Ankylosis of Permanent First Molar: Diagnosis by Cone Beam Computed Tomography

Anquilosis del Primer Molar Permanente: Diagnóstico por Tomografía Computarizada con Haz Cónico

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ABSTRACT: Ankylosis is an anomaly of tooth eruption characterized by the fusion of cementum and alveolar bone, and may affect from small regions to the entire root surface. Clinical assessment combined with imaging exams can aid diagnosis. Radiographic testing enables assessing only proximal regions of possibly affected roots. Whereas cone beam computed tomography (CBCT) allows a three-dimensional assessment of axial, coronal, and sagittal planes of all dental extension, eliminating thus overlapping images and helping to confirm the correct diagnosis. The present study contains a case report of a male patient with ankylosis in tooth 16 diagnosed by CBCT, aiming at providing information for dentists about this anomaly, its characteristics and situations in which CBCT should be indicated.

KEY WORDS: dental ankylosis, diagnosis, cone beam computed tomography.

INTRODUCTION

Dentoalveolar ankylosis is an anomaly of dental eruption, caused by mechanical failure of eruption (Frazier-Bowers *et al.*, 2007), characterized by the fusion of cementum and alveolar bone (Loriato *et al.*, 2009; Pithon & Bernardes, 2011; Chae & Paeng, 2012; Guimarães *et al.*, 2015; Mohadeb *et al.*, 2016), with destruction of the periodontal ligament (Pithon & Bernardes; Lin *et al.*, 2014) and gradual replacement by bone tissue (Alves *et al.*, 2011; Bertl *et al.*, 2012; Silva, 2015).

Ankylosis can affect both sexes (Silva) and it is more frequent in deciduous teeth (10:1) (Loriato *et al.*; Cohen-Levy *et al.*, 2011; Bertl *et al.*; Silva), with frequency between 1.5 % and 9.9 % (Atobi *et al.*, 2009; Loriato *et al.*), especially when the permanent successor is missing (Bertl *et al.*), affecting mainly

mandibular deciduous first molars (Loriato *et al.*; Alves *et al.*; Bertl *et al.*; Parisay *et al.*, 2013), followed by second mandibular and maxillary deciduous molars (Parisay *et al.*).

Traumatic lesions are considered the main factor for development of ankylosis (Atobe *et al.*, 2009; Cohen-Levy *et al.*; Chae & Paeng; Gault *et al.*, 2013; Lin *et al.*; Mohadeb *et al.*; Silva). Moreover, these are also considered causal factors: metabolic disorders, local deficiency in vertical alveolar bone growth (Atobe *et al.*; Loriato *et al.*; Cohen-Levy *et al.*; Alves *et al.*; Parisay *et al.*; Lin *et al.*; Guimarães *et al.*), failure of eruption force (Alves *et al.*), genetic factors (Atobe *et al.*; Cohen-Levy *et al.*; Chae & Paeng; Lin *et al.*; Guimarães *et al.*; Silva), focal inflammation/infection, chemical/thermal irritants (Cohen-Levy *et al.*; Gault *et*

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al.; Parisay *et al.*; Silva), and soft tissue pressure (Atobe *et al.*; Cohen-Levy *et al.*). It should also be noted that ankylosis may affect teeth that have been extracted and subsequently reimplanted (Takahashi *et al.*, 2005; Chae & Paeng; Silva), but in these cases ankylosis is not considered an anomaly of dental eruption.

The differential diagnosis of ankylosis includes other types of eruption disorders, such as: impaction, primary retention, secondary retention and primary eruption failure (Janssen *et al.*, 2014). In the impaction, the eruption is impaired due to the presence of a physical barrier or due to the ectopic position of the tooth. Primary and secondary retentions are caused by failures in the eruption mechanisms, and in the primary type, the interruption of the eruption occurs before the tooth reaches the gingival level. In the secondary, the tooth ceases the eruption when reaching the gingival level (Magnusson & Kjellberg, 2009). The primary failure of the eruption mainly affects the posterior teeth (Rhoads *et al.*, 2013). In such cases, the tooth may erupt partially, becoming relatively submerged or may not erupt (Frazier-Bowers *et al.*; Smith *et al.*, 2012). Although there is no cement union to the alveolar bone in these cases, they present clinical features very similar to ankylosis.

