The Use of Limited CBCT in the Early Diagnosis of Root Vertical Fracture: A Case Report

Emanuele Ambu¹, Claudio Citterio², Alberto Pellegratta², Maria Sofia Rini³*, Daniele Boari⁴, Federico Campedelli⁵ and Marcello Maddalone²

¹Tuscan School of Dental Medicine, University of Siena, Italy; ²Department of Medicine and Surgery University of Milano, Bicocca, Italy; ³University of Bologna, Bologna, Italy and Marconi University of Rome, Italy; ⁴Private Practitioner in Casirate d’Adda, Bergamo, Italy and ⁵Private Practitioner in Carpi, Modena, Italy

Abstract: The diagnosis of vertical root fractures is often very difficult; according to many Authors, a proper diagnosis is only possible after flap elevation and after detecting the fracture rim. In the case here described, the fracture rim was not detected in the first endodontic surgery nor after the second one, although they were both performed under the operative microscope and using methyl blue staining. The root crack has been detected only after the extraction of the tooth performