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Use of cone beam computed tomography in the diagnosis, planning and follow up of a type III dens invaginatus case

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Running Title: Treatment of type III dens invaginatus

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Abstract

Aim To present the case of a maxillary left lateral incisor with Oehlers' type III dens invaginatus in which cone beam computed tomography (CBCT) was used as an adjunctive resource in the diagnosis as well as in the planning and two-year follow-up of the nonsurgical/surgical treatment.

Summary The tooth had two root canals: a primary (main) canal with vital pulp that appeared to be closed apically and an invaginated canal that was necrotic, wide-open at the portal of exit and associated with a large chronic periapical lesion extending to the apex of the maxillary left central incisor. Radiographic tracking of a sinus tract in the labial gingiva of the affected tooth with a gutta-percha point revealed its origin to be the invagination. The CBCT scans revealed that the periapical radiolucency was significantly larger than seen radiographically and an increased thickness of the buccal cortical plate. Conventional root canal treatment of the primary canal was under taken. As nonsurgical access to the invaginated canal was not possible, endodontic surgery was performed for curettage of the lesion, root-end cavity preparation using ultrasonic tips and root canal filling with white mineral trioxide aggregate. CBCT scanning after 17 months and clinical and radiographic follow-up after 24 months revealed complete periapical repair and absence of symptoms. **Key learning points:** The combination of non-surgical and surgical treatments produced periapical repair in a tooth with type III dens invaginatus with two root canals. CBCT may aid the diagnosis as well as the management plan and follow-up of teeth with this developmental anomaly.

Key words: anomalies, cone beam computed tomography, dens invaginatus, endodontic treatment, endodontic surgery.

Introduction

Dens invaginatus is a developmental anomaly that results in an enamel-lined cavity intruding into the crown or root before the mineralisation phase (Shafer *et al*. 1983, Reddy *et al*. 2008). Over the years several theories have been proposed to explain the aetiology of these invaginations: constriction of the dental arch on the enamel organ, a retardation or acceleration of growth of the internal enamel epithelium, a distortion of the enamel organ during tooth development or inadequate nutrition of a portion of a single tooth germ (Souza & Bramante 1998).

The classification system proposed by Oehlers (Oehlers 1957) is probably the most clinically relevant and is by far the most commonly used in clinical studies, case reports and case series. The cases are grouped in three major categories, according to the depth of the invagination and the existence of communication with the pulp tissue or periodontal ligament, regardless of the affected tooth (anterior, posterior, supernumerary). A single tooth can present multiple invaginations, but each one may fall into a different classification: type I is an enamel-lined minor invagination occurring within the confines of the tooth crown not extending beyond the cementoenamel junction; in type II, the invagination extends apically beyond the cementoenamel junction, but remains as a blind sac and it may or may not communicate with the dental pulp; in type III, the invagination penetrates through the root, perforating the apical area and having a second foramen in the apical or periodontal area, but there is no immediate communication with the pulp.

The most frequently affected tooth is the maxillary lateral incisor (Shafer *et al* 1983, Rotstein *et al* 1987,Yeh *et al*. 1999, Alani & Bishop 2008), with a reported incidence of approximately 1% and a bilateral involvement of under 1%. In decreasing order of frequency, other teeth that develop this anomaly are the maxillary central incisors, premolars, canines, and molars (Yeh *et al*. 1999).

The clinical appearance of dens invaginatus varies considerably. The crown of affected teeth can have normal morphology or it can also be associated with unusual forms such as greater buccolingual dimension, peg-shaped, barrel-shaped, conical shapes and talon cusps (Souza & Bramante 1998, Reddy *et al*

2008). A deep foramen caecum might be the first clinical sign indicating the presence of an invaginated tooth. As this area is difficult to access and clean, caries develop with subsequent pulp necrosis and evolution to apical pathosis (Yeh *et al* 1999, Jung 2004).

Dens invaginatus may require treatment that can range from less invasive procedures to the combination of different therapies (Hülsmann 1997) associated with advanced technical resources for diagnosis and treatment planning (Reddy *et al* 2008, Alani & Bishop 2008). In case of pulp involvement, root canal treatment has been recommended with high success rates (Rotstein *et al* 1987, Szajkis & Kaufman 1993). Endodontic surgery is the treatment modality indicated when endodontic therapy fails, or when endodontic treatment or retreatment is impossible or would not achieve better results. It is also indicated for cases of severe forms of dens invaginatus. In other cases, combined treatment may be necessary, that is, root canal treatment followed by endodontic surgery due to the complexity of the root morphology or in case of large apical lesions (Rotstein *et al*. 1987, Souza & Bramante 1998, Schmitz *et al*. 2010).

The bulky and irregular volume of the invaginated canal makes cleaning and shaping difficult. The use of ultrasonic tips has been described as being of great efficacy in these cases (Skoner & Wallace 2008). Lateral condensation of thermoplasticized gutta-percha has been recommended for canal filling when conventional access to the invaginated canal is possible (Rotstein *et al*. 1987, Lichota *et al*. 2008). Mineral trioxide aggregate (MTA) has also been largely used in the treatment of invaginated teeth because of its biocompatibility, reparative capacity by stimulation of mineralised tissue deposition, superior sealing capacity in the presence of moisture, and reduction in the treatment time (Jaramillo *et al*. 2006, Sathorn & Parashos 2007, Reddy *et al*. 2008, Demartis *et al*. 2009).