However, in the primary failure, the treatment is more complex, frequently involving all the teeth adjacent to the affected tooth, resulting in lateral opened bite (Frazier-Bowers *et al.*; Rhoads *et al.*; Smith *et al.*). This disorder is caused by genetic changes associated with the parathyroid hormone (PTHPR1) (Rhoads *et al.*; Smith *et al.*).

Primary diagnosis of ankylosed teeth is made by clinical assessment through mobility and percussion tests, in these cases the tooth makes a metallic sound (Campbell *et al.*, 2005; Lim *et al.*, 2008; Berl *et al.*, 2012; Gault *et al.*; Lin *et al.*; Mohadeb *et al.*; Silva), unlike healthy teeth, in which the sound is neutralized by periodontal ligament (Berl *et al.*, 2012; Parisay *et al.*; Silva).

However, since only one third of the patients present these clinical signs (Cohen-Levy *et al.*; Lin *et al.*), it is necessary to carry out imaging tests to confirm clinical signs of ankylosis. Although periapical x-rays are daily used in dental clinics, their value is limited for diagnosis of ankylosed teeth (Paris *et al.*, 2010; Cohen-Levy *et al.*; Berl *et al.*, 2012; Cha *et al.*, 2012; Gault *et al.*; Lin *et al.*; Mohadeb *et al.*), because ankylotic areas only visible when it is present in proximal surfaces of

the root, not being possible to identify lingual/palatal and buccal surfaces (Takahashi *et al.*; Cohen-Levy *et al.*; Berl *et al.* 2012; Silva *et al.*). Besides, in this examination the presence of ankylosis becomes evident only when at least 20 % of the root surface is affected (Campbell *et al.*; Cohen-Levy *et al.*; Mohadeb *et al.*).

Whereas computed tomography (CT) is considered superior to radiography (Kirziolu *et al.*, 2007) because of the possibility of a three-dimensional evaluation of the structures, allowing precise observation of the whole extent of the root surface (Paris *et al.*; Chae & Paeng; Silva), the degree of irregularity of the root, and the relationship between the root and the adjacent teeth (Gault *et al.*), helping in early diagnosis of ankylosed teeth. With equal accuracy, cone beam computed tomography (CBCT) can also be used for the diagnosis of ankylosed teeth (Balaji, 2013; Hashim *et al.*, 2013; Silva), having as advantage the lower dose of radiation (Holberg *et al.*, 2005; Balaji; Kamburoglu, 2015; Silva) and lower cost compared with CT (Holberg *et al.*; Balaji; Kamburoglu).

In the initial stages, the primary failure of eruption and ankylosis may have similar clinical presentations (Frazier-Bowers *et al.*). With the lack of accessibility of genetic tests in dental offices to confirm the occurrence of primary failure (Rhoads *et al.*), it is important resorting to accurate imaging methods, such as CBCT, to distinguish these two eruption disorders, providing the correct diagnosis and the best treatment options for patients.

Considering the limitation in the literature concerning the diagnosis of ankylosis using CBCT (Silva), the aim of this study was to provide information to dentists on the importance and the situations when to use CBCT in diagnosis of ankylosed teeth.

CASE REPORT

Male patient, 16 years old was referred for clinic of the Oral Radiology to perform CBCT, in order to plan the next steps of the orthodontic treatment. When he was referred, infraocclusion of the maxillary right first molar was reported and it did not respond to orthodontic forced eruption. The patient did not report pain and remembered the trauma that occurred in the region, when he was a child during a football game. The patient did not present relevant data regarding systemic

Fig. 1. CBCT panoramic reconstruction. Infraocclusion of tooth 16 in contact with the maxillary sinus (white arrow).

Fig. 2. CBCT sagittal planes showing absence of periodontal ligament space on tooth 16 buccal root (A) and palatal root (B).

Fig. 3. CBCT coronal plane showing absence of periodontal ligament space in the roots. (A) Distobuccal and palatal root and (B) Mesiobuccal root.

Fig. 4. CBCT sagittal (A), axial (B) and coronal (C) planes showing hypodense image on cervical region of tooth 17, compatible with external resorption (white small arrows).

situation and there were no cases in the family of infraocclusion of teeth.

The CBCT was conducted on I-CAT® CB500 (Imaging Sciences, Hatfield, PA) under the acquisition protocol: 120 kVp, 5 mA, 0.25 mm voxel, and Field of View (FOV) of 13x8. Multiplanar reconstructions (MPR) were obtained and in the panoramic reconstruction, in sagittal and coronal planes, it was observed that in addition to unerupted teeth 18 and 28, the patient had tooth 16 partially erupted, with its roots in contact with the maxillary sinus and absence periodontal ligament space along the roots (Figs. 1, 2, and 3). It is possible to verify still that the distal surface of the crown of tooth 16 was in contact with the mesiocervical area of tooth 17, causing external resorption. The hypodense image identified in the occlusal surface is a dental cavity affecting enamel and dentine (Fig. 4). Comparing clinical signs, symptoms and CBCT image, the hypothesis of dental ankylosis was suggested, because infraocclusion of tooth 16 was below the contact area of the teeth 17 and 15 (Fig. 5).

The ethics committee on human research exempted this study approval since only CBCT images would be disclosed without the possibility of patient identification.

Fig. 5. Three-dimensional (3D) reconstructions of right hemi maxilla. A) Buccal view; B) Palatal view; C) Buccal view: Use of bone extraction tool.

DISCUSSION

Ankylosis is defined as the anatomical fusion of cementum with alveolar bone (Loriato *et al.*; Pithon & Bernardes; Chae & Paeng; Guimarães *et al.*; Mohadeb *et al.*), due to the destruction of the periodontal ligament (Pithon & Bernardes; Lin *et al.*), occurring at any time during the course of eruption (Mohadeb *et al.*).

Ankylosis is a common complication after traumatic episodes (Atobe *et al.*; Cohen-Levy *et al.*; Chae & Paeng; Gault *et al.*; Lin *et al.*; Mohadeb *et al.*; Silva) causing a severe injury in the periodontal ligament, which does not regenerate (Gault *et al.*), triggering an inflammation process (Mohadeb *et al.*) and a gradual replacement by alveolar bone tissue (Lin *et al.*). Although the incisors teeth are more susceptible to ankylosis after a trauma (Cohen-Levy *et al.*; Lin *et al.*), in the case reported the patient reported trauma in the posterior region of the face, which may have triggered ankylosis during eruption of tooth 16. Besides, another peculiarity of the present case is that ankylosis occurred with a permanent tooth, because it rarely affects permanent dentition (Atobe *et al.*; Loriato *et al.*; Cohen-Levy *et al.*; Silva) and the frequency in permanent molars is 0.06 % (Cohen-Levy *et al.*).

As observed in the case reported, the more evident clinical sign of ankylosis is the presence of infraocclusion (Cohen-Levy *et al.*; Pithon & Bernardes; Bertl *et al.*; Gault *et al.*; Lin *et al.*; Guimarães *et al.*; Silva), as a result of the continuous vertical growth of the alveolar bone (Bertl *et al.*), which can be classified into slight, when the occlusal face is up to 2 mm from the occlusal plane; moderate, when the occlusal face of the ankylosed tooth is at the level of the contact surface of adjacent teeth; and severe, when infraocclusion is below the contact area

of the adjacent teeth (Alves *et al.*; Parisay *et al.*).

In the present case, as in the primary eruption failure, a posterior tooth was affected. However, unlike the primary failure, normal eruption of adjacent teeth was observed. Besides, the CBCT exam confirmed the presence of ankylosis in the roots of the teeth. Thus, once the crown of the tooth was below the point of contact of teeth 17 and 15, it was suggested that the ankylosis occurred early in the phase of the eruption process during the patient's childhood.

