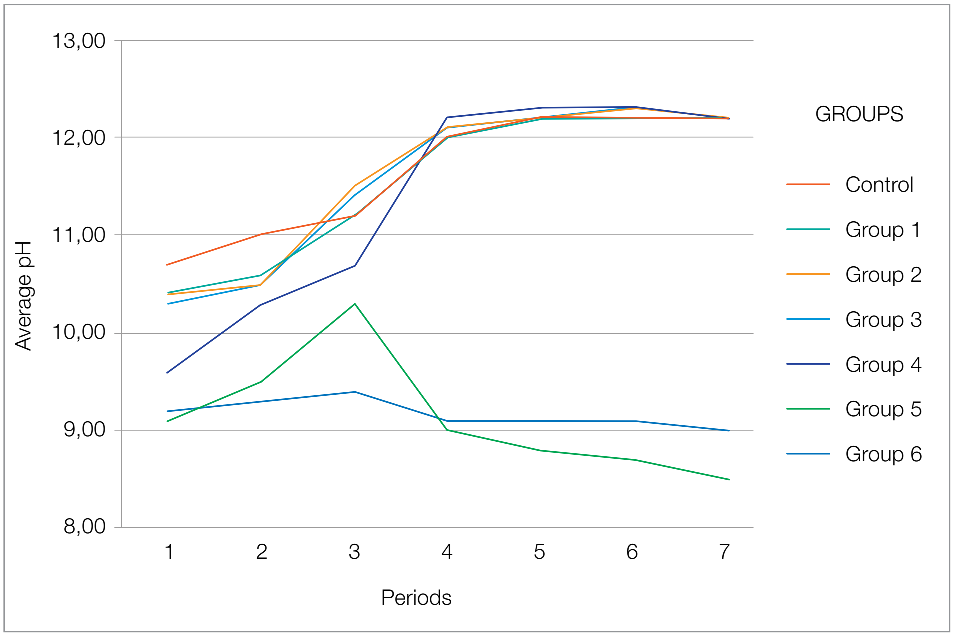

Figure 1. Alteration of the average pH against time, produced by the medicinal pastes in the first stage of the assay.

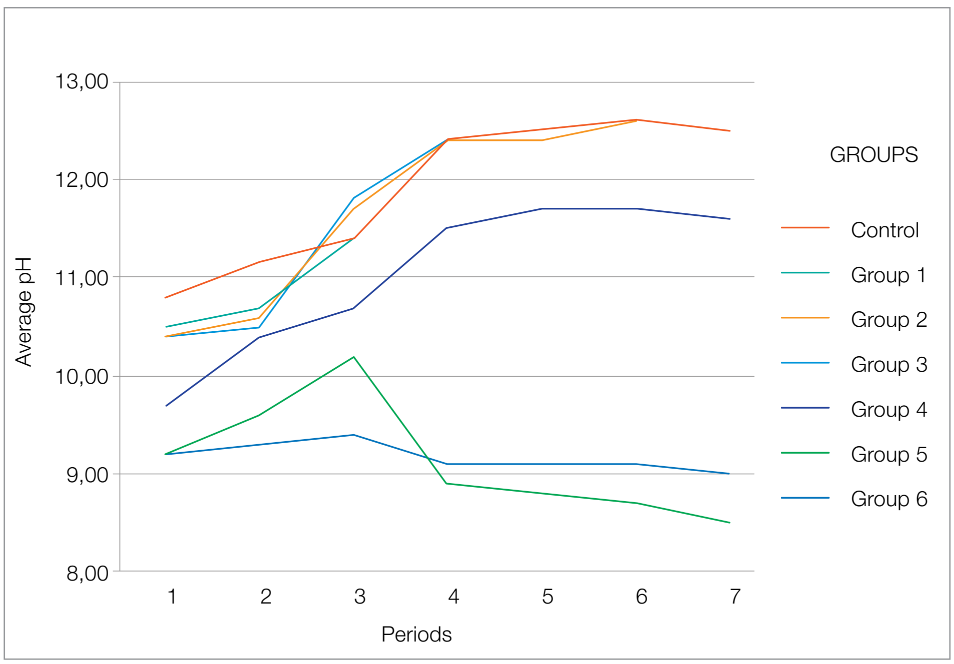

Figure 2. Alteration of the average pH against time, produced by the medicinal pastes in the second stage of the assay.

When comparing the two stages of the assay, it was observed that in the second stage (with periodic exchange of water where the pastes were inserted) pH values were lower, however, such difference decreased over the periods. Such difference was not statistically significant ($p = 0.709$).

Discussion

The combination of various substances to the $Ca(OH)_2$ has been proposed as a way to enhance its beneficial effects to periapical tissues.[7] Among those, we highlight the importance of the alkalinization promoted by $Ca(OH)_2$-based pastes in the success of endodontic treatment in various common clinical situations, like in cases of pulp necrosis, especially with periapical lesions, root resorption, and during the preservation of dental trauma.

The inflammatory and infectious processes promote tissue pH acidification, which is ideal for the growth of microorganisms. The alkaline atmosphere created by the $Ca(OH)_2$ often prevents the development of those processes, and such effect is directly proportional to its alkalinizing potential. The alkaline pH promoted by such medications are effective in stopping the growth or eliminating pathogenic strains present in persistent endodontic infections, such as Enterococcus faecalis.[1,10,11]

The effects of the dissociation of hydroxyl ions, through the reading of pH values, and the release of calcium ions from different vehicles added to the $Ca(OH)_2$ were studied by several authors.[6,8,9,12-16] In all those experiments, we found higher pH values for pastes with viscous vehicle, which, theoretically, provide a faster ionic dissociation to hydroxyl ions than oily vehicles. That statement is consistent with the results of the present study, in which the vehicles with viscous pastes (GI, GII, GIII, GIV and GVI) had higher pH values regarding the combination containing olive oil (GV), an oily vehicle.

The use of a pH meter with high impedance increases the accuracy of the results, as well as provides numeric data which can be analyzed. Although other methods may be used, such as the paper strips with pH indicators, these have lower precision and can hinder the accurate interpretation of the results.[17]

The pH measurement periods must comply with the time required for the manipulation of the pastes, their insertion in flasks containing distilled water and the beginning of the analyses. In the present study, the first measurements were performed after 15 minutes, since, according to the methodology applied, lower periods would be impossible due to the number of flasks to be measured in each group by the same operator. We observed that in some studies, however, pH measures with similar methodologies were carried out in shorter periods of time.[1,9,15,16]

The results of the present study demonstrated that in the first stage of the experiment, most groups have kept alkaline initial pH with exponential growth up to the period of 24 hours. After that period we observed equalization and stabilization of the pH reading. Such behavior, however, was not observed for GV – $Ca(OH)_2$ and for olive oil – as well as for the control group: besides presenting a lower pH than the other groups, they also showed an inverse behavior, with a pH decrease during the periods observed. Such pH behavior is consistent with the results found by Pacios et al,[14] Ferreira et al.[15] and Nunes and Rocha.[18]

The regular exchange of the water where the pastes to be tested were immersed in the second stage of the experiment was performed to avoid saturation of the medium, since it would not present ion exchange, as it occurs in the clinical situation of the intracanal medication.[8] Those authors showed that the pH values of the medicinal pastes they studied were different for most of the groups only in periods prior to 24 hours. From that range, such groups showed no pH changes between each other, indicating no interference of such variable. They concluded that all pastes presented similar pH behavior in all periods analyzed. Such findings are in agreement with the results in the present study for the majority of the pastes analyzed (GI, GII, GIII and GIV).

Calcium hydroxide has been currently the most widely used intracanal medication. According to Herrera et al,[19] calcium hydroxide is a suitable material to be used as delay dressing in teeth with periapical lesion, since the long-term assessment demonstrates satisfactory clinical results after the endodontic treatment. Most likely, its mineralizer and antimicrobial effect is due to its chemical dissociation in calcium ions and hydroxyl.[20]

The addition of some substances to the $Ca(OH)_2$ for the formulation of a clinically viable medicinal paste must preserve its main properties, such as chemical dissociation in calcium and hydroxyl ions, alkaline pH and tissue biocompatibility. It is believed that most of the combinations proposed in this study preserved the ionic characteristics desirable for an endodontic drug.

Conclusion

The medicinal pastes examined had alkaline pH values, whereas the pastes with viscous vehicles (PEG, PMCC, Otosporim® and chlorhexidine) showed high pH values compared to the ones found for the combination containing olive oil, an oily vehicle. The water exchanges in the media were the medicinal pastes were immersed did not interfere significantly in the ionic dissociation of the combinations.

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Endodontic Treatment of a fused mandibular incisive

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ABSTRACT

Introduction: Dental fusion is characterized by the union of two dental germs during the development stage, in consequence of the germ layer aberration in the ectoderm and mesoderm. **Objective:** The purpose of this study was to describe the endodontic treatment of lower incisor with supernumerary tooth. **Methods:** Patient sought for attention with spontaneous and severe pain in tooth #41. The dental element presented atypical crown, with aspect of fusion. By the radiographic image was observed the presence of single root and two root canals. It was determined the necessity for endodontic treatment, performed by nickel-titanium instruments. Each instrument exchange was carried out irrigation with 2.5% sodium hypochlorite solution and 17% EDTA. The filling was performed by active lateral condensation technique of gutta-percha associated to cement and complemented by thermofilling. The cone beam tomography was realized for the filling quality verification and inner anatomy architecture. The patient returned to clinical and radiographic control of 1 year with the tooth showing signs of normality. **Conclusion:** The dentist should develop competence and ability for the adequate diagnosis of dental anomalies, providing good conditions for the promotion of patients' oral health.

Keywords: Ebstein Anomaly. Endodontics. Dental Pulp.

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Introduction

Anomalies are defects caused by genetic disturbances and environmental factors during the dental formation.[1-3] The tooth development begins around the sixth week intrauterine and is divided in many stages. Any alteration in any of these phases can result in the abnormal development of size, shape and dental structure.[3-5] The anatomical changes, as a result of formation anomalies, can lead to changes in the dental crown, root and root canal.[6,7] In cases of fusioned teeth, the crowns are fused by the enamel and/or dentin, but show two roots or two root canals in single root.[8] It is characterized by the union of the two dental germs during the developmental stage, in consequence of the aberration in the germinative layer of the ectoderm and mesoderm.[9,10] The fusion etiology is unclear, but the influence of the pressure or physical forces producing close contact between two teeth in development, genetic predisposition and racial differences have been reported as possible causes.[9,11] Canines and incisors are the most affected, rarely occurs in molars and there is no prediction when the dental arches are compared.[12,13] In the permanent dentition, it has low incidence (0.1%), while in the primary one it appears around 0.5%, equally distributed in genders.[14] In thorough clinical and radiographic exams, it shows to be differentiated from germination cases.

Gemination is defined as the attempt of dental germ division by the invagination during the developmental stage.[15,16] The reduction of teeth number in the dental arch is not observed and, by imaging exam, one root and one pulp chamber is noted in a single crown, partial or totally separated.[15,17] In these cases, the two parts of the crown are symmetric.[16]

In the anterior region, the presence of anomalous tooth can cause an undesirable anatomical aspect due the irregular crown morphology. There is greater predisposition to dental caries and periodontal diseases and, in some cases, difficulties in endodontic treatment in consequence of the alteration in radicular shape.[17] The endodontic treatment has the goal of ideal cleaning, by instruments, irrigants, intracanal dressing and finalization with endodontic and coronal sealing.[18] The morphological endodontic characteristics, related to frequency of number, localization, direction and shape, can determine the therapeutic success.[19] The inner anatomy knowledge is fundamental for the localization and proper treatment of the present root canals.[8,19] However, variation in normal conditions may occur. The aim of this study was to describe an endodontic treatment of a fused mandibular incisor.

Case report

A 24 year-old female patient sought dental care at the Brazilian Dental Association – Branch office of Imperatriz-MA with chief complaint of severe and spontaneous pain in the inferior anterior region. In the clinical exam, the presence of all inferior teeth in the dental arch and atypical crown in tooth #41 were observed (Fig 1A). The tooth presented large crown towards mesio-distal and fusion appearance of #41 and supernumerary tooth (Fig 1B). The radiographic exam showed normality aspect in the periapical region, however, differentiated anatomy, featuring the dental element fusion and the presence of single root with two radicular canals (Fig 3A). The vitality pulp test was realized with EndoFrost (Roeko- Wilcos do Brasil Ind. e Com. Ltda, Rio de Janeiro, Brazil), the response was positive, featuring the probable clinical diagnosis of symptomatic pulpitis. Then, the necessity of endodontic treatment was determined. Initially, the patient was anesthetized and in sequence, the absolute isolation of operative field with rubber dam and clip 212 (Fig 2A). The coronal opening was realized with 1014 long shaft spherical diamond tipped (Maillefer, Dentsply, Baillagueses, Switzerland) and Z-Endo (Maillefer, Dentsply, Baillagueses, Switzerland). The entrance orifices were located and the exploration done by 10, 15 and 20 K-file instruments (Maillefer, Dentsply, Baillagueses, Switzerland). The cervical and medium third of the radicular canal were prepared with Line-Angle Axxess 20.06 bur (SybronEndo, Sybron Dental Specialities, USA). The working length was determined in 22 mm for both root canals (Fig 3B). The cleaning and shaping of the root canal were done in sequence with ProTaper® (Maillefer, Dentsply, Baillagueses, Switzerland) Ni-Ti instruments, from the F1 to F5. In each instrument changing, a copious canal irrigation with 2.5% sodium hypochlorite and 17% EDTA (Biodinâmica, Quím. e Farm., Ibiporã-PR, Brazil), for 5 minutes, was performed and finalized by the final irrigation with 5mL of 2.5% hypochlorite. The gutta percha cone proof was determined according to the last instrument diameter used in the preparation. The root canal filling was realized by the lateral condensation technique, using principal and accessories gutta-percha points (Dentsply, Petrópolis, RJ, Brazil), Sealapex® cement (SybronEndo, Sybron Dental Specialties, USA) and by n.55 MacSpadden gutta condenser (Maillefer, Dentsply, Baillagueses, Switzerland). After the root canal filling, a final toilet of the coronary chamber was done and the tooth sealed with universal restaurateur Filtek Z-350 XT (3M ESPE, Sumaré, SP, Brazil) (Fig 3C). The patient returned for one-year follow-up with the tooth in occlusal function, absence of pain, fistula, edema, periodontal pocket, tooth and tissue with normal color, radiographic (Fig 3D) and tomographic (Fig 4A to 4D) aspects of normality.