Conventional radiography has an important role in the evaluation of the complex morphology of the root canal system, but they only provide two-dimensional representation of a three-dimensional structure (Jung 2004, Reddy *et al*. 2008). The use of more advanced imaging methods, such as cone beam computed tomography (CBCT), has become ever more common in a number of dental specialties. Endodontic applications of CBCT include the diagnosis of periapical lesions due to pulpal inflammation, more detailed visualisation of canals, elucidation of internal and external resorption, and detection of root fractures (Tyndall & Rathore 2008). CBCT has been specifically designed to produce undistorted three-dimensional reconstruction of the maxillofacial skeleton as well as three-dimensional images of the teeth and their surrounding tissues (Al-Rawy *et al*. 2010). This is usually achieved with a substantially lower effective radiation dose compared to conventional CT, though higher than that of conventional dental radiography techniques (Roberts *et al*. 2009). Periapical disease may be detected sooner using CBCT compared to periapical images, revealing the actual size, extent, nature and position of periapical and resorptive lesions. In addition, CBCT scans provide valuable information about dental anatomy (Patel 2009), and can be used prior to periapical surgery to assess the thickness of the cortical and cancellous bone and the inclination of roots in relation to the surrounding jaw (Patel *et al*. 2007), and thus help plan the treatment (Reddy *et al*. 2008, Demartis *et al*. 2009).

This paper describes the use of CBCT as an auxiliary resource in the diagnosis as well as in the planning and 2-year follow-up of the non-surgical/surgical treatment of a maxillary left lateral incisor with Oehlers' type III dens invaginatus in which the invaginated canal was associated with chronic apical periodontitis and the primary (main) canal contained vital tissue.

Case Report

A 12-year-old boy was referred by a general dentist for root canal treatment of the maxillary left lateral incisor tooth. The patient was under fixed orthodontic treatment. Root canal treatment of the maxillary left central incisor had been iniciated by the general dentist after confirmation of pulp necrosis, though without remission of a sinus tract in the labial gingiva of the lateral incisor. Radiographic tracking of the sinus tract with a gutta-percha point revealed its origin to be in wide-open apical end of an invaginated canal of this tooth.

In spite of the sinus tract indicating development of necrosis, the lateral incisor responded to cold and hot stimuli. The tooth presented greater mesiodistal width than usual (Fig. 1a), normal color, normal gingival tissues and probing depth (<3mm), and a composite resin restoration on the palatal aspect (Fig. 1b). Review of medical history was uneventful and no previous dental trauma was reported.

Radiographic examination revealed that the tooth had Oehlers' type III dens invaginatus and two root canals: a separate primary (main) canal that appeared to be closed apically and an invaginated canal that was wide-open at the portal of exit and associated with a large periapical lesion extending to the apex of the maxillary left central incisor (Fig. 1c). Approximately two thirds of the invagination seemed to be lined by enamel. The lack of communication between the vital pulp tissue in the main canal and the necrotic tissue in the invaginated canal explained the positive response of the tooth to the pulp tests. Radiographic examination of the contralateral tooth did not reveal a malformation.

A CBCT scan of the involved teeth was performed as a complementary examination (i-CAT CBCT scanner, Imaging Sciences International, Inc, Hatfield, Pennsylvania, USA), at 120KVp, in sections of 1.0mm thickness. The CBCT scans revealed the periapical radiolucency was larger than seen radiographically, measuring 2.0 x 1.5 cm axially (Fig. 2a). The two canals were visualised: the main canal located distally, which tapered progressively towards the apex; and an invaginated canal mesial to and separate from the main root canal, which was obliterated in the cervical third, appeared wide in the middle third, and then became discontinuous in the apical third (Fig. 2a). An increased thickness of the buccal cortical plate was observed (Fig. 2b) and the lesion was in continuity with the incisive foramen (Fig. 2).

As non-surgical access to the invaginated canal was not possible, endodontic surgery was planned. Conventional root canal treatment of the main canal was achieved prior to surgery due to the high risk of rupture of its neurovascular bundle during curettage of the periapical lesion. After local anaesthesia with 2% lidocaine and epinephrine 1:100,000 (DFL, Rio de Janeiro, RJ, Brazil), access to the pulp chamber was gained under rubber dam isolation and the working length was established 1 mm short of the apex using an electronic apex locator (Bingo 1020; Forum, Rio Comprido, RJ, Brazil) followed by radiographic confirmation (Fig. 3a). The canal was instrumented according to a crown-down technique to a size 50 Flexofile instrument (Dentsply Maillefer, Ballaigues, Switzerland) followed by a step-back preparation from the working length at 1 mm increments to a size 70 Flexofile instrument. Throughout the preparation, the canal was copiously irrigated with 2.5% sodium hypochlorite (Farmácia Botânica, São Sebastião do Caí, RS, Brazil), followed by a final flush with 17% EDTA (Biodinâmica Europa S.L., Ibiporã, PR, Brazil) for 3 min and neutralisation with 2.5% sodium hypochlorite. The canal was the dried with sterile absorbent paper points filled with lateral condensation of gutta-percha cones (Tanari, Manaus, AM, Brazil) and AHPlus sealer (Dentsply DeTrey, Kontanz, Germany). The root canal treatment of the maxillary left central incisor was also completed following the same protocol (Fig. 3b). The access cavities of both teeth were restored with Filtek-Z250 composite resin (3M ESPE, St. Paul, MN, USA).

The orthodontist was asked to discontinue temporarily the application of forces to the maxillary teeth. Endodontic surgery was performed in a subsequent session. After local anaesthesia with 2% mepivacaine (DFL, Rio de Janeiro, RJ, Brazil), incision and elevation of a full-thickness flap (Fig. 3c), the large lesion involving the roots of the central and lateral incisors was curetted and root-end resection was performed in both teeth (Fig. 3d). Root-end cavity preparation of the invaginated canal was carried out with ultrasonic tips followed by root canal filling with white MTA (Angelus, Londrina, PR, Brazil) (Fig 3e).

The flap was repositioned, sutured with nylon 4.0 sutures (Somerville, Jaboatão dos Guararapes, PE, Brazil) and an immediate postoperative periapical radiograph was taken (Figure 4A). Sutures were removed one week later. The histopathological diagnosis of the lesion was chronic periapical abscess. Radiographic examination 3 months (Fig. 4b), 6 months and 12 months (Fig. 4c) postoperatively showed ongoing periapical repair.

The CBCT scan was repeated 17 months after treatment because the buccal cortical plate on the left side (adjacent to the dens in dent) exhibited an increased volume in comparison to the same region on the right side, although much smaller than observed in the previous examination. This clinical finding, however, was not supported by any radiographic evidence, as the 3-, 6- and 12-month postoperative radiographic images showed good repair of the area. Sagittal CBCT sections of the left central and lateral incisors revealed a discrete residual apical rarefaction associated with the maxillary left lateral incisor and discrete periodontal ligament widening of the maxillary left central incisor, probably due to the orthodontic treatment (Fig. 5a,b). The axial CBCT sections of the maxillary left lateral incisor showed complete filling of the main and invaginated canals as well as apical repair. In addition, the axial CBCT sections allowed the assumption taht the anatomical feature of type III dens invaginatus may cause a thick buccal plate (Fig. 5c-e). At 24 months, the radiographic examination revealed an excellent periapical repair with the patient having remained symptom-free.

Discussion

This paper presents an interesting case of Oehlers' type III dens invaginatus in a maxillary left lateral incisor with two root canals, a primary canal with vital tissue and a invaginated canal with necrotic tissue, which was associated with a periapical lesion extending to apex of the maxillary left central incisor, as confirmed by apical axial CBCT sections (Fig. 2a). Periapical radiographs are limited in revealing the type, extension and complex morphology of dens invaginatus as well as the actual bone loss compared to tomographic techniques. More advanced imaging techniques, such as CBCT, may aid the diagnosis as well as the management plan and follow-up of teeth with this dental developmental anomaly.

Although the maxillary left lateral incisor was responsive to the pulp sensibility tests, a sinus tract had developed on the labial gingiva close to the apical region of this tooth. Radiographic tracking of the sinus tract revealed it originated from the invaginated canal. An explanation for the contamination of this canal could be the presence of a cavitated carious lesion in the palatal surface of this tooth, which had greater mesiodistal width than usual (Pai *et al*. 2004) and had been previously removed and restored with composite resin. The presence of caries in this region could have led to bacterial penetration into the invaginated canal, causing apical periodontitis. Hülsmann (1997) has reported that the enamel is fragile and hypomineralized in invagination. It is possible that the dentist who placed the original composite filling did not notice the presence of a small perforation that served as a pathway of communication between the floor of the cavity and the invaginated canal.

De Smit *et al*. (1984) performed a histological investigation of six invaginated human maxillary incisors, and found that the outlines of the invaginations resembled bottles with narrow necks directed at the incisal edge of the teeth. Structurally normal enamel forms a uniform layer between dentine and inner connective tissue of the invagination. At the entrance of the invaginated portion, both enamel layers are so close that only one band of connective tissue can be observed. Apically, the centrally positioned connective tissue was richly supplied with blood vessels and lined with layers of epithelial tissue, demonstrating various stages of an involutive enamel organ. De Smit *et al*. (1984) believed that after eruption, these teeth would lose this blood supply in the central portion of the invagination, resulting in necrosis of this tissue. This could be another explanation for the development of chronic apical periodontitis associated with the invaginated canal.

Because of their unusual root canal anatomy and wide apical foramen, teeth with Oehlers' type III dens invaginatus can be treated with a combination of non-surgical and surgical procedures or extraction, as the last resort in more severe cases (Pai *et al*. 2004). The complex anatomy of these teeth makes conventional root canal treatment challenging, especially in those cases with a wide open foramen. An immature apex causes additional problems due to the possibility of overfilling and the difficulty in achieving a satisfactory apical seal (Sathorn & Parashos, 2007, Reddy *et al*. 2008). Therefore, although conservative root canal treatment is one of the possibilities for Oehlers' type III dens invaginatus (Chen *et al*. 1998, Holtzman 1998, Gonçalves *et al*. 2002, Jung, 2004, Pai *et al*. 2004, Jaramillo *et al*. 2006, Lichota *et al* 2008, Demartis *et al*. 2009, Kusgoz *et al*. 2009), non-surgical and surgical endodontic interventions were combined in the present case (Ortiz *et al*. 2004, Reddy *et al*. 2008, Schmitz *et al*. 2010). Surgical apical access was necessary because it was not possible to locate the canal a coronal access due to an accentuated cervical narrowing, as shown on the axial CBCT scans (Fig. 2a) and also because the invaginated canal had an unusual anatomy and was wide-open at its portal of exit. Cleaning and shaping of the dens track was achieved by root canal preparation with ultrasonic tips (Skoner & Wallace 1994, Girsch & McClammy 2002). Skoner & Wallace (1994) affirmed that the use of ultrasonic tips improves significantly the surgical phase of the treatment. The use of an operative microscope could have aided locating the canal in the cervical third (Jung 2004). However, as an operative microscope was not available, conventional access to the canal was not attempted because of the risk of accidents such as lateral perforation with burs.

Most authors (Yeh *et al*. 1999, Jung 2004, Pai *et al*. 2004, Jaramillo *et al* 2006, Schmitz *et al*. 2010) recommend successive changes of calcium hydroxide dressing in immature teeth to stimulate the formation of a mineralised tissue barrier prior to root filling. However, this treatment protocol requires longer chairtime and several clinical sessions. In the present case, as the patient lived in a city far from the dental office and was undergoing orthodontic treatment, surgical treatment of the invaginated canal seemed to be indicated. It should be mentioned that the application of orthodontic forces to the tooth was discontinued until apical repair was observed.

Kusgoz *et al*. (2009) presented a case of type III dens invaginatus that was resolved successfully with non-surgical root canal treatment and exhibited healing after 18 months without any need for further surgical intervention despite the complex anatomy of dens invaginatus. However, the treatment of the invaginated canal was performed exclusively in its enamel-lined portion. It is known that the invagination can be completely lined by enamel, but cementum is frequently seen in its apical portion (Oehlers 1957). In the present case, the apical lesion was extensive, also reaching the maxillary left central incisor (Figs. 1a, 2, 3d,e). Therefore, the treatment of choice, that is, disinfection and retrofilling of the apical portion of the canal not lined by enamel with MTA would increase the chances of success since bacteria could have remained in this part of the canal. In addition, MTA sets in the presence of moisture, is biocompatible and stimulates apical repair (Torabinejad *et al*. 1998, Economides *et al*. 2003), being the material of choice in a number of cases of dens invaginatus (Reddy *et al*. 2008, Jaramillo *et al*. 2006, Demartis *et al*. 2009).

Teeth with Oehlers' type III dens invaginatus present two canals with (Chen *et al*. 1998, Yeh *et al*. 1999, Jaramillo *et al*. 2006, Lichota *et al*. 2008, Demartis *et al*. 2009) or without (Szajkis & Kaufman, 1993, Holtzman 1998, Gonçalves *et al*. 2002, Kusgoz *et al*. 2009) communication between them. Endodontic treatment of the primary canal is indicated when there is communication with a necrotic invaginated canal (Chen *et al*. 1998, Lichota *et al*. 2008, Demartis *et al*. 2009). However, several authors have stated that root canal treatment of the primary canal is not necessary if it is not communicating with the invaginated canal or when pulp necrosis is not diagnosed (Szajkis & Kaufman 1993, Holtzman 1998, Gonçalves *et al*. 2002). In the present case, although the canals were separated, endodontic treatment of the primary canal was done prior to surgery because rupture of its neurovascular bundle could occur during surgical removal of the apical lesion, causing necrosis and worsening the prognosis of the case.

This case illustrates that the combination of treatments produced periapical repair in a tooth with type III dens invaginatus with two root canals. While the primary canal was treated by conventional non-surgical therapy, endodontic surgery was necessary to treat the invaginated canal with a wide apical opening associated with the large periapical lesion. In addition, CBCT was an important auxiliary resource in the diagnosis, treatment planning and follow-up. CBCT has shown great benefit in the localisation and identification of root canals (Baratto Filho *et al*. 2009) provides the unique possibility of evaluating periapical lesions three-dimensionally with respect to their extension, size and nature (Patel 2009). In the present case, it was possible to determine that the lesion extended from the maxillary left central incisor to the maxillary left lateral incisor as well as its intimate relationship with the nasopalatine (incisive) foramen, the presence of increased thickness of the buccal cortical plate. The CBCT scans revealed that the invagination was narrowed in the cervical third and lined by enamel, which made it difficult reaching the invaginated portion via coronal access.

CBCT could have been used as a diagnostic aid solely in the initial phase of the treatment, respecting the “ALARA” Radiation Principle (*As Low As Reasonably Achievable)*. Nevertheless, the CBCT scan was repeated 17 months after treatment because the buccal cortical plate on the left side (adjacent to the dens in dent) exhibited an increased thickness in comparison to the same region on the right side, although much smaller than observed in the previous examination. This clinical finding, however, was not supported by any radiographic evidence as the 3-, 6- and 12-month postoperative radiographic images showed good repair of the area. It was unclear if the buccal plate thickness was due to the maintenance of the lesion, or if it was due to the anatomical feature of the dens invaginatus, as the patient was not seen before the lesion was present. It was not possible to evaluate this feature precisely using through bi-dimensional periapical radiographs, and the decision to request another CBCT was because if the lesion persisted, this could lead to a new surgery, or even to the progression of a lesion. CBCT provided an accurate view of the repair process and assuring that healing was ocorring. Following of the new CBCT scan, it became clear that it was probably the anatomical feature of type III dens invaginatus that caused the remaining thickness on the buccal plate, and no further intervention was necessary. Therefore, in this case, repeating the CBCT scan was useful to avoid misinterpretations. The decision to repeat the CBCT was also supported by the fact that the extent of the lesion was much greater in the initial CBCT scan than it appeared in the initial radiographic view. In the same way, the follow-up radiographic views showed complete healing, whilst discrete residual apical rarefaction associated with the maxillary left lateral incisor and discrete periodontal ligament widening of the maxillary left central incisor could still be seen on the new CBCT scan. In addition, it confirmed the periapical repair as well as the quality of the root filling of the invaginated canal with MTA (Al-Rawy *et al*. 2010).

Conclusion

The use of CBCT contributed to determine the actual extension of the chronic apical periodontitis associated with a maxillary left lateral incisor with type III dens invaginatus and provided more details of the internal anatomy of this developmental dental anomaly. .

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Figure Legends

Figure 1 Panel of preoperative images. (a) Buccal clinical photograph showing tooth 22 had greater mesiodistal width than usual and normal color; (b) Palatal clinical photograph showing a composite resin restoration (white arrowhead); (c) Periapical radiograph showing the tooth 22 had an Oehlers' type III dens invaginatus and two root canals as well as a periapical radiolucency extending from the wide-open apical extent of the invaginated canal to the apex of tooth 21. Note that approximately two thirds of the invagination is lined by enamel (white arrowhead).

Figure 2 CBCT images. (a) Axial CBCT sections from the cervical, middle and apical thirds of the dens invaginatus. Note that the apical osteolytic zone is significantly larger than seen radiographically, measuring 2.0 x 1.5 cm axially. The two canals can be seen: the main canal (white arrowhead) located distally, which tapered progressively towards the apex; and an invaginated canal mesial (black arrowhead) to and separate from the main root canal, which was obliterated in the cervical third, appeared wide in the middle third, and then became discontinuous in the apical third. (b) The sagittal CBCT sections of tooth 22 (top) show an increased thickness of the buccal cortical plate, the involvement of the tooth with the periapical lesion and the lesion in continuity with the incisive foramen. The sagittal CBCT sections of tooth 22 with the *dens invaginatus* (bottom) show different aspects of the invaginated and main canals.

Figure 3 Periapical radiographs showing root canal length determination (a) and filling (b) of tooth 22 with Oehlers' type III dens invaginatus. Note completion of root filling of tooth 21. Endodontic surgery performed after nonsurgical treatment of the main canal. (c) Exposure of the lesion after full-thickness flap reflection. (d) Bone window enlarged for removal of the lesion involved the apices of teeth 22 and 21 followed by root-end resection of both teeth. (e) Root canal filling of the invaginated canal with white MTA.

Figure 4 Periapical radiographs taken immediately (a), 3 months (b), 12 months (c) and 24 months (d) after endodontic surgery showing periapical repair.

Figure 5 Seventeen-month postoperative CBCT images. (a) Coronal CBCT section showing apical healing. (b) Sagittal CBCT sections showing discrete residual apical rarefaction associated with tooth 21 and discrete periodontal ligament widening of the tooth 22 (*dens invaginatus*). Panel of axial CBCT sections. (c) Image of the cervical third showing filling of the main canal (grey arrow) and invagination lined by enamel (black arrow), (d) Image of the middle third showing complete filling of the main canal (grey arrow) and the invagination (black arrow), (e) Image of the apical third showing healing.

Figure 1

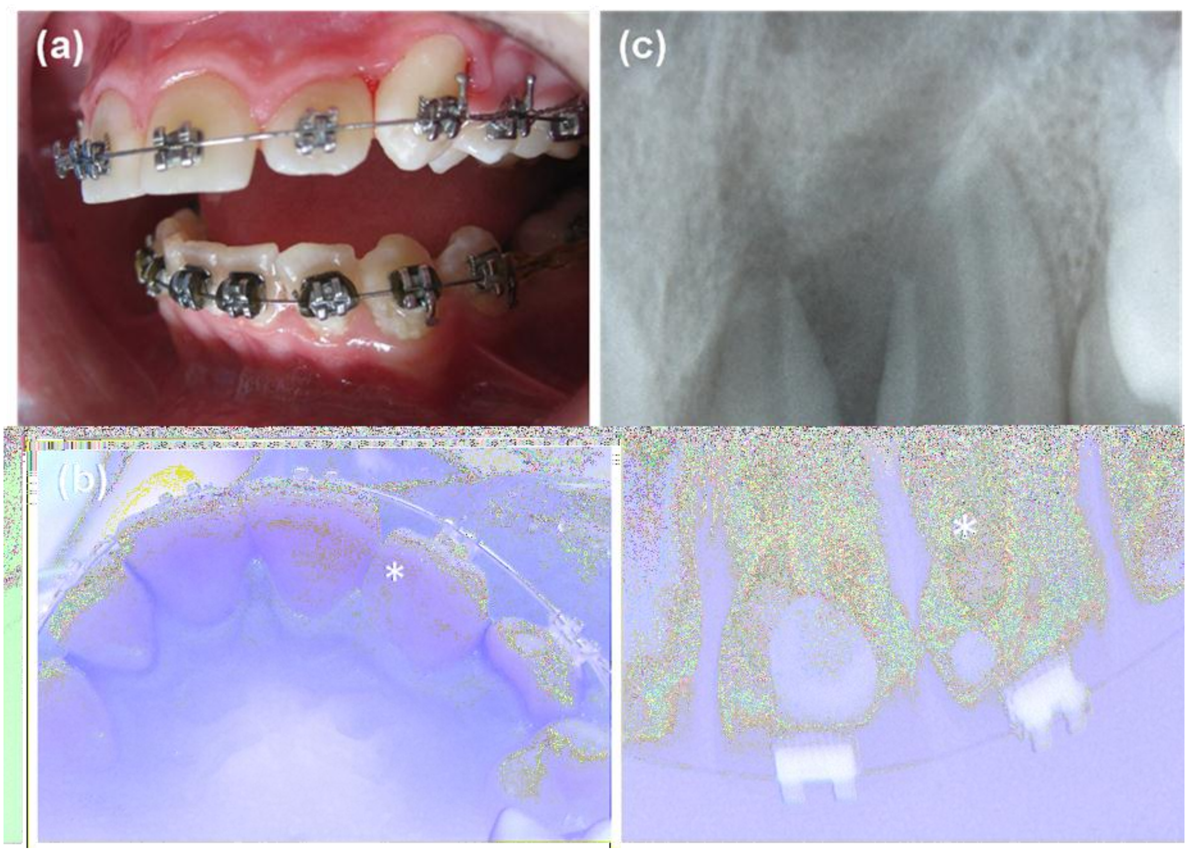


Figure 2

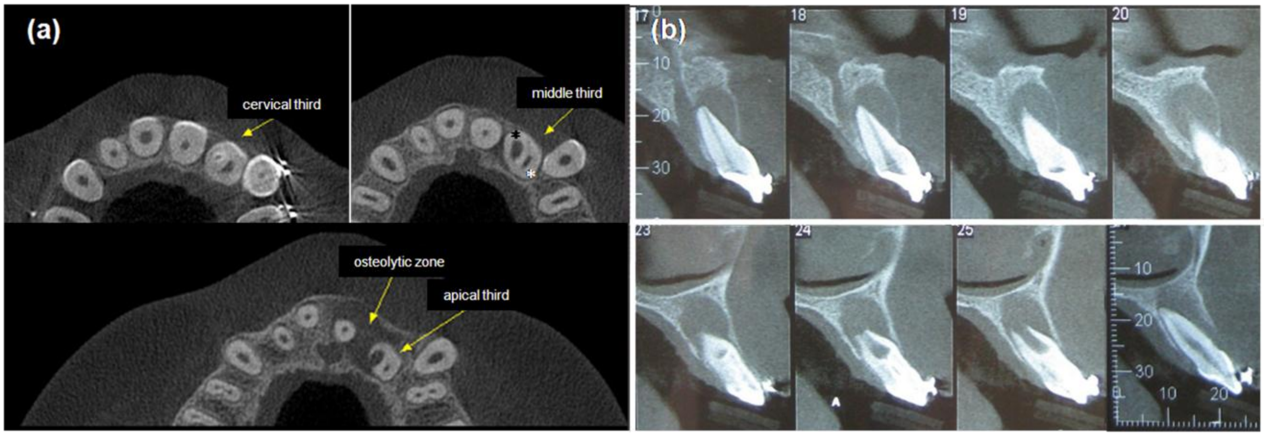


Figure 3

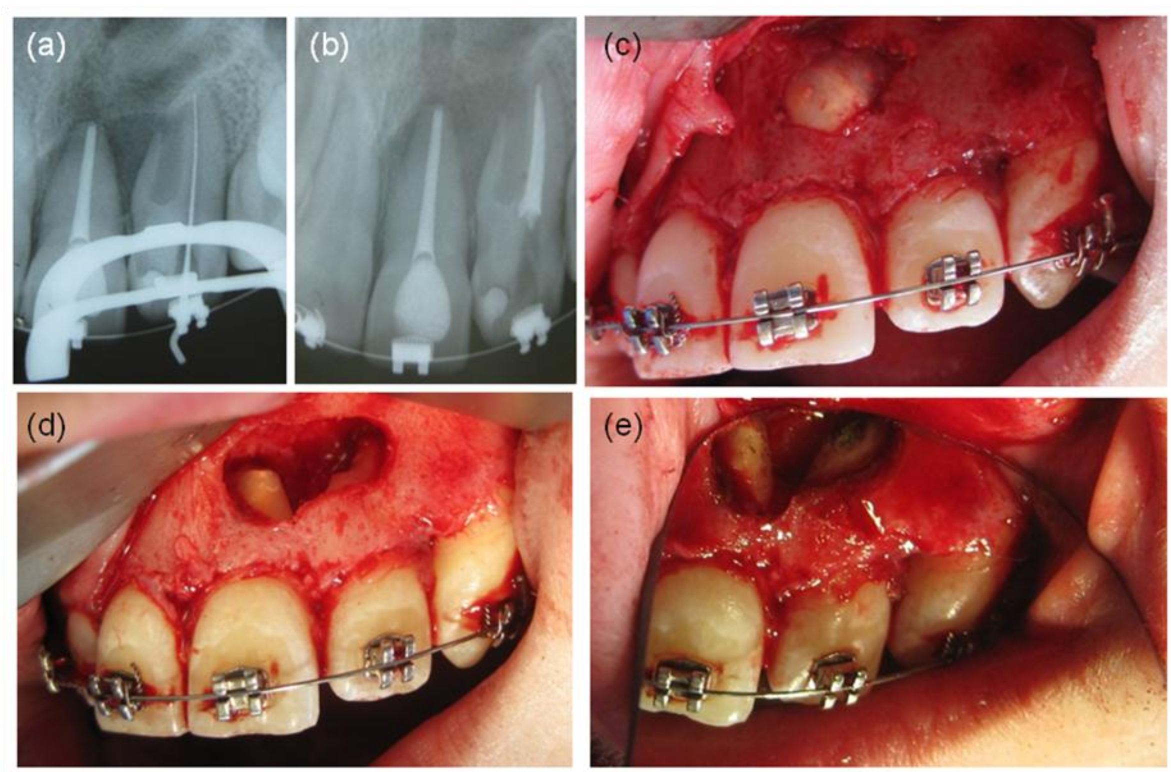
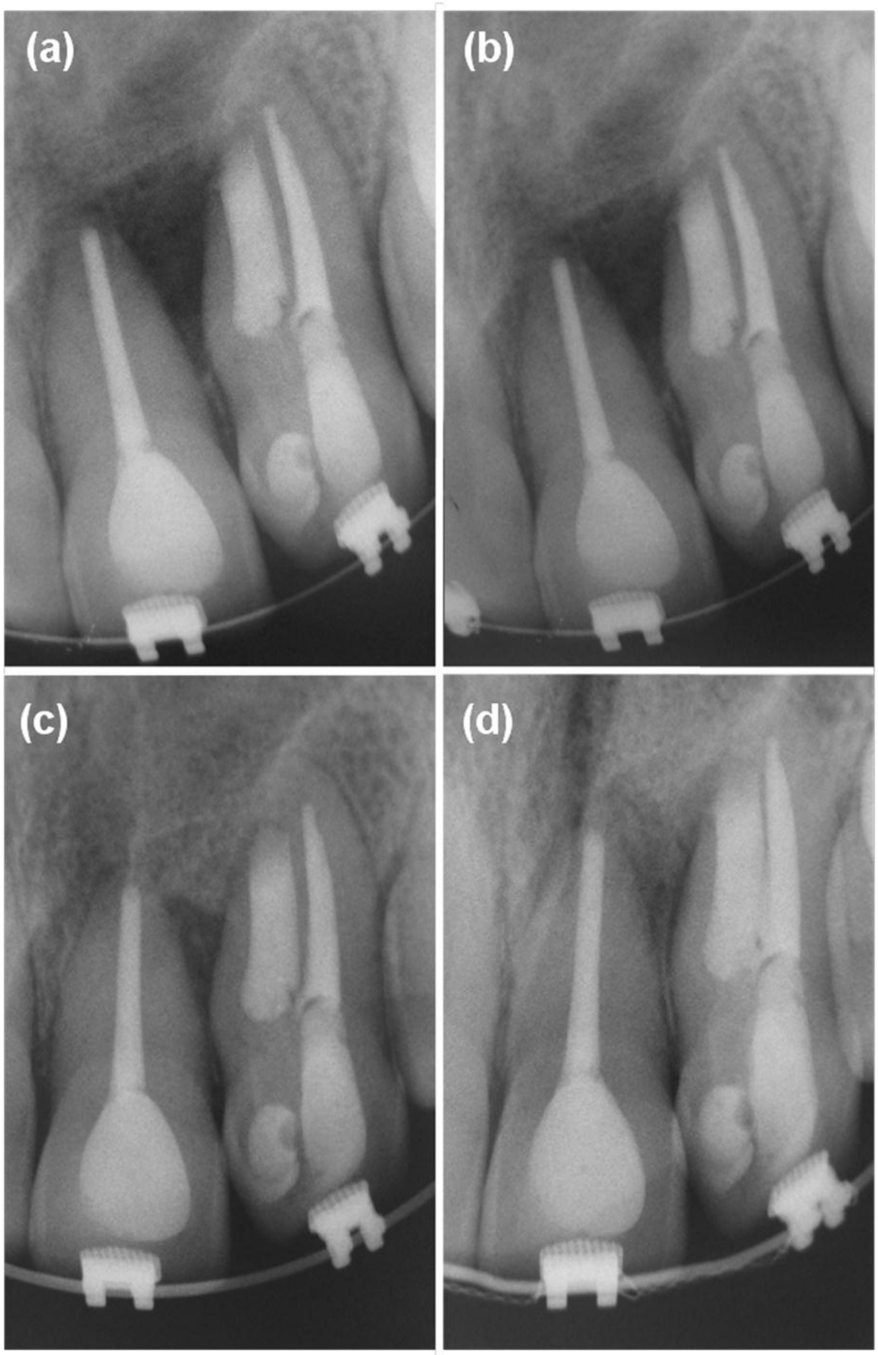
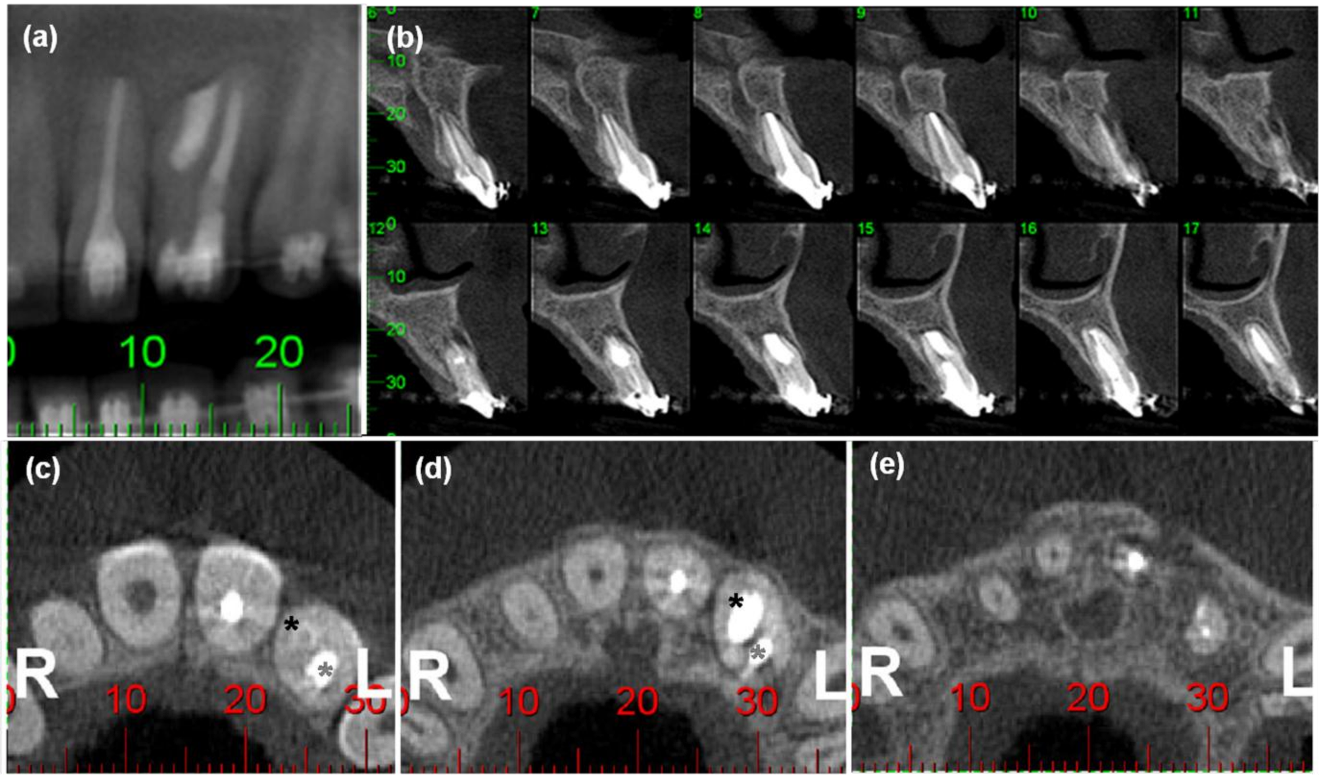


Figure 4





(a)
(b)
(c)
(d)
(e)
R
L