Therefore, depending on the level of infraocclusion, it may trigger several clinical implications during jaws development and growth, e.g., open bite (Atobe *et al.*; Loriato *et al.*; Cohen-Levy *et al.*; Alves *et al.*; Bertl *et al.*; Lin *et al.*; Guimarães *et al.*), inclination of the adjacent teeth, overeruption of the antagonist tooth (Kirziolu *et al.*; Cohen-Levy *et al.*; Pithon & Bernardes; Alves *et al.*; Bertl *et al.*; Lin *et al.*; Guimarães *et al.*), vertical alveolar bone loss (Lin *et al.*), and a shift of the dental midline to the affected side (Loriato *et al.*; Cohen-Levy *et al.*; Pithon & Bernardes, 2011; Lin *et al.*).

Regarding other complications, there is greater difficulty in cleaning due to the tooth position below the occlusal plane (Pithon & Bernardes; Alves *et al.*; Bertl *et al.*), causing food impaction and higher caries risk, and periodontal disease affecting adjacent teeth (Takahashi *et al.*; Loriato *et al.*; Silva). Moreover, because the cementum of the ankylosed tooth is in direct contact with the alveolar bone, its root is more susceptible to suffer bone resorption by replacement (Takahashi *et al.*; Loriato *et al.*; Silva). Another problem identified in our case report was the presence of resorption of the crown of tooth 17, probably caused by pressure exerted by tooth 16.

Ankylosis treatment depends on infraocclusion degree. In slight cases, follow up is recommended (Lim *et al.*; Cohen-Levy *et al.*; Pithon & Bernardes; Alves *et al.*; Parisay *et al.*). When infraocclusion is less than 5 mm, it is possible to carry out restorative treatment with the use of restorative materials or prosthetic crowns for reestablishing dental occlusion (Lim *et al.*; Cohen-Levy *et al.*; Pithon & Bernardes; Parisay *et al.*; Mohadeb *et al.*). On the other hand, if the infraocclusion is severe, the treatment is more complex and has the following options: orthodontics associated with luxation – although there are risks of fracture, recurrence of ankylosis and endodontic problems (Lim *et al.*; Cohen-Levy *et al.*; Pithon & Bernardes; Parisay *et al.*; Mohadeb *et al.*); segmental osteotomy; ankylosed tooth transplantation (Cohen-Levy *et al.*; Gault *et al.*; Mohadeb *et al.*); and extraction followed by implant (Lim *et al.*; Cohen-Levy *et al.*; Pithon & Bernardes; Parisay *et al.*; Mohadeb *et al.*). Although in adults ankylosis treatment is less challenging due to the possibility of rehabilitation with prosthesis or implants (Mohadeb *et al.*), the patient has not yet reached skeletal maturity, making this kind of intervention impossible.

It is worth mentioning that surgical extraction often causes bone defects in the alveolar area affected by ankylosis (Lim *et al.*; Pithon & Bernardes). In the present case report, the close relationship of tooth 16 roots with the floor of the maxillary sinus may also hinder their surgical extraction and lead to complications such as oroantral communication.

According to Lin *et al.* it is difficult to predict if a tooth that suffered trauma will have ankylosis in the future, and as in the present case, it can be noticed only after many years when functional and aesthetic complications become evident. However, ankylosis early diagnosis is difficult, for in the beginning areas absence periodontal ligament are small and the tooth still presents mobility (Cohen-Levy *et al.*).

Besides, percussion clinical tests and metallic sound produced are only reliable in about one-third of the cases (Cohen-Levy *et al.*; Lin *et al.*) and are strictly dependent on the professional's judgment and experience (Campbell *et al.*; Cohen-Levy *et al.*). Moreover, radiographic examination is also inaccurate (Kirziolu *et al.*; Cohen-Levy *et al.*; Bertl *et al.*; Chae & Paeng; Mohadeb *et al.*), because absence of the periodontal ligament is identified only when 20 % of the root surface is ankylosed (Campbell *et al.*; Cohen-Levy *et al.*; Mohadeb *et al.*), even when present only

in proximal surfaces (Takahashi *et al.*; Cohen-Levy *et al.*; Bertl *et al.*; Silva *et al.*). Also, it is not possible to visualize the root bifurcation area (Silva). In the present case, because the tooth was a molar tooth, radiographic diagnosis is even more challenging, for it is a multiradicular tooth due to overlapping structures.

Hence, ankylosis diagnosis may occur incidentally, when the patient undergoes an orthodontic treatment and the tooth does not respond to orthodontic movement (Takahashi *et al.*; Lim *et al.*; Lariato *et al.*; Alves *et al.*; Chae & Paeng; Gault *et al.*). Nevertheless, CT examination is essential for diagnosis confirmation and for exact identification of the root region affected by ankyloses (Chae & Paeng). In this sense, as CBCT has accuracy similar to CT for bony structures (Stutzki *et al.*, 2015), and for being a three-dimensional imaging examination widely used in Dentistry (Balaji; Kamburoglu; Silva), for precisely assessing dental anatomy and bone structures affected by ankylosis, it can also be used in the diagnosis of dental ankylosis (Holberg *et al.*; Balaji; Silva), as observed in the present case.

In order to be acknowledged with the subject, we made a research in the PubMed database, using the following key words: “dental ankylosis”, “diagnosis”, “dental trauma”, “computed tomography”, and “cone beam computed tomography”. Studies on diagnosis of ankylosis using CT are limited (Kitai *et al.*, 2003; Kirziolu *et al.*; Paris *et al.*; Chae & Paeng; Gault *et al.*) and even more using CBCT (Balaji; Tsukiboshi & Tsukiboshi, 2014). However, for identifying the root region extent and exact location where ankylosis is present, the examination by three-dimensional imaging is essential (Paris *et al.*; Gault *et al.*; Silva), especially in severe cases of ankylosed molar teeth (Berl *et al.*, 2012).

Thus, CBCT provides this diagnosis with lower radiation doses (Balaji; De Cock *et al.*, 2015; Kamburoglu) and lower costs than CT (Balaji; De Cock *et al.*; Kamburoglu; Stutzki *et al.*), besides being frequently requested in orthodontics (Kamburoglu), specialists who are often involved in the treatment of dental, occlusal, and aesthetic complications caused by ankylosis (Chae & Paeng). In complex cases, CBCT may also be required for surgical treatment of ankylosed teeth (Balaji), when the tooth is near noble structures, e.g., the mandibular canal (Kirziolu *et al.*) or the maxillary sinus, as in the present case. CBCT is therefore an important diagnostic tool for examination and treatment planning (Balaji), safe for professionals and patients as well.

CONCLUSION

The importance of the early diagnosis of ankylosis should be highlighted, because the maxillo-mandibular growth turns the orthodontic and surgical treatments more complex, due to the worsening of occlusal problems and deficiencies of the alveolar bone. In this context, the CBCT imaging allows identified with high accuracy all root surfaces affected by ankylosis and it may be requested for accurate diagnosis of the presence and location of ankylosis in molar teeth, showing anatomical details that could not be visualized in conventional radiographic techniques because of their two-dimensional nature and overlapping structures.

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RESUMEN: La anquilosis es una anomalía de la erupción del diente caracterizada por la fusión de cemento y hueso alveolar, y puede afectar desde pequeñas regiones hasta toda la superficie de la raíz. La evaluación clínica combinada con los exámenes de imagen puede ayudar a diagnosticar esta anomalía. Las pruebas radiográficas permiten evaluar sólo las regiones proximales de las raíces posiblemente afectadas. La tomografía computarizada de haz de cono (CBCT) permite una evaluación tridimensional de los planos axial, coronal y sagital de toda la extensión dental, eliminando así las imágenes superpuestas y ayudando a confirmar el diagnóstico correcto. En el presente estudio se presenta un reporte de caso de un paciente con anquilosis en el diente 16 diagnosticado por CBCT, con el objetivo de proporcionar información para los dentistas sobre esta anomalía, sus características y situaciones en las que debe indicarse la CBCT.

PALABRAS CLAVE: anquilosis dental, diagnóstico, tomografía computarizada de haz cónico.

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