Discussion

Although there is wide literature about dental gemination and fusion, heated debate about the appropriate nomenclature happens. Usually, the definition occurs by the amount of tooth present in the arch or the aspect of radicular morphology.[20] Both dental fusion and gemination are formation anomalies characterized by teeth with large clinical crowns and by the imaging exams may present one or two pulpar chambers and two root canals.[8,17] Fusion,

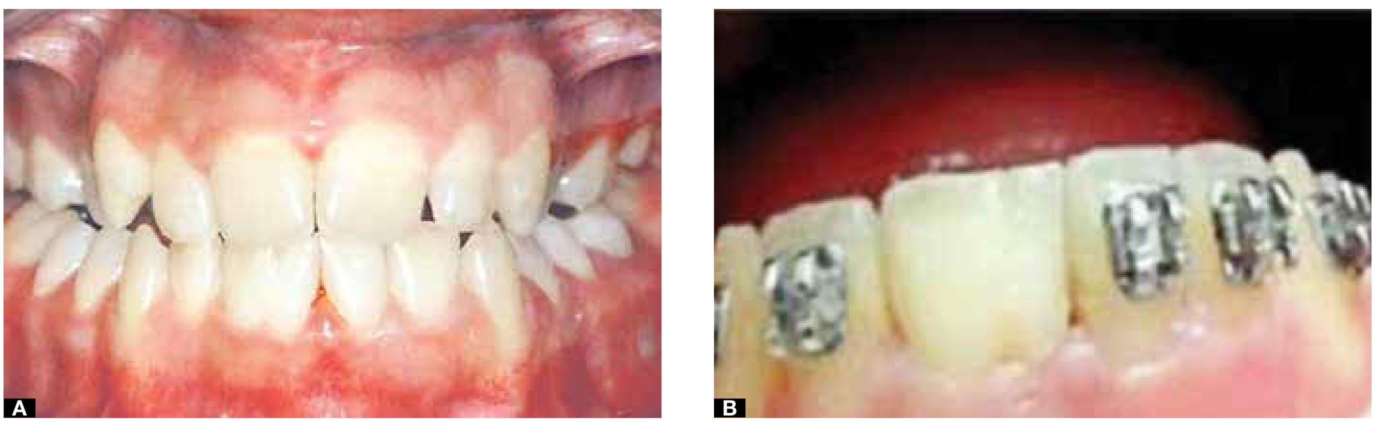

Figure 1. A) Image of the presence of all mandibular teeth in the arch, and atypical crown in the #41 **B)** Clinical aspect of the large crown e appearance of fusion between #41 and supernumerary.

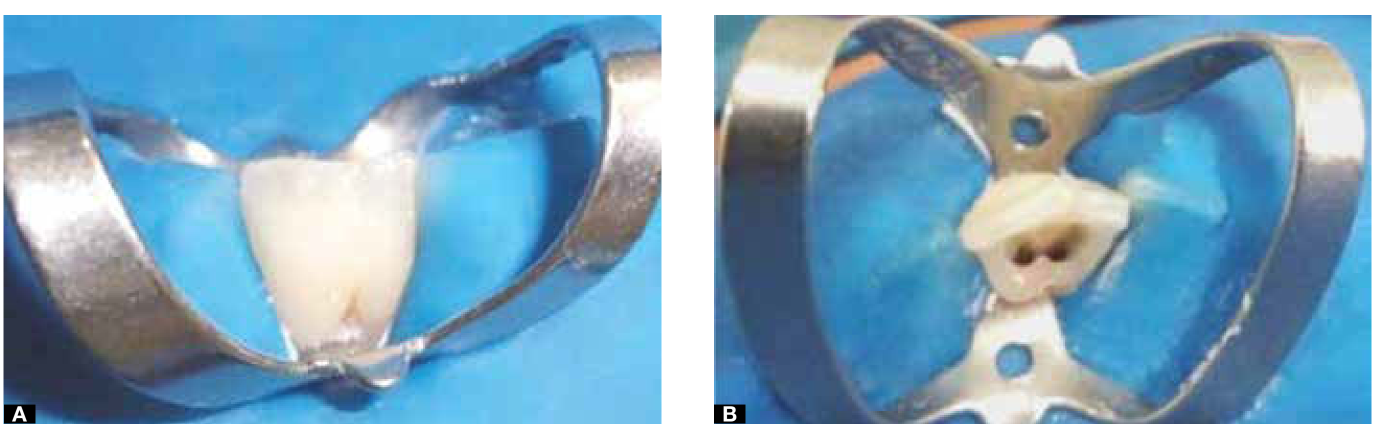

Figure 2. A) Image of the absolute isolation of operative field with rubber dam and clip 212. **B)** Coronal opening and the entrance orifices were located.

Figure 3. A) Image of periapical radiograph showing normal aspect and differentiated anatomy, featuring the dental element fusion and the presence of single root with two radicular canals. **B)** Determination of working length. **C)** Root canal filling and tooth sealed with universal restaurateur. **D)** One year follow-up.

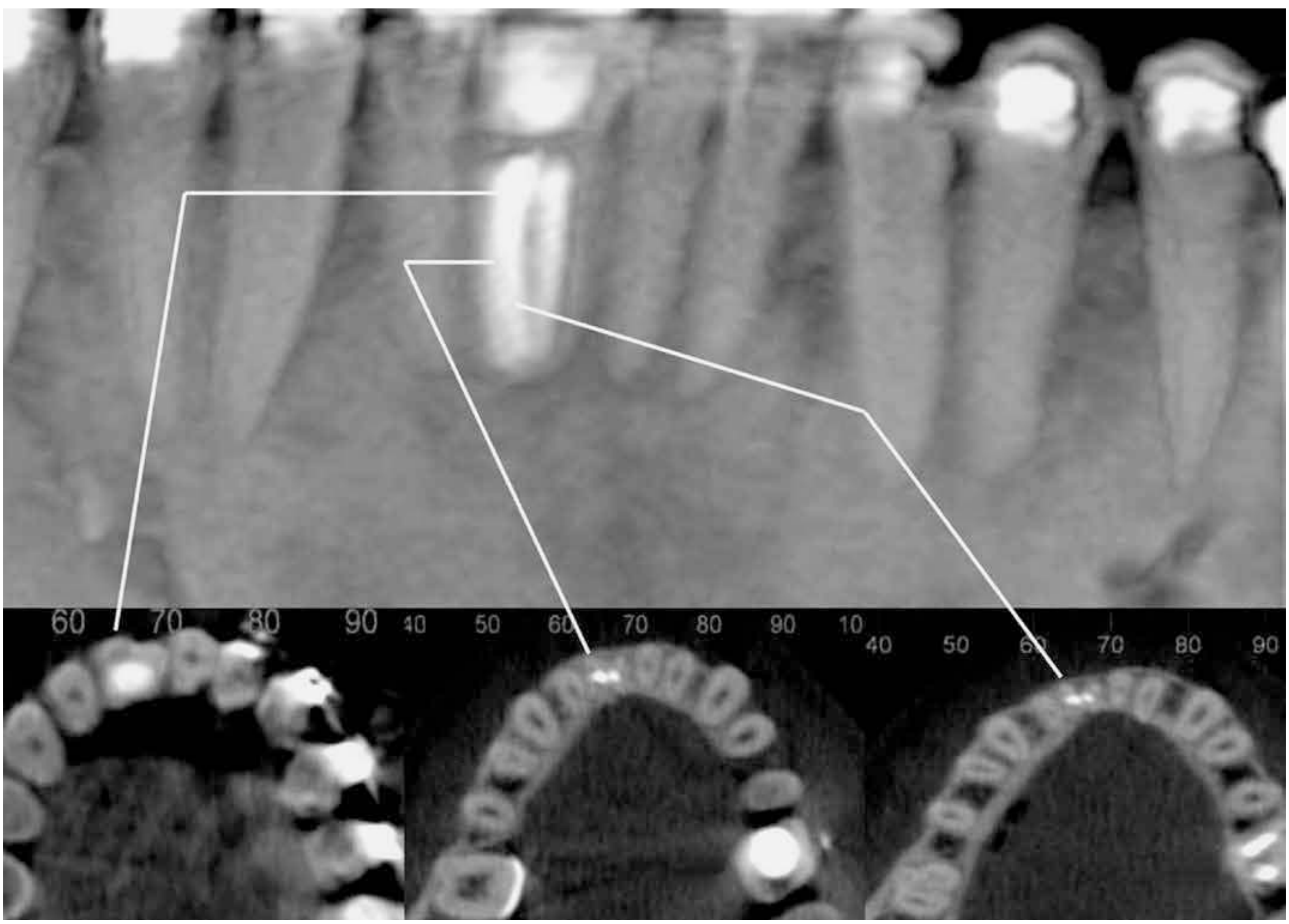

Figure 4. A) Image of panoramic exam, showing tooth #41 filled. **B)** Axial cut showing the cervical third of the tooth #41 root canal **C)** Axial cut showing the middle third of the tooth 41 root canal. **D)** Axial cut showing the apical third of the tooth #41 root canal.

conceptually, is defined as the union between dentin and/or enamel of two or more teeth in developmental stage, being partial or total, depending the phase in the moment of the union.[9,10] In these cases, in the dental arch are found less teeth.[9,11-14] By other side, the gemination is conceptualized as an attempt of dental germ division.[3,15,16] The teeth are presented with deformed appearance depending on the irregularities of the enamel.[21] The tooth amount present, in function of this situation, is not altered.[3] A rare case of fusion between a central inferior incisor and supernumerary tooth was presented in this study. Thus, the tooth amount in the dental arch did not alter and a possibility of diagnosis of gemination was considered. In this way, the medical history and clinical-radiograpic exams are definitely important for the correct diagnostic.[17]

The fused teeth do not present clinical symptoms and therefore, do not need treatment, unless there is occlusal and esthetic interference for the patient.[7] Many conducts have been proposed in the way of this anomaly treatment, however, the dental morphology is so variable that a particular condition is recommended for each case, including surgical separation or even extraction and prosthetic treatment.[22] In the presented case, the patient showed history of spontaneous pain and based in clinical and radiographic characteristics, the endodontic radical treatment was choosed.

Dental fusion shows a great variety in pulpar chamber size, varying obliteration degree and root canals configuration, being a challenge for the endodontists.[8,17,20] The anomaly can be confirmed by imaging exam and the success of the treatment depends on the cleaning of the root canal system.[19] The complications during the endodontic treatment are related to irregular dental morphology, increasing the difficulty of instrumentation and filling.[17] Thus, the clinical and radiographic exams are determinant for the success of endodontic therapeutic. In this context, the computed tomography is an effective resource for diagnostic and treatment of fused teeth in function of greater clarity that this exam offers to recognize inner and external anatomy.[23]

Conclusion

Dental fusion is a developmental anomaly characterized by the union of two dental germs, diagnosed by clinical and radiographic exams. In the cases of endodontic treatment, the professional should develop competence in the diagnostic and adequate treatment, promoting conditions to patients' oral health.

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Therapeutic proposal for avulsed teeth using calcium hydroxide associated to 2% chlorhexidine gel and zinc oxide

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ABSTRACT

Tooth avulsion deserves great attention in dentistry due to its esthetic and functional implications. The prognosis of tooth replantation is usually related to the need of endodontic treatment, and several substances have been used as intracanal dressing. The objective of this study was to present a case of a dental replantation that was endodontically treated with a new therapeutic proposal for avulsed permanent teeth that associates calcium hydroxide P.A., 2% chlorhexidine gel and zinc oxide. A 10-year-old patient suffered tooth avulsion of both right and left central incisors due to a bicycle accident. Both teeth were replanted and endodontically treated, with different protocols. The right incisor was conventionally treated with periodic changes of calcium hydroxide intracanal medication and the left incisor was maintained with the filling paste composed of calcium hydroxide, 2% chlorexidine gel and zinc oxide during all the period of apexification, without changes. During 3 years of follow-up, both teeth showed absence of symptomatology and apical repair. This intracanal dressing played an important role as a filling paste with effective elimination of microorganisms present in the root canal system, stimulated the formation of a mineralized apical barrier, and stabilized root inflammatory resorption.

Keywords: Chlorhexidine. Dental Trauma. Calcium Hydroxide. Intracanal Dressing.

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Introduction

Dental trauma may be considered a dentistry urgency condition since its consequences may damage pulp and periodontal tissues and cause irreversible injuries that may lead to tooth loss.[1] The prevalence of dental trauma is still considered high, affecting 13-30% of permanent dentition in young patients, being upper central incisors the most frequently traumatized.[2,3,4] The treatment of this injury is complex and requires multidisciplinary planning. With this, the prognosis is directly related to conduct adopted in the moment of traumatic accident.[5]

Dental trauma affects not only hard tissues and pulp, but also periodontal tissues, isolated or in association. Considering the diversity of trauma modalities, it is observed that tooth avulsions present more severe consequences, being external inflammatory resorption and replacement resorption the most common complications.[6] The mechanisms involved are little defined, however it is known that extra-alveolar time and storage medium are the main factors related in the progression of resorption.

Treatment protocol of avulsed teeth is contradictory. According to International Guide of Dental Trauma, it is suggested the reposition of the tooth, stabilization with flexible splint, which avoid excessive movement during healing period.[7] Clinical and radiographic follow-up are very important considering preventive diagnosis of pulp necrosis and root resorption would direct the professional to rapid intervention with endodontic therapy.[8] During endodontic treatment in replanted tooth, it is recommended the use of intracanal dressing to complement disinfection, paralyze or prevent inflammatory resorption,[9-14] and stimulates mineralized barrier formation in immature teeth.[16-21] Meantime, intracanal dressing dissolve inside root canal, and some authors recommend periodic changes of this in a period of one to six months.[22,23] Recently, a new therapy has emerged for the treatment of avulsed teeth, which associates calcium hydroxide, 2% chlorhexidine gel and zinc oxide.[24,25] This association allows the formation of an obturation paste that is kept in root canal during long periods, not being necessary to perform periodic changes.

Considering this new proposal, the aim of this study is to present a case treated with a new therapeutic protocol, composed of calcium hydroxide, 2% chlorhexidine gel and zinc oxide as an obturation paste, without periodic changes in an avulsed tooth.

Case report

A 10-year-old female patient was referred to Dental Trauma Service of Piracicaba Dental School (FOP-UNICAMP) for evaluation of upper right and left central incisors. The parents reported that patient suffered a bicycle fall in the previous month. In the accident moment, there was tooth avulsion of left central incisor and extrusion of right central incisor. The avulsed tooth was kept in dry conditions for 60 minutes and for 30 minutes in milk. Immediate attendance was performed by a dentist that replanted left incisor and repositioned right incisor. After this, it was confectioned a flexible splint.

After 30 days, the patient was attended in Dental Trauma Service of Piracicaba Dental School. It was observed negative responses of right and left central incisor to cold sensitivity test (Endo-Frost, Roeko™, Germany), and patient reported pain on vertical percussion. It was also noted that left incisor presented crown discoloration and that flexible splint was not removed. Radiographic exam revealed immature teeth and radiolucent image suggesting root inflammatory resorption in the left central incisor (Fig 1). Considering clinical and radiographic exams, teeth were diagnosed with pulp necrosis.

Patient´s parents were clarified about the complications of late replantation of the avulsed tooth and agreed with the proposed treatment. It was proposed an obturation paste composed of calcium hydroxide (Biodinamica™, Ibiporã, Brazil), 2% chlorhexidine gel (Endogel, Itapetininga, Brazil) and zinc oxide (Biodinamica™, Ibiporã, Brazil) in 2:1:2 proportion, without periodic changes, which was suggested by Soares[24] and Buck,[25] to induce apical closure of traumatized teeth and prevent or paralyze root resorption.

Initially, flexible contention was removed and then it was performed cavity access, isolation with rubber dam, neutralization of toxic content and crown-down chemical-mechanical prepare with gates-glidden burs numbers 5, 4 and 3 (Dentsply Maillefer™, Ballaigues, Swiss) in the cervical and middle thirds of right central incisor. Working length was established with periapical radiographs with a K-file #35 (Dentsply Maillefer™,

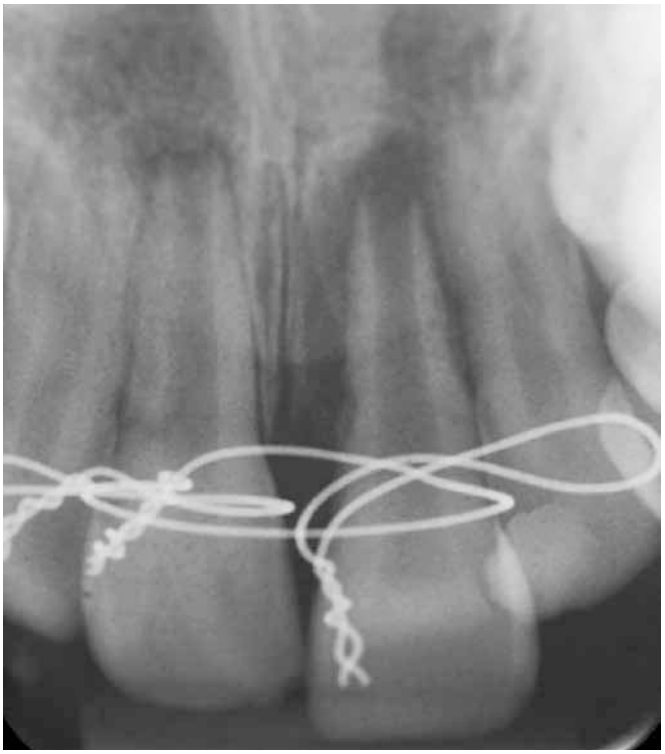

Figure 1. Initial radiography: It is observed immature teeth and external root resorption on the upper left central incisor.

Ballaigues, Swiss) introduced inside root canal. Apical instrumentation was performed manually till k-file diameter of #50 (Dentsply Maillefer™, Ballaigues, Swiss). During chemical-mechanical prepare of 2% chlorhexidine gel (Endogel™, Itapetininga, Brazil) it was used as chemical substance which was changed in each instrument change, followed by copious irrigation with 5 mL sterile solution. After these procedures, it was observed presence of exudate inside root canal, being used intracanal medicament composed of calcium hydroxide (Biodinamica™, Ibiporã, Brazil) and 2% chlorhexidine gel (Endogel™, Itapetininga, Brazil). The tooth was sealed with composite resin (Z250, Filtek 3M Espe™, Sumaré, Brazil).

The same protocol composed of cavity access, isolation with rubber dam and decontamination was performed in left central incisor. After this, the root canal was dried with absorbent paper points (Konne™, Belo Horizonte, Brazil) and filled with the obturation paste composed of calcium hydroxide (Biodinamica™, Ibiporã, Brazil), 2% chlorhexidine gel (Endogel, Itapetininga, Brazil) and zinc oxide (Biodinamica™, Ibiporã, Brazil). Paste was manipulated in 2:1:2 proportion, in consistency similar to coltosol and inserted with condensers sized medium and fine medium (Konne™, Belo Horizonte, Brazil) in the whole extension of root canal. Canal filling was conferred with periapical radiographs, followed by sealing with coltosol (Coltene/Whaledent™, New Jersey, USA) and restored with composite resin (Z250, Filtek 3M Espe™, Sumaré, Brazil) (Fig 2).

After one month, patient missed the appointment and returned only one year later. In the radiographic exam, it was noted apical closure of both right and left central incisors, presence of obturation paste in the left incisor and stabilization of inflammatory resorption (Fig 3). Soon after, it was planned obturation of right central incisor and conservation of obturation paste on left incisor.

For the obturation of right incisor (Fig 4), intracanal medicament was removed using k-file number #35 (Dentsply Maillefer™, Ballaigues, Swiss) in working length, in association with decontamination with 2% chlorhexidine gel (Endogel™, Itapetininga, Brazil) and irrigation with sterile saline solution. Smear layer was removed with 3 mL of EDTA 17% (Biodinamica™, Ibiporã, Brazil) for 3 minutes, followed by drying root canal with medium paper points sized #55 (Konne™, Belo Horizonte, Brazil). Obturation cement was Endomethazone (Septodont™, Saint-Maur-Deˆs-Fosse´s, France) through lateral condensation technique.

After these procedures, it was emphasized to the patient the importance of clinical and radiographic follow-up. Patient returned to follow-up and after 3 years it was not observed clinical pain on percussion neither to palpation, and it could be noted the presence of obturation paste in all the extension of left central incisor (Fig 5).

Discussion

The prevalence of dental trauma is high, mainly between children and young adults.[2,3] Some etiological factors are very common such as falls, bicycle accidents, sports practice and agression.[26,27] In the present case, dental trauma occurred in a 10-year-old patient due to a bicycle fall.

An immediate conduct front a dental trauma may influence significantly its prognosis, and incorrect

Figure 2. Intracanal dressing in the right central incisor and obturation paste in left central incisor.

Figure 3. Periapical radiograph one year later.

Figure 4. Obturation in right central incisor.

Figure 5. Radiograph follow-up after 3 years.

treatment may determine future complications.[6] In avulsion cases, immediate replantation refers to the better option of treatment and factors that may interfere in the prognosis are: Stage of root development, extra-alveolar time, storage medium and immobilization.[28-33] Studies report that after 30 minutes of extra-alveolar period, periodontal ligament cells become non-vital and it is possible to initiate root resorption process. In the present case, it is believed that long periods of extra-alveolar time in dry conditions and delay to seek endodontic treatment contributed to necrosis and development of inflammatory root resorption.[21]

Many therapeutic protocols have been proposed to minimize complications after tooth replantation, and some authors[23,34,35] proposed periodic changes of intracanal medicament in variable intervals. Recently, an obturation paste composed of calcium hydroxide, 2% chlorhexidine gel and zinc oxide without periodic changes was proposed as an alternative to avulsed teeth treatment with both immature and completed developed apexis. This association was also studied *in vitro* and demonstrated antimicrobial activity and capacity of keeping alkaline pH.[36-38] Literature reports demonstrated that this association presents high capacity of diffusion in root dentin, producing bacterial inhibition in external root surface.[39,40] In the present case report, obturation paste was inserted in left central incisor, and in right central incisor it was not possible due to presence of exudate, which prevented immediate insertion of the paste. Considering it, right central incisor was dressed with calcium hydroxide and 2% chlorhexidine gel.

Patient did not attend to follow-up visits due to personal reasons, returning to Dental Trauma Service one year after the beginning of the treatment. According to Soares,[24] obturation paste may be kept for long periods of time inside root canal without changes, promoting decrease in clinical symptons and signals, with exception of replacement resorption which is a progressive process. This protocol also is supported by Chawla;[41] Felippe et al;[23] Steiner et al,[42] that advocated the maintenance of intracanal medicament for long periods of time.

Obturation was performed only in right central incisor, after being confirmed presence of mineralized tissue barrier in the apical region. It was decided to maintenance of obturation paste in left incisor, because according to Buck,[21] the association of calcium hydroxide, 2% chlorhexidine and zinc oxide acts as an temporary obturation in avulsed teeth, remaining inside root canal for long periods of time. In addition, this author reinforced some advantages of this paste such as reduction in clinical attendance visits, low costs, and the maintenance of teeth and periodontal structures till future rehabilitation with implants, when replantation was unsuccessful.

Conclusion

The paste composed of calcium hydroxide, 2% chlorhexidine and zinc oxide may be used as an obturation paste and it proved to be a promising alternative with satisfactory results for avulsed permanent teeth. The present case report showed absence of clinical signals and symptoms in the treated tooth. In addition this paste remained without dissolution for 3 years. More studies are necessary to prove the efficiency of this paste in the treatment of permanent traumatized teeth.

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Assessment of apical third morphology in root canals after biomechanical preparation: Alternate and continual rotations (Easy RaCe system)

Artur Fernandes de **PAIVA NETO**[1]

ABSTRACT

Objective: This study aimed to analyze the presence of apical deviation according to the instrumentation technique and instruments used during mechanical preparation of root canals. **Methods:** It was carried out *in vitro* tests with the two types of preparation in root canals, in a total of 24 dental units divided into two groups according to the types of mechanical preparations made. **Conclusion:** At the end of the experiment it was observed that there was no significative difference between the two types of instrumental techniques. This suggests a greater attention to the alternate preparation due to its low cost, being possible to include it in CEOs (specialized dental clinics) of Ministry of Health - Brazil.

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Introduction

Among the problems faced to achieve the prevention of dental units, there is the caries disease, which is the main pathological change responsible for the loss of dental units before the natural chronology.

Endodontics is the science and art involving etiology, prevention, diagnosis and treatment of pathological changes of the dental pulp and its impact on the periapical region and, therefore, in the body.[11]

To perform endodontic treatment, whatever is the nature, there are various techniques, medicines and tools to prepare and / or treat periapical pathophysiological changes.

The instrumentation or chemi-mechanical preparation is still for many the most important stage of endodontic treatment. For its special significance and relevance this step was chosen as the basis of this study, which focused on one of the major problems that happens during biomechanical preparation — the apical deviation — along with two forms of instrumentation and their respective instruments. Thus, it will be assessed more than one face of endodontic instrumentation. The study is based on analysis of the apical third morphology in root canals after biomechanical preparation performed with alternating or continual rotation, considering the instruments used. So, it will be highlighted the instrumentation technique and endodontic instrument that does not allow the occurrence of apical deviation after biomechanical preparation. This will be clarified by means of radiographic double exposure to presence or absence of apical deviation after alternated or continual rotating instrumentation.

Development

According to classical literature, it is observed that the biomechanical preparation aims at emptying, sanitizing and expansion of root canals, in conical shape and continuously. This requires hand skills, patience, mastery of technique and anatomical knowledge, and respect for the principles present in the biological treatment process.

The final shape must be a replica of the original configuration of the root canal, in shape and conicity, but with larger diameter, allowing for proper cleaning and filling. The greatest difficulty in achieving these goals is related to the preparation of curved and / or atretic canals. These ideals can be achieved using both the manual and automated preparation. However, we must remember that hand tools, in some cases, do not reach these goals, because they have physical limitations.

The most common change is the apical deviation by the action of endodontic instruments during biomechanical preparation of the apical third of root canals.

To decrease its occurrence, as well as other changes, other methods have been proposed and new instruments for root canal preparation, highlighting the instruments of nickel-titanium (NiTi or Nitinol) with composition of 55 to 60% of nickel and 40 to 45% titanium. The instruments are fabricated by machining from a conical metal rod of circular section.

These NiTi instruments have the following physical properties: They are anticorrosive, antimagnetic, have low elastic modulus, superelasticity and shape memory effect, which enables the NiTi alloy to return to its original shape after deformation. These qualities allow the instruments to monitor the anatomy of the channels more easily, preventing the apical displacement and maintaining its original form.

Some changes are observed when these systems are compared to conventional instruments, such as different conicity and modifications in radial surfaces, incidence angles of the cutting blade, helicoidal angles, tip morphology (penetration guide) and cross-section.

There is a range of options of NiTi systems for continual rotation and each manufacturer has its own characteristics with instruments. However, it is observed that such instruments do not follow the identification and / or setting of ISO / IDF. These instruments were designed to be activated and placed inside the root canal spinning clockwise at a constant speed. The preparation has the crown-apex sense, promoting the cleansing and modeling of channels simultaneously.

The use of rotatory instrumentation with NiTi instruments has been proposed in order to overcome bends and avoid possible distortions generated by the deficiency of conventional stainless steel instruments, trying to get an ideal preparation, without promoting changes in apical foramen, while minimizing the transporting material to periapex. Following the study line of the present work, some works which have studied the anatomical accidents can be observed. The work of Aguiar et al,[7] in 2006, can be cited, which had as its theme the radiographic assessment of apical deviation in canals instrumented with NiTi system. In this study it was observed that after instrumentation, the images obtained by radiographic superimposition showed greater efficiency in the canals prepared with NiTi systems compared to conventional NiTi files. However, the differences were not statistically significant.

Pereira et al,[6] in 2007, compared qualitatively areas reached by instruments using stainless steel instruments and NiTi system. Thirty-two mesiovestibular roots of maxillary molars were used *in vitro*. After laboratory procedures, the moldings were examined and separated, as in the preparations of faces and thirds, based on the classification presented in similar jobs. According to the results, no significant differences were found between preparations with both techniques.

Material and Methods

This study was based on the following methodology: An experimental study in laboratory type, with 24 human posterior teeth, with mesiovestibular canals on lower molars as experimental units.

The samples were provided by the Center for Dental Specialties (CEO) Senhor do Bonfim, in accordance with Federal Law 10.211.23, March 2001, the declaration of donations to ethical and legal research and Resolution 196/96 of the National Health Council upon the importance of the scientific work carried out in relation to oral health promotion. It was used in the research a sample of 24 molar teeth with curved roots, being randomly distributed 12 teeth in each experimental group: Group I and Group II. Each specimen had identification number (Fig. 1).

In order to obtain minimal interference from cervical third of the samples in instrumentation process or mechanical preparation, surgery was performed to access the units using a round burr (cutter) #2 and a Endo-type Z (Dentsply Maillefer®) to get a better view of the cutting line of the crowns on the cervical third. Following, it was carried the crown section of the 24 teeth, in the cervical third, near the cemento-enamel junction, with a carborundum disk.

In all units of the two groups was performed cervical preparation with Drill Gates I and II, and CP Drill (injecta). CP Drill drills were used in the following sequence: Red (D1 = 0.25 mm and 0.14 mm/mm conicity) Blue (D1 = 0.30 and 0.18 mm/mm conicity) and Black (D1 = 0.40 and 0,22 mm/mm conicity).

In all samples, the working length was established by introducing, in each root, a file type Flexofile #10 or #08, until its tip appeared in foramen; then it was reduced about 1.5 mm, confirming the apical limit of work. It was considered the first instrument the one that would fit in the working length. According to the adjustment of the first instrument, the root apex was protected by utility wax light blue, preventing the obliteration of the apex by acrylic resin at the time of formation of the cubes for the experiment. Then we proceeded to identify the unit by its number.

This cubes were made from colorless acrylic resin, following the "cell" plastic mold having the same dimensions of the "cell" which would be attached to the

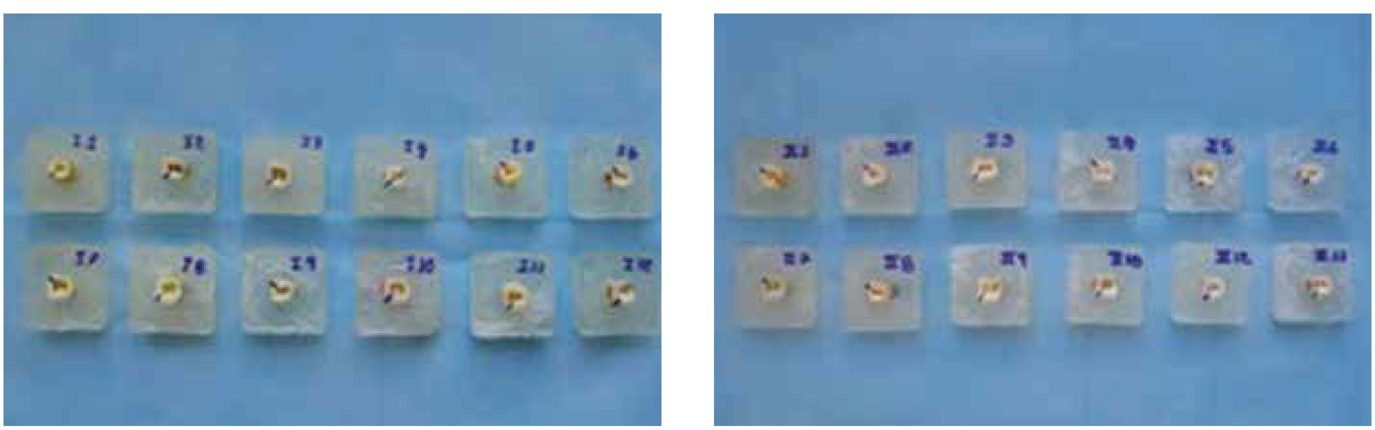

Figure 1. Samples properly divided into two groups at random: Observe the indication in mid-buccal root.

radiographic positioner in order to achieve a standardized radiograph.

The first radiograph was performed with a file that would fit to the channel in its working length. This first radiograph taken was performed for all units, regardless of group.

Keeping the radiographic standard, after preparation of the apical third with the last file, the second radiograph was made. For no movement of the film and change of radiograph position, and therefore some kind of alteration in the tooth positioning in the second radiograph, the film was kept in a radiographic positioner (Sydney ®) during endodontic treatment of the respective tooth – remembering that there were two radiographs taken on the same film, one with the first file (the one that fits) and one with the last file.

The alternate system is just a contra-angle presenting difference from the conventional contra angle, regarding the reduction in the frequency of rotation per minute, with a Push-Button head type for engagement of stainless-steel tools that can be connected to the electric motor or the micromotor of the dental equipo. In this study, the contra angle was connected to the equipo and worked by air pressure. When the handpiece was used coupled to equipo, working by air, there was no control of the speed, i.e. the r.p.m. - which is a disadvantage in the preparation of root canals, for not having greater control of the movement of the instruments. Thus, one should have greater sensitivity with regard to the preparation of the conduits, especially in atretic channels and with accentuated curvatures.

The handpiece used in this study was the NSK - Tep E16R, with degree of oscillation of 45 ° and a reduction of 16:1. The micromotor used is capable of 5,000 to 20,000 rpm. Thus, there was obtained, with the reduction 1.250 rpm. This reduction makes the instruments acquire a certain torque which facilitates instrumentation (Fig. 2). The channels of the units of Group I were prepared with Flexofile type files (Dentsply Maillefer ®), up to #30 taper from 0.2 mm / mm. In Group II, the instrumentation of the channels was performed using the RACE system FKG ® - Dentaire ® instrument until the #30 taper from 0.2 mm / mm. Thus a pattern was maintained for both groups.

To maintain the standard instrumentation in Group I, each set of files was used four times, and during the mechanical preparation, the patency of the foramen maintained with file #10. In Group II, each set RaCe system was used five times, following the patency of the foramen, as Group I. Throughout the preparation, the channels were irrigated with sodium hypochlorite at a concentration of 2 to 2.5% (Q-good ®). At each change of instrument, the irrigation was performed with 20:5 Luer syringe, taking care to enter, without exerting any pressure, with the needle of .019 "type Capillary Tips (Ultradent) around 2mm beyond the channel inlet . Always followed with the recapitulation to remove debris from dentin, with a conicity lower tool between the exchange.

Biomechanical preparation

» Group I: In this group were used files Flexofile type (Dentsply Maillefer ®), which are instruments made from a special stainless steel rod of triangular section and, after going through a process of twisting around its own axis, acquire a spiral shape. By owning the angle of the cutting blade at 45 ° or 60 ° acquire greater flexibility than the files type K. These instruments are identified by the symbol of a triangle on its handle. The instrumentation technique called sequential inversion was chosen in the use of stainless steel instruments (files type Flexofile). This technique was described by Souza,[10] in 2003.

The next step in the sequential inversion technique would be to use Batt bur #12. However, this study was chosen the CP Drill, following the sequence for use in accordance with the manufacturer.

With the completion of the preparation with CP Drill it was obtained the preparation of the cervical third of the root canal. Then, it was the preparation of the middle and apical third, the latter being the main focus of the study.

It is important to remember that the sequence of instruments should follow the instrumentation in crown-apex orientation untill the instrument chosen as final, which was the file #30. To achieve the preparation of these two-thirds it was used the alternate system coupled to the micromotor dental unit. After instrumentation of root canals, went up to the second radiography, with the last instrument in working length - in this case, a file #30.

» Group II: To prepare this group were chosen instruments from FKG industry, RaCe™ system, also linked to the same handpiece of Group I, but with the head adaptation of NiTi instruments and continual rotation. RaCe instruments have a triangular section, alternate cutting blades and inactive tip. Its design has two functions: To eliminate the screw effect and locking. Five different pre-race and eleven RaCe instruments are available. However, in this study the following instruments were used for biomechanical preparation: PRE-RaCe: 40/10 and 35/08; Easy RaCe: 25/06; 25/04; 25/02 and 30/02. After biomechanical preparation with this system, it was placed a file type Flexofile #30 for the completion of the second radiography.

The samples were divided into two groups of 24 teeth each:

- Group I: Alternating technique – sequential inversion
- Group II: Continual technique – Easy RaCe® system.

To evaluate the presence of apical deviation, radiographs of Groups I and II were separately placed on the negatoscope and analyzed by two dentists, with the aid of magnifying loupe with 2X, recording on the form the presence or absence of apical deviation. Once completed, the forms were referred for evaluation and processing of results.

Results

After assessment of the radiographs of the negatoscope and filling the sheet containing markings for the presence/absence of apical deviation in each unit, it can be observed the following:

» In Group I, from the 12 canals of instrumentation, 3 presented and 9 did not presented apical deviations (25% with apical deviation and 75% without deviation).

» In Group II, none of the 12 instrumented canals suffered apical deviation (100% without apical deviation).

» Deviations present in Group I were not severe, but were approximately of 0.5 mm between the first instrument (first radiograph) and the last instrument (last radiograph) (Figs. 3, 4, 5).

Discussion and Conclusion

According to the results, we can conclude that the biomechanical preparation by the two techniques presented is of fundamental importance for the evolution of endodontic treatment.

Because of the study conducted in clinic/laboratory, there are some points to be considered:

1) The specimens did not present a single configuration, being the anatomy of the roots the main condition for the success of endodontic treatment.
2) The mechanical preparation was carried out without a fixed support, i.e. with the block supported on a bench and fixed only by the operator's hand. This interferes the surgery.
3) The study, being conducted *in vitro*, with the sectioned units and the previous preparation with Gates Glidden drills and CP Drill facilitated instrumentation up to file #30.

Figure 2. Handpiece Tep E10R 16:1 with head rotation alternating linked to conventional pneumatic micro-motor.

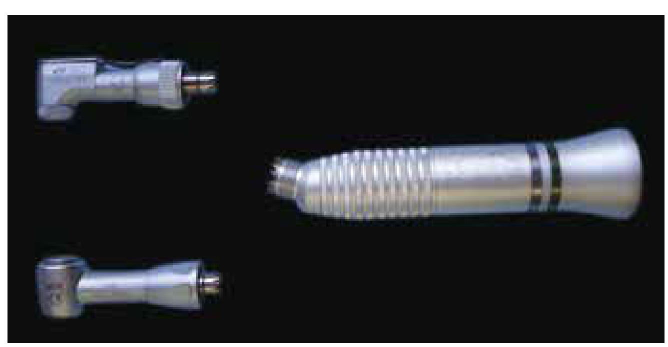

Figure 3. Handpiece Tep NSK E16R 16:1, with continual head rotation, linked to conventional pneumatic micro-motor.

Figure 4. Radiographic image analysis for Group I: Observe the preservation of the internal anatomy of the root canal.

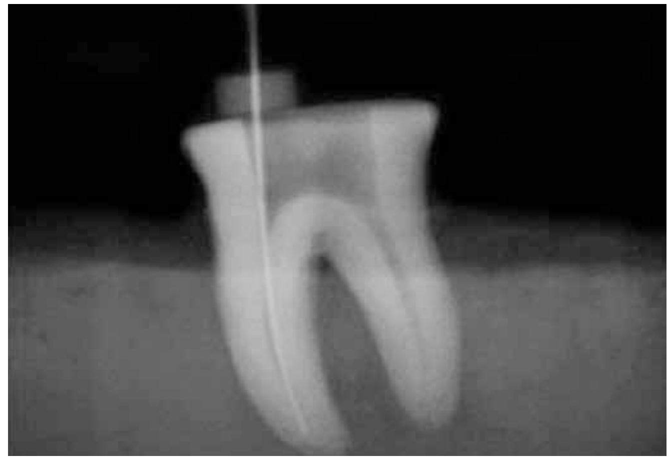

Figure 5. Radiographic image analysis for Group I: Observe the preservation of transport, i.e., apical deviation.

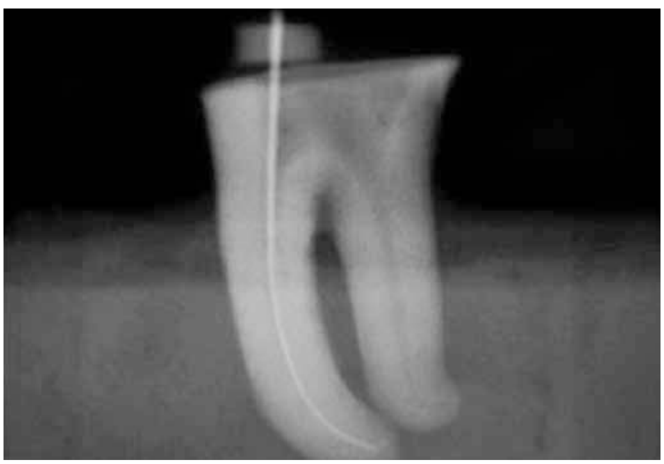

Figure 6. Radiographic image analysis for Group II. Note the preservation of the internal morphology of the conduit, without the occurrence of apical deviation.

4) In Group I, the performance of instrumentation was with recapitulation in most cases. For a better preparation, it is suggested instrumentation with the aid of intermediate files, such as files Golden Medium (Dentsply Maillefer ®). It is suggested to carry out a study analyzing instrumentation with and without these files mentioned.

The most important in choosing the equipment to perform the automated preparation - whether for continual or alternating movements - is the master of scientific and technical operative steps, a thorough knowledge of the instruments and the dynamics of its use. Over time, the clinician will realize that the equipment is "adapting" to their treatment philosophy, thus having total control over it. As reported in the presentation of this work, it is suggested the inclusion of alternating rotation systems in specialized dental clinics, the Ministry of Health, the public health system, once they are low cost, beyond all qualities reported during this study.

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CBCT and microscopic analysis of the incidence of second mesiobuccal canal of maxillary molars

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ABSTRACT

Introduction: The objective of successful endodontic treatment is a complete chemical-mechanical cleaning of root canals and filling. Therefore, a root canal not located represents a possible cause of endodontic failure, due to lack of cleaning and filling. **Objective:** The aim of this study was to determine the incidence of second mesiobuccal (2MB) canal in mesiobuccal roots of maxillary molars, comparing the efficacy of three methods for their identification: Cone beam computed tomography (CBCT), clinical analysis (CA) and operating microscope (OM). **Methods:** The existence of the second mesiobuccal (2MB) canal was evaluated by two examiners in 42 first and second molars without pulp involvement. The teeth were subsequently evaluated by the three methods and later these mesiobuccal roots were sectioned at 3 and 7 mm from the apex in the axial plane and observed with a digital microscope. **Results:** Was revealed the real presence of 10 2MB canals (23.81%). Statistical analysis by McNemar test showed that there was no statistically significant difference ($p < 0.05$) in the efficacy of 2MB canals localization between the three methods. **Conclusion:** None of the three methods made possible the determination of the 2MB canal in all cases, however CBCT showed the better results.

Keywords: Dental Pulp Cavity. Molar tooth. Cone-Beam Computed Tomography. Microscopy.

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Introduction

The objective of successful endodontic treatment is the complete chemical and mechanical cleaning of the root canal system and filling with inert material.[1] Therefore, a canal not located is a possible cause of endodontic failure, result of lack of cleaning and filling.[2]

The morphology of the permanent molars has been studied extensively[1,3-6] reporting the presence of two canals in the mesiobuccal root of maxillary molars[7-18]

Clinical and *in vitro* studies differ as to the prevalence and location of the second mesiobuccal canal (2MB). Its occurrence appears to be greater than 50%,[2,3,5,12,15] having the direct visualization the lowest detection index (40%) for the first and second molars.[14,16,18]

The periapical examination still represents the gold standard for endodontic diagnosis[9] but new techniques have been introduced to facilitate the evaluation of the anatomical variations of the roots, among them the cone beam computer tomography (CBCT). This type of imaging study has several applications in endodontics, including periapical diagnosis, evaluation of root canal anatomy, surgical planning, evaluation of resorption (external and internal), suspected perforation and the diagnosis of dental trauma.[19-22]

Another device that can facilitate the location of root canals as a result of its clear magnification and significant field of view, is the operating microscope (OM).[16] Studies have shown that its use facilitates the detection of 2MB canal *in vitro* and clinically,[5,8,10] the incidence increased to 71.1% when the operating microscope was used.[10]

The objective of this study was to determine the incidence of 2MB canal orifice of first and second molars from clinical analysis (CA), CBCT and OM at *in vitro* environment.

Material and Methods

Sample Selection

After approval by the Ethics Committee in Research of the Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo (HRAC-USP) (protocol # 124/2011), 42 extracted teeth were selected, from the Human Teeth Bank of Bauru School of Dentistry. Thirty-four teeth contained existing coronal restorations, without pulp involvement.

Preparation of teeth

All teeth were washed and stored in saline solution until the beginning of the experiment at room temperature.

Evaluation with Cone Beam Computed Tomography

Upon verification of ideal positioning, the 42 teeth were scanned with CBCT (SI i-CAT Imaging Sciences International, Hatfield, PA, USA). The voxel of 0.2 mm was used with an exposure of 20 seconds. During this evaluation, the images were manipulated and analyzed. The record of the number of canals and their variations were recorded by two examiners.

Coronary Opening

The access to the pulp chamber was performed in all teeth by a single operator with round burs (1014 and 1015 KG Sorensen, São Paulo, Brazil) in high speed until reaching the pulp chamber. To remove the pulpal roof was used a conical diamond bur (3082, KG Sorensen, São Paulo, Brazil) also in high speed. Subsequently the access was expanded with the classical outline design. After the palatal, distobuccal and mesiobuccal canals were located, an attempt was made to locate the 2MB using K-file #8 and #10 (Dentsply-Maillefer, Ballaigues, Switzerland) and water irrigation. After recording the location or not of the 2MB canal, there was a negotiation attempt with K-file in the canals found.

Analysis with Operating Microscope

The teeth were evaluated by using MO (Dental F. Vasconcelos, M900, São Paulo, Brazil), with 40X magnification. The location and number of canals were recorded by the examiners.

Sectioning and analysis of the roots with an optical microscope

The mesiobuccal roots of all teeth were sectioned with cutting system (Exakt Technologies Inc, Oklahoma, USA) at 3 and 7 mm below the apex in an axial plane.

By Dino Lite Digital Microscope® AM3013T (Anmo Electronics Corporation, New Taipei, Taiwan) with an increase of 6.4X was verified the actual presence/absence of 2MB in all roots sectioned. (Fig 1).

Results

After sectioning all the mesiobuccal roots, it was verified the real presence of 10 2MB canals (23.81%). Table 1 shows the number of real canal orifices located with different methods after sectioning all the mesiobuccal roots. The CBCT showed the highest frequency of real canals.

The results of the two examines are shown in Table 2, in which there is the occurrence of 2MB canals for the number of canals found and confirmed after sectioning. The intraexaminer reliability was established using the Kappa coefficient, obtaining a substantial agreement between them.

Statistical analysis with the McNemar test ($p < 0.05$) showed no statistically significant difference between methods to detect the canal orifice in maxillary molars.

Table 3 shows the percentage of 2MB canal found in the literature including the current study.

Discussion

Several studies demonstrate the high frequency of the fourth canal in first and second maxillary molars and its prevalence has been reported and discussed by several authors using a variety of study methods including X-rays, clinical assessments, CBCT microscopy and sectioning of roots.[7-18] However, divergent results regarding the percentages have been reported. These differences result in part to difficulties found in the study of root canals.[2] The CBCT and OM were chosen as methods of identifying the presence of 2MB canal in extracted teeth for its reliability, when compared with other methods such as radiographic evaluation.[3,23] Other methods for 2MB canal identification as the CBCT have been effectively used in endodontics to evaluate the morphology of the root canal. The advantage of CBCT method is to allow the operator to view tomographic slices in different planes, with the possibility of manipulating the images, making a full assessment of the root canal system.[20]

In this *in vitro* study, CBCT positively identified the 2MB canal in five teeth demonstrating their superiority and reliability compared to other diagnostic methods for detecting the presence or absence of the 2MB canal. Although not 100% accurate, CBCT certainly shown as a method for treating root canals according to Matherne et al,[23] that showed results in the identification of a larger number of root canals than the digital images, and this is important, especially in situations where the 2MB canal not been initially treated.

Using the OM provided a better observation and lighting, improving the location of the canal orifices. Despite the low incidence of 2MB canal, several studies, showed the OM importance in the location of the 2MB in first molars and validate its use in pursuit of quality of endodontic treatment.[1,5-8,10,11]

The results of this study also showed that three 2MB canal were detected clinically using only a K-file #10.

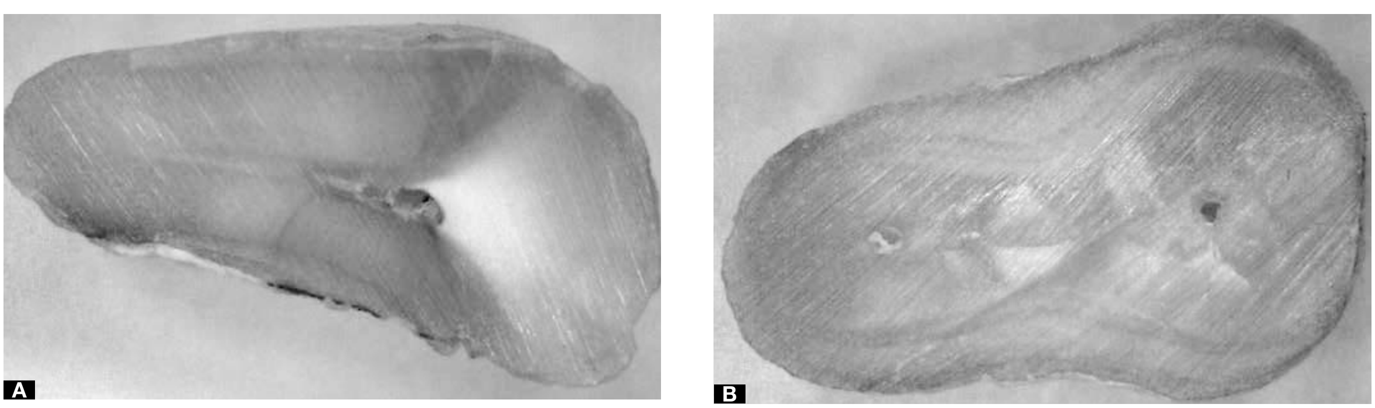

Figure 1. Digital microscopy photographs (6.4X) of two sectioned mesiobuccal roots. **A**) mesiobuccal root showing the presence of only one canal, **B**) mesiobuccal and 2MB which are distinct canals.

Therefore, highlights the clinical method as a tool to detect the canal orifice of first and second molars in endodontic procedures. Especially when performed by a trained professional with greater morphological and anatomical knowledge, and experience.

The effectiveness of evaluation 2MB canal was defined by the detection of real canals. From this was

Table 1. Distribution 2MB canals successfully detected by cone bean computer tomography (CBCT), clinical analysis (CA) and operating microscope (OM) and their frequency for canals found after sectioning (n = 10).

Methods	# real canals (mean ± Standard deviation)	Frequency
CBCT	5.5 ± 0.70	55.0%
CA	3.0 ± 1.41	30.0%
OM	1.5 ± 0.70	15.0%

Table 2. Number of 2MB canals located by each technique and number of canals confirmed by sectioning of the roots (n = 42).

Methods	Examiner 1		Examiner 1	
	Located	Confirmed by sectioning	Located	Confirmed by sectioning
CBCT	11	6	10	5
CA	11	2	12	4
MO	7	1	13	2

Table 3. Summary of the literature on frequency 2MB canals.

Investigators	YEAR	Molar	Model	%	Total sample
Weine et al	1969	1	*In vitro*	62	208
Pineda	1973	1	*In vitro*	54.3	245
Hartwell e Bellizzi	1982	1 e 2	*In vivo*	18.6 e 9.6	1976
Weller e Hartwell	1989	1 e 2	*In vitro*	39.1 e 21.4	1134
Kulild e Peters	1990	1 e 2	*In vitro*	95.2	83
Fogel et al	1994	1	*In vivo*	71.2	208
Stropko	1999	1 e 2	*In vivo*	73.2 e 50.7	1732
Sempira e Hartwell	2000	1 e 2	*In vivo*	33.1 e 24.3	200
Buhrley et al	2002	1 e 2	*In vivo*	93	660
Baldassari-Cruz et al	2002	1	*In vitro*	90	39
Coutinho Filho et al	2006	1	*In vitro*	90.7	108
Smadi e Khraisat	2007	1	*In vitro*	77.32	100
Alaçam et al	2008	1	*In vitro*	82	100
Hartmann et al	2009	1	*In vitro*	29.2	65
Baratto Filho et al	2009	1	*In vitro* e *In vivo*	67.14 e 53.26	100 e 291
Blattner et al	2010	1 e 2	*In vitro*	68.4	20
Current study	2011	1 e 2	*In vitro*	23.81	42

established a mean that for CBCT was 5.5. The results suggest that the clinical analysis combined with CBCT increases the detection 2MB canals of first and second molars.

Taking into account the methodology employed and results can be stated that there are no differences between experienced and an inexperienced operator to locate the canal orifices when CBCT was used being that external factors (poor knowledge of anatomy and geometry of irradiation) are eliminated.[21]

The reason CBCT had the highest detection rate of the 2MB canal compared than clinical analysis and OM may be by the use of a classification of permeable or not permeable root canals up to the apex, during the exploration. This factor initially discards a large number of 2MB canals found by the OM and CA by using a K-file only. Therefore, these criteria would be the most likely cause for the average decrease of 2MB canals found, compared to other studies.[7,8,11,15]

In the present study, 42 mesiobuccal roots were sectioned, and the prevalence of ten 2MB canals represents a rate of 23.81%. This is similar to results obtained in previous studies, and suggests the great difficulty to detect 2MB canal of maxillary molars. Since for detection, it is necessary, besides the knowledge of the morphology of the root canal system, training for detection according to the location of typical and atypical canal orifice.[2,3,5,12,14,15,18]

Based on the frequency of canal orifices found in this study, we suggest a special care in the coronary opening to locate the canal orifices in the upper molars through dedication of more time for treatment, use of appropriate techniques and magnification in order to achieve better results and ensure a good prognosis for the endodontic treatment. The non-detection of canals, such as 2MB may contribute to the failure of endodontic treatment, and may cause the need for retreatment and subsequently the surgical solution of the case.

Conclusions

Due to the methodology presented in this *in vitro* investigation, it can be concluded that none of the three methods made possible the location of the 2MB canal in all cases, nevertheless CBCT showed better results in the detection of 2MB canals in molars.

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The use of calcium hydroxide as an intracanal medication for the apexification of immature permanent teeth

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ABSTRACT

The objective of this study was to present, through a clinical case, the treatment of two traumatized dental elements with incomplete root formation, extensive periapical lesion and root resorption. The treatment of choice for teeth with incompletely formed apices was the apexification by changing the intracanal medication to promote apical closure, periapical lesion repair as well as root resorption stabilization. The intracanal dressing, calcium hydroxide paste mixed with propyleneglycol as a vehicle, was changed a total of four times during a period of one year and two months. It has been concluded that this technique for apexification provides favorable conditions for the closure of root apices as well as repairing periapical lesions and stabilizing root resorption.

Keywords: Apexification. Incomplete root formation. Calcium hydroxide. Intracanal dressing. Dental traumatism.

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Introduction

The eruption of the permanent dentition has its onset around the age of six, continuing until the age of twelve, with a root development for a continuous period of one year and a half to two and a half years after the eruption. Thus, trauma to the oral cavity in patients aged between six and fourteen and a half years old has a potential to disrupt, modify or intercept the complete formation of the root. The functional and aesthetic importance of the traumatized tooth with incomplete root formation associated with the young age of the patient, has motivated several studies in an attempt to ensure their stay for as long as possible in function .According Andreasen, literature review makes clear that school children have a high incidence of traumatic injuries in permanent teeth with incomplete root formation and can often develop pulp and periapical complications, developing pulp mortification, diffuse calcifications of the pulp, internal or external root resorption, even after a long period of time of the dental trauma. The disease and degenerative processes of these complications, however, are not well understood. When the incomplete root formation is associated with pulp necrosis, the situation becomes even more complicated because the process of root formation by deposition of dentin ends. In these cases, endodontic treatment is aimed to promoting the full apical closing. According Heithersay the apicification is a treatment which allows the apical closure and allows the root elongation if the Hertwig's epithelial sheath has not been irreversibly damaged. The disadvantage of this technique is that the time required for treatment is prolonged. Thus, in teeth with incompletely formed apex, the use of the instruments and auxiliary chemical substance does not allow a complete cleaning of the root canal, a unfavorable condition to tissue repair in the apical region, because the healing process only occurs in the absence of contamination. The auxiliary chemical substance, with its multiple properties, should provide an effective antimicrobial activity and increased the permeability of the root canal system in order to complete the cleaning. Numerous medications have also been used in endodontic treatment of teeth with incomplete root formation to complement the cleaning, emphasizing its capacity to diffusion in the endodontic system. According Estrela and Sydney, to achieve the apicification, must obtain an alkaline medium within the root canal system which facilitates the formation of a barrier apical of mineralized tissue even after the pulp had lost its vitality. Thus, the high pH of calcium hydroxide is fundamentally important for the success of treatment. Therefore, this work was carried out to verify the effectiveness of the apicification technique using the folder calcium hydroxide as intracanal dressing and observe the time required for closure apical of teeth 21 and 22 with pulpar necrosis, incompletely formed apex and root resorption

Case Report

Patient MP, female, 16 years old, attended the private clinic to perform endodontic treatment accompanied by his mother. During interview, when asked about dental history, was aware that with six-year-old the patient suffered a fall injuring the dental elements 21 and 22. Since then, the patient underwent several professionals who could not resolv the problem. In the intra-oral clinical examination, there was edema in the region of the palate and on the bottom of the hall in the region of the elements 21 and 22. Although it was noted that access cavities that were open were very retentive with presence of the roof of the pulp chamber. In the radiographic examination it was found that the teeth 21 and 22 had incomplete root formation, extensive radiolucent periapical and root resorption (Fig 1).

After the patient aware of the difficulties of, endodontic treatment has been proposed by apicification using calcium hydroxide. Agreeing with the proposed treatment, the first session was carried on 14/01/1998 by performing local anesthesia, rubber dam installation and improvement of access openings. The biomechanical preparation of root canal was done with hand endodontic files and sodium hypochlorite 2.5%. During root canal preparation, odontometry was performed to confirm the working length. In the two dental elements the patency was performed and the apical third was prepared with K # 80 files to 1mm from the radiographic apex (Figs 2 and 3).

After biomechanical preparation, the root canals were dried with sterile paper cones and flooded with EDTA trisodium 17% for three minutes. After removal

Figure 1. Initial radiograph showing incomplete root formation, extensive radiolucent periapical and root resorption.

Figure 2. Tooth 21 odontometry for confirmation of the working length.

Figure 3. Tooth 22 Odontometry for confirmation of the working length.

of EDTA, another drying was carried out. Calcium hydroxide paste P. A with propyleneglycol was inserted into the root canal, which is replaced when it appeared radiographically that the intra-canal medication had been partially resorbed. This was done to induce apicification or formation of a barrier mineralized in the apical foramen, as well as stabilization of root resorption. After four exchanges of intracanal dressing over a period of nine months, regression of the periapical lesion was observed radiographically, stabilization of resorptions and root closuret (Fig 4).

In 20/03/1999, one and two months after the beginning of root canal treatment, was performed the final filling of the root canal with gutta-percha (Figs 5 and 6) and sealer with zinc oxide and eugenol (Endofill-Dentsply) by lateral condensation followed by vertical condensation (Fig 7).

After three years of completion of treatment the patient was called for the first radiographic control, when radiographically it was observed repair of the periapical lesion with absence of root formation and root resorption. In element 21 in the third apical was possible to observe slight thickening of the periodontal ligament (Fig 8).

Figure 4. Teeth with intracanal dressing after a period of nine months, showing regression of the periapical lesion, stabilization of the beginning of resorptions and root closure.

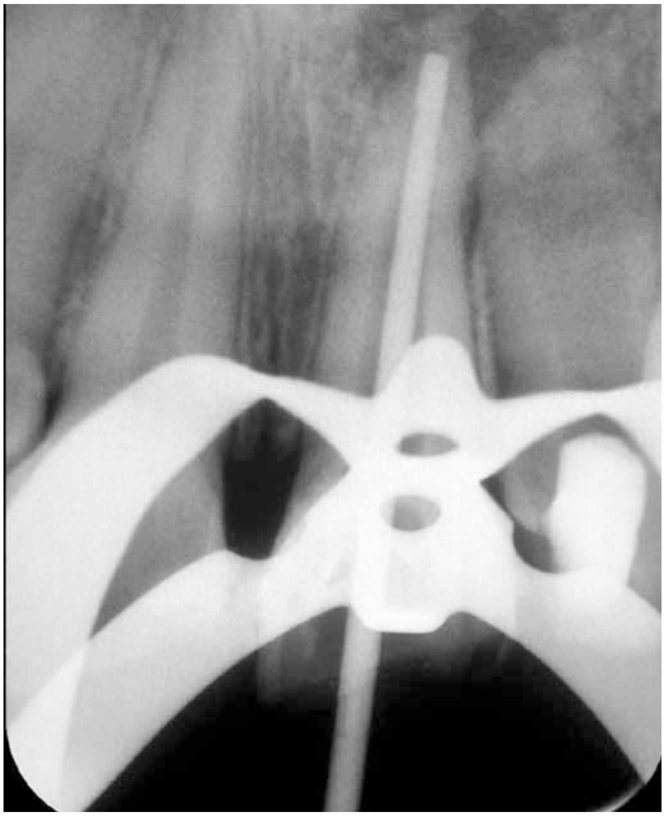
Figure 5. Proof of the master cone, tooth 21.

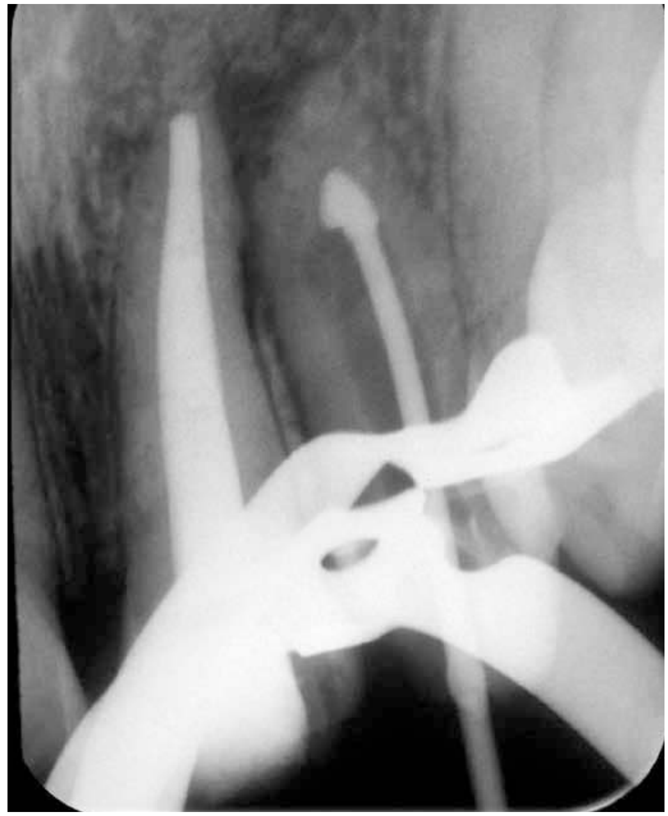
Figure 6. Proof of the master cone, tooth 22.

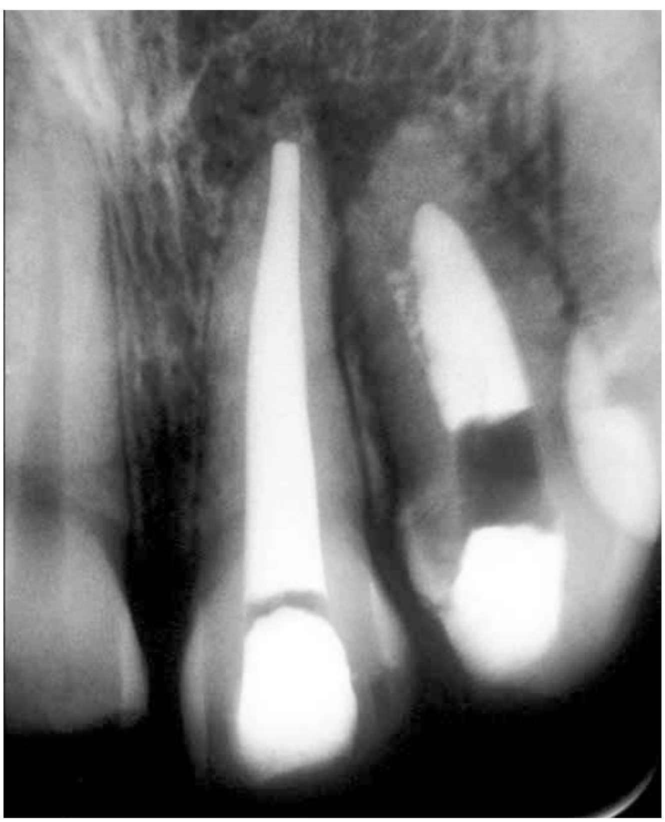
Figure 7. Final root canal fillings after one year and two months of the beginning of the endodontic treatment.


Figure 8. Radiography of preservation after three years of root canal filling showing periapical lesion repair and absence of root formation and root resorption.

Discussion

Young patients present as most frequent cause of pulp involvement besides caries, dental trauma due to accidents that may sofrer.[5] Crona-Larsson and Noren[6] assessed the etiology, incidence, predisposition and occurrence of dental trauma. The authors report regarding gender was two boys for every girl and rugged that the large number of traumatic injuries occurred between eight and eleven years old, and 40% of traumatized children suffer more than once dental trauma. Most cases involved the maxillary central incisors being responsible for 70% of traumatized teeth and a third of these teeth had the root partially developed at the time of the accident. Our work agrees with those reported in the literature since the injury occurred in this case report was when it was six years old and the roots of the teeth 21 and 22 had not reached the stage ten of Nolla, and was not acting the complete root development, with the pulp involvement with subsequent necrosis and periapical lesion development. The teeth of the reported case are carriers of chronic periapical lesions and incompletely formed apices. Accordingly, the endodontic therapy is faced with a complex root anatomy makes it difficult endodontic treatment, which is why we chose to start with sanitation removal of necrotic tissue and combat the bacterial infection through copious irrigation with sodium hypochlorite solution, due to its solvent properties of organic matter and antimicrobial.[7,8] The E.D.T.A. was used prior to application of the medication in every session and before the final filling of the root canal in order to increase the permeability of dentin and facilitate the diffusion of ions of calcium hydroxide on dentin, it is justified because it is large in literature the number of studies that use of EDTA at different concentrations and associations in order to promote a greater cleaning of the root canal walls, with the removal of the residual layer of magma dentinário.[9,10] The use of intracanal dressing with calcium hydroxide paste between sessions to complete disinfection and stimulate apical closure and / or deposition of mineralized tissue resorption and stabilize, corroborate with the study of Holland et al;[11] Holland et al;[12] Hulsmann;[13] Holland et al;[14] Nedley and Powers[15] and contrasts Felippe et al[16] who argued that there advantages to make exchanges of calcium hydroxide paste during treatment of teeth with incomplete root formation and pulped canals contaminated. The choice of propyleneglycol as a carrier for the calcium hydroxide is based on studies of O'Neil[17] Lide,[18] which has a great capacity to solubilize organic materials and also because Seidenfeld Hanzlik,[19] propyleneglycol has approximately the same density as water and when used as solvent and vehicle is less toxic than ethyleneglycol with no demonstrable cumulative effect. The antimicrobial activity of the propyleneglycol for systemic use has been studied by Olitzky[20] who reported that concentrated solutions of this compound have a proven efficiency germicide and its use as a vehicle can provide a potential for the prevention or treatment of microbial infections. Thomas, Bath and Kotian[21] reported that addition of propyleneglycol as a vehicle is well recognized for pharmaceutical, it has also been shown to be less cytotoxic than other vehicles commonly used to intracanal dressing and has antibacterial properties highly beneficial in endodontic treatment. Cruz et al[22] reported that propyleneglycol has the ability to spread through the root dentin and cementum possibly even in the presence of anatomical abnormalities such as calcifications and ístms. The authors also reported that propylenglycol has been used in endodontics almost exclusively as a vehicle for cálcio hydroxide.[23] The authors concluded that propyleneglycol is an excellent vehicle for intracanal dressing. It opposes the results found by Safavi and Nakayama[24] who found that calcium hydroxide does not dissociate when in contact propyleneglycol because calcium hydroxide needs water to dissociate. The time to achieve the beginning of apical closure after initiation of treatment in this case was from nine months to a year and two months approximately. Yates[25] considers the apical aperture size prior to initiation of treatment influences the apical closure. Ghose, Baghdady and Hikmat,[26] sad 78% of apical closure was obtained from five or six months after completing treatment sessions and two intracanal dressing with calcium hydroxide. Mackie, Bentley and Worthington[27] obtained a median time of 10.3 months, whereas Yates[25] nine months. According Shabahang et al[28] and White,[29] the apexification with calcium hydroxide has several disadvantages, including the variability of treatment time for the patient proservation (to meet the calls) and an increased risk of fracture healing after tooth material by extended periods. Ding et al,[30] say the open apex can be "closed" by a calcified barrier, the apexification does not promote the further development of the tooth. The authors are not unanimous as to the time when a tooth with incomplete root formation to be treated with a slurry of calcium hydroxide or where the time interval in which the tooth should have changed the dressing. On average, the authors suggest the exchange of medication every thirty days to three months, during apexification it takes twelve to eighteen months, in the absence of infecção.[2,25,31,32,33] In view of this it is necessary to use substances which induce the formation of an apical barrier which prevents leakage of the filling material as well as its perfect accommodation, being the calcium hydroxide and mineral trioxide aggregate (MTA) substances of choice due to its biocompatibility, antibacterial properties and induce mineralization, which agrees with the Estrela.[34] Regarding the MTA, Ruiz et al[35] demonstrated that it is a biocompatible material with osteoinductive capacity that promotes an appropriate marginal seal, preventing leakage, besides presenting antimicrobial effect. Demonstrated that in treatment of immature pulped teeth, the more favorable prognosis has been achieved with the procedure apexification with MTA, which showed greatest resistance to displacement in a thickness of 4mm compared to 1mm. According Dotto et al.36, MTA is used for making apical stop by the excellent results obtained in different studies as well as with the aim to reduce the number of sessions since it is unnecessary successive exchange material as occurs when employing calcium hydroxide, and also conclude that the apical closure in teeth with open apexes and necrotic pulps can be obtained with sanitizing system canal obtained from the canal preparation and use of pastes containing calcium hydroxide for two months followed by placement of MTA for sealing and forming the apical barrier. But it is a global consensus that calcium hydroxide has shown satisfactory results regardless of the apexification whatever the technique used.[16,37,38] Recent3studies 30, 39.40 report the effect of a revascularization procedure on teeth with necrosisand incomplete root formation and apical periodontitis by the use of poly-folder antibiotic or stimulation of blood clot, as a viable alternative for the treatment of teeth with incomplete rhizogenesis. These studies showed root development complete with a positive response to pulp testing. Another challenging situation for the clinician today is the decision between evaluated key factors allowing the clinician to make decisions based on the best evidence and the best interests of the patient. Endodontic treatment is a viable way, practical and economical to preserve function in a wide range of cases and implants serve as a good alternative in selected indications in which the prognosis is poor. Hannahan and Eleazer[42] compared the success of implants and root canal treatment. One hundred and twenty-nine implants with median follow-up of 36 months showed a success rate of 98.4%. One hundred and forty three endodontically treated teeth were followed for an average of 22 months with a success rate of 99.3%. In this study, the success of the implant and endodontically treated teeth was essentially identical, but implants required more postoperative treatments to keep them. Root canal therapy is a highly predictable way to save the tooth, the implant natural. The excellence of endodontic treatment followed by immediate restoration of equal quality promises to give to patients service and function while maintaining aesthetic for years. The decision aimed at planning and endodontic treatment with high survival rate leads the clinician to consider additional factors including local and systemic conditions of the case, economic, desires and needs of the patient, aesthetics, potential adverse outcomes and ethical factors. Thus, endodontic treatment is always safe and feasible and based on the best interests of the patient and sensitive to the quality of life in long term 43. Taking into consideration that the treatment of teeth with incomplete root formatio in most affects individuals in bone development and that this treatment has achieved high success rates, it seems reasonable to suggest that endodontic treatment is the option to conduct the election and to achieve the ultimate goal which is the root development may be through of calcium hydroxide paste as intracanal dressing or, by revascularization.

Conclusion

Endodontic treatment of teeth with incompletely formed apex are difficult to be performed. However, in our case we can conclude that the technique for apicification in teeth with incompletely formed apex and necrosis, using the calcium hydroxide paste as intracanal dressing is effective and the time required for the occurrence of the apical closure can occur between five months to one year and six months. And that the resorption can be stabilized when this technique of apicification was used. As the apicifica-

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Influence of coronal opening in the location of root canals in mandibular incisors

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ABSTRACT

Objective: This study evaluated the influence of shapes of coronary opening on the localization of root canals in lower incisors. **Methods:** It were used 32 teeth extracted from humans, being 16 with a single canal and 16 with two root canals that received, initially, conservative oval coronary opening, followed by random setting on mannequin, for clinical evaluation of number of root canals by two specialists. After that, the openings were enlarged to non-conservative triangular shape, being submitted to a second clinical evaluation regarding the number of root canals. **Results:** On the examination of the conservative opening, the examiners 1 and 2 obtained, respectively, 15(94%) and 14(87%) scores for the teeth with one canal, with none (0%) and 5 scores (31,2%) for the teeth with two canals. After enlarging the opening, the examiners 1 and 2 obtained, respectively, 16 scores (100%) in cases with one canal, with 5 (31,2%) and 10 (62%) scores in cases with two canals. Between the examiners, on the non-conservative opening it was obtained Kappa = 0,456 and, on the conservative, Kappa = 0,629, determining mild concordance. According to results, the non-conservative triangular coronary opening lead to a greater percentage of scores on the localization of canals of lower incisors than the oval conservative opening, being this difference statistically significant (p < 0,05).

Keywords: Root canal preparation; Endodontics; Pulp cavity.

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Introduction

The clinical access to the root canals system, obtained through an opening ideally planned and performed on the tooth crown, aims not only to access the pulp chamber but to prepare it properly to locate and explore the root canals that will be submitted to procedures of cleaning, modeling and obturation of the canals system, contributing for the success of the treatment.

On the opening of lower incisors, a single root canal with larger vestibulolingual dimension is localized in most cases, however, such teeth may present two root canals (buccal and lingual) in an incidence ranging from 11,5 to 45,0% according to the studies performed by Madeira and Hetem,[1] Benjamin and Dowson,[2] Kartal and Yanikoglu[3] and Oliveira et al.[4]

For Buchanan,[5] the traditional or classic access cavity that involves all the circumference of the pulp chamber in a triangular or oval shape, results in an access 50% larger than the necessary, which means a huge waste of healthy dental structure. Thus, it is recommended that during access of anteroinferior teeth the shape of the contour be oval, with conservative detrition of 1,5 mm on the mesiodistal direction. However, Nielsen and Shahmohammadi[6] mentioned that the appropriate shape of access depends more of the anatomy itself and on the case of lower incisors, considerable attention must be given on the preparation of the access cavity in order to locate two canals. Therefore, to enlarge mesiodistally more than 1 mm is reasonable, if it is necessary to obtain adequate visualization and instrumentation of the canal.

According to Peters,[7] the openings errors usually are originated from openings shorter or longer than the necessary. Small openings may not lead the professional to find the canals, or if it was found and not with a straight access, it increases the chances of file fracture or canal transportation. Very large cavities usually originate unnecessary removal of dental structure and weaken the remaining crown, maybe causing, in the long term, irreparable compromising of the dental element.

Before this, the present work has as objective to compare whether conservative oval coronary opening and non-conservative triangular coronary opening affect the localization of root canals in lower incisors.

Material and Methods

It were used human permanent lower incisors, granted by the Bank of Teeth of the Federal University of Alagoas (FOUFAL), not being recorded the reason of extraction, the antimere, age, gender and race of the patient. The project was approved by the Committee of Ethics in Research (CER) under the protocol number 000470/2011-85.

Took part in the survey only the lower incisors with healthy crowns or with small restorations on the proximal surfaces with no implication on the pulp chamber, carriers of healthy roots, free of calcifications on the pulp cavity, having one or two root canals with bifurcation on the cervical third. To confirm the absence of calcification, as well as the number of canals, it were performed digital radiographs from mesial to distal and from buccal to lingual using an x-ray device (Intra-oral Focus, Kavo®), of 60 kVp and 10 mA, set for 0,3 seconds of exposure (Fig 1).

A total of 32 lower incisors, being 16 with a single canal and 16 with two root canals (buccal and lingual) were used. To evaluate if the shape of the opening affected the localization of root canals, all samples had their accesses done in conservative way (oval conservative group), followed by clinical evaluation by two examiners specialists in Endodontics. Completed this step, the same teeth received an additional detrition in their openings, originating the second group (triangular non-conservative group), for posterior clinical evaluation regarding the number of root canals.

On the oval conservative coronary opening it was used a high rotation spherical diamond tip, number 1011 (KG Sorensen®) to work in enamel on the center of the lingual surface, aiming to obtain an oval shape with

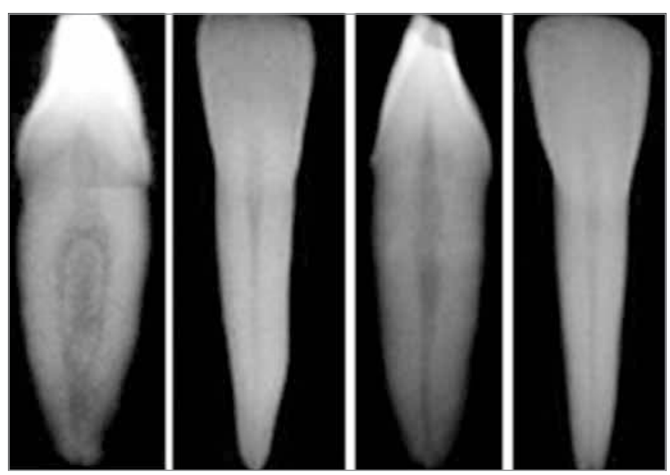

Figure 1. Periapical radiographs of two samples, on vestibulolingual (VL) direction and mesiodistal (MD) direction to confirm the absence of calcification as well as the number of canals.

larger cervico-incisal diameter, which went from the incisal edge to an area above the cingulum. After giving the initial oval shape, the pulp chamber was perforated with the spherical tip and, with a conical diamond tip of inactive extremity, number 3028 (Kg Sorensen®), in high rotation, it was removed the roof of the pulp chamber and buccal interference, slightly inclining the diamond tip to the incisal edge of the opening. Then, it was performed the detrition of the lingual dentin located underneath the cingulum. The mesiodistal width of the conservative opening was between 1,0 and 1,25 mm (Fig 2).

On the triangular non-conservative coronary opening the oval contour shape was enlarged with the same diamond tip 3028 (KG Sorensen®), leaving the proximal walls of the access slightly devious to incisal. On the incisal edge of the opening it was performed a bevel aiming to comprise the incisal edge of the tooth and, cervically, the opening was extended to the cingulum area, receiving an additional detrition of the dentin located on the lingual wall of the opening. The mesiodistal extension of the opening was between 1,5 and 2 mm (Fig 3).

For examination of the number of root canals, the incisors with one and two canals, previously identified, were randomly positioned on the anteroinferior segment of a mannequin for periodontia (Prodens®) and evaluated in both moments by two specialists in Endodontics with different periods of experience (the observer 1 with 7 years of experience and the observer 2 with 25 years of experience).

With the mannequins properly positioned on the dental chair and under lighting from a floodlight (Gnatus, Persus Simple), each observer received a form for identification of dental elements, plane dental mirror, an endodontic probe and files type K #10 of 21 mm (Dentsply Maillefer) to explore and identify the number of root canals.

For analysis of agreement inter and intraexaminers it was used the Kappa index and for comparison of the results obtained with different types of openings it was used the McNemar test ($p = 0,05$).

Results

On Table 1, it was observed that on the conservative opening the examiners 1 and 2 obtained, respectively, 94% and 97% of scores on the identification of cases with a single canal, obtaining 0 and 31% of scores in cases with two canals. Besides, from the 16 cases that had a single canal, the examiners 1 and 2 mistakenly classified one and two teeth as carriers of two root canals, respectively. After examined the enlarged openings (triangular non-conservatives), the examiners 1 and 2, respectively, obtained scores of 5 (31,2%) and 10 (62%) of the 16 cases with two canals, with 100% of score for the cases with a single canal.

Table 2 shows that the examiner 1 obtained 15 scores and 11 errors on the localization of the canals on the same teeth on the two shapes of opening (oval and triangular). However, with the six errors occurred on the examination of the teeth with conservative openings, it occurred scores when they were examined after enlarging the cavity. To compare the results obtained by examiner 1, it was used McNemar test, obtaining a p value

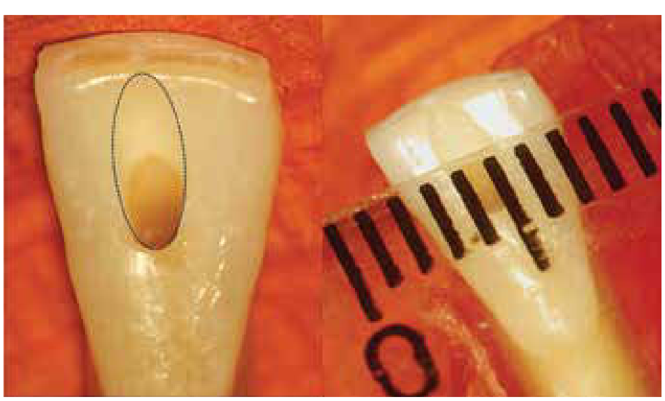

Figure 2. Conservative oval opening.

Figure 3. Non-conservative triangular opening.

Table 1. Identification of root canals in lower incisors with conservative and non-conservative opening.

	Coronary opening			
	Conservative (oval)		Non-conservative (triangular)	
	Examiner 1	Examiner 2	Examiner 1	Examiner 2
Scores / single canal (n = 16)	15 (94%)	14 (87%)	16 (100%)	16 (100%)
Scores / two canals (n = 16)	0 (0%)	5 (31%)	5 (31%)	10 (62%)
Scores / total (n = 32)	15 (47%)	19 (59%)	21 (66%)	26 (81%)

Table 2. Results of Examiner 1 on the identification of canals of incisors with conservative and non-conservative coronary opening.

Non-conservative Triangular	Conservative Oval		Total
	Score	Error	
Score	15	6	21 (65.6%)
Error	0	11	11 (34.4%)
Total	15 (46.9%)	17 (53.1%)	32 (100%)

Table 3. Results of Examiner 2 on the identification of canals of incisors with non-conservative and conservative coronary opening.

Non-conservative Triangular	Conservative (oval)		Total
	Score	Error	
Score	18	8	26 (81.3%)
Error	1	5	6 (18.7%)
Total	19 (59.4%)	13 (40.6%)	32 (100%)

of 0,031, which indicates the existence of significative difference between the techniques ($p < 0,05$), where the non-conservative coronary opening had a score percentage higher than the conservative opening. The coefficient of concordance between the techniques of opening to locate root canals for examiner 1 was Kappa = 0,632, indicating that there was mild concordance between the two techniques of coronary opening on the localization of root canals.

Table 3 demonstrates that for examiner 2 there were 18 scores and 5 errors both in oval conservative shape and triangular non-conservative shape, being observed that in 8 cases of error of conservative opening occurred scores when the cavity was enlarged. To compare the results, it was used McNemar test, with p value of 0,039, which indicates the existence of significative difference between the techniques ($p < 0,05$), where the triangular non-conservative coronary opening had a percentage of scores of 81,3% versus 59,4% of the oval conservative opening.

The coefficient of concordance between the techniques was Kappa = 0,363, indicating that for examiner 2 there was a low concordance between the two techniques of coronary opening on the localization of root canals. The coefficient of concordance between examiners 1 and 2 for triangular non-conservative opening was Kappa = 0,456 and, for oval conservative opening, was Kappa = 0,629, thus determining that examiners 1 and 2 presented mild concordance. The highest concordance of results between examiners on the determination of number of canals occurred in the shape of oval conservative opening because the number of errors was higher for both examiners in this stage. However, for both examiners the triangular non-conservative opening was more efficient than the conservative on the detection of number of canals.

Discussion

For the lower incisors with two canals Warren and Laws[8] and Clements and Gilboe[9] recommend that the coronary opening is performed by buccal or, according to LaTurno and Zillich,[10] Mauger et al[11] and Johnson,[12] that the cavity is extended more to vestibular, once the opening by lingual will difficult the localization and exploration of the second canal because of the presence of prominent protuberance of the dentin in the cingulum area. About the extension of the cavity of access to vestibular, Mauger et al[11] concluded that on teeth with greater detrition of the incisal edge, the ideal place to obtain access in straight line switches from buccal to incisal edge. In this work the best results obtained on triangular shaped openings may have been affected by the involvement of the incisal edge of teeth in the access cavity, according to mentioned by authors that defend this approach.

On the other side, Janik states to be essential to extend the access cavity to the cingulum area to locate and properly debride the lingual canal, should radiographic evidences suggest the possibility of existing two canals in lower incisors. In agreement with this approach, are authors such as Ingle et al,[14] Vertucci et al,[15] Buchanan[5] and Peters.[7] Similar procedures were adopted in this study, where non-conservative openings had the cavity enlarged to the cingulum area, with greater detrition of the lingual dental wall, which may have facilitated the higher score obtained by the examiners in relation to the localization and determination of the canals in lower incisors.

Regarding the shape and size of the access cavity Stock,[16] Ingle et al[14] and Vertucci et al[15] asserted that the external contour of coronary openings in lower incisors can be triangular or oval, depending on the prominence of the mesial and distal pulp horns. Ruddle[17] recommends that the size of the access cavity is determined by the position of the inlet orifice of canals and, regarding the axial walls, he recommends that are laterally extended so that the orifice is in continuity with them. About this, Janik[13] reports that in an overly small access, the file inserted in the tooth generally will freely pass on the buccal canal, not locating the lingual canal. Such fact was observed in the present work where the difficulty to locate two canals was greater in oval conservative openings, when compared to non-conservatives, for both examiners.

Corcoran et al[18] demonstrated in a study that the professional experience affects the localization of additional canals. In the present work, by examining the dental elements with oval conservative coronary openings, no case that had two canals was identified by examiner 1 (less experienced). However, on the same conservative group, the examiner 2 (more experienced) scored 5 (31,2%) from the 16 cases that presented two root canals. When the same 16 teeth were examined in the second moment, i.e., after enlarging the conservative opening, the examiner 1 increased the scores, localizing in 5 (31,2%) from the 16 cases the two canals, and the examiner 2 scored 10 from the 16 cases that presented two root canals. On the conservative opening, 6,2% (1 tooth) and 13% (2 teeth) from the 16 teeth that had single canal, were mistakenly classified as carriers of two canals by the examiner 1 and 2, respectively, not being observed cases of error on the identification of cases with one canal after obtaining the shape of triangular non-conservative opening, both for examiners 1 and 2.

This work shows the necessity for procedure of access on anterior inferior teeth with two canals present a greater amplitude on mesiodistal and cervico-incisal directions to facilitate the localization of the lingual canal. The non-involviment of the incisal edge, as well as of the cingulum area of the tooth on the cervico-insical extension of the conservative oral opening, made it very difficult the localization of the second canal and, according to Janik,[13] many times the preservation of the cingulum may lead to failure in locate the lingual canal, as well as the traditional access through lingual may leave a second canal without treatment, according to Warren and Laws[8] and Clements and Gilboe,[9] who defend the involvement of the vestibular surface or of the incisal edge on the opening of lower incisors. The small extension of the oval opening on the mesiodistal direction (1,0 a 1,25 mm), defended by authors such as Buchanan,[5] may have injured the lighting and indirect inspection on the clinical examination of the teeth that had two canals, because its walls are not expulsive as on the non-conservative triangular openings, which allows better transition of the light reflected by the mirror to the inner part of the cavity. Besides, according to Nielsen and Shahmohammadi,[6] to mesiodistally enlarge beyond 1 mm is reasonable if it is necessary to obtain the appropriate visualization and instrumentation of the canal.

Conclusion

Based in this study, it can be concluded that the non-conservative triangular coronary opening favors significantly the localization and determination of root canals of lower incisors when compared to conservative oval opening. However, as in none of both shapes of opening there was 100% of score on the localization of presence of two canals, aditional researches are necessary to observe if coronary opening with buccal approach affect the localization of the second canal of lower incisors.

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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.

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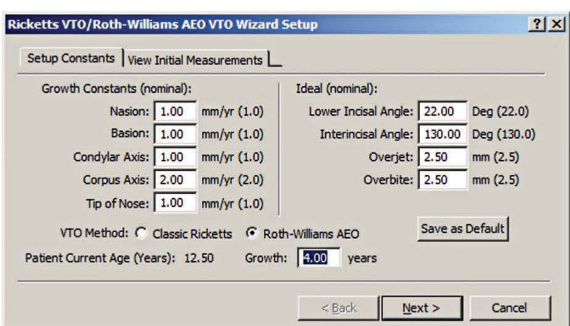
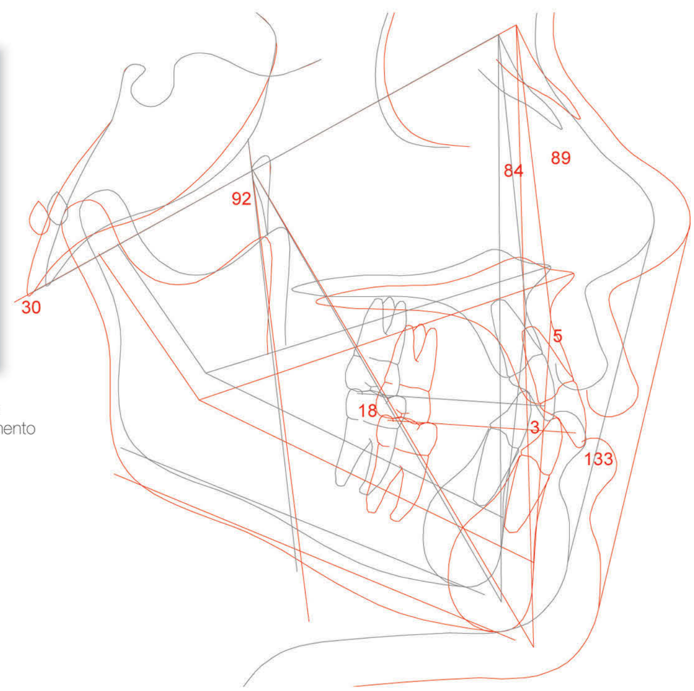
- Nova Prescrição de VTO Roth/Ricketts
- Adotado pelo Grupo de Educação Avançada em Ortodontia (Roth/Williams)

Visualize resultados para seu preciso plano de tratamento e apresentação de caso. Os aplicativos otimizados da versão Dolphin Imaging 11.0 oferecem novas ferramentas como a prescrição de VTO Roth/Ricketts. A simples programação passo a passo reduz e facilita o trabalho necessário para realizar adequada e sistematicamente o diagnóstico e tratamento de pacientes. Para saber mais, acesse: www.dolphinimaging.com/imaging ou contate: comercial@renovatio3.com.br / fone: +11 3286.0300.



VTO AEO/Roth para paciente em crescimento



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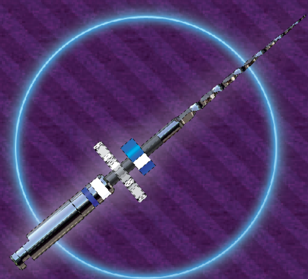
*Imagens meramente ilustrativas

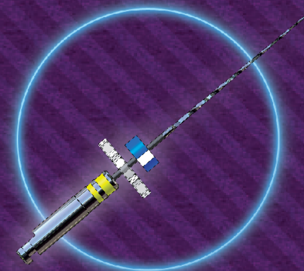
RaCe

Um novo conceito em instrumentos rotatórios de Níquel-Titânio (NiTi).



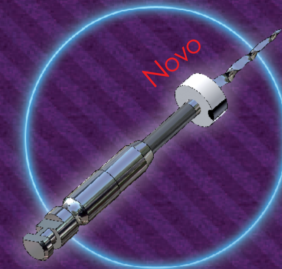
iRaCe

Sequência RaCe para a maior parte dos casos.



iRaCe Plus

Sequência RaCe para casos difíceis (severamente curvos, estreitos e/ou calcificados).

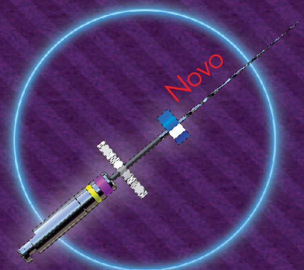


D-RaCe

Para desobturação dos canais radiculares durante as manobras de reintervenção endodôntica.

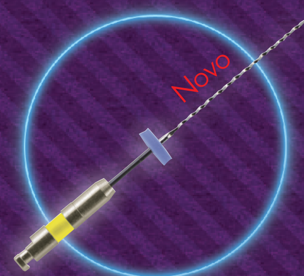
Easy RaCe

Sequência RaCe para maioria dos canais (acima de 80% dos casos!).



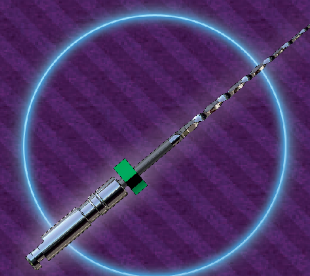
Scout-RaCe

Possibilita as manobras de exploração, primeiro acesso e pré-moldagem em toda a extensão do canal.



S-ApeX

Novo, único instrumento rotatório NiTi com conicidade invertida.



BioRaCe

Sequência RaCe que preenche os requisitos biológicos para o sucesso endodôntico.

Informações e pedidos pelo telefone (11) 5542.5855 ou e-mail vendas.fkg@labordental.com.br.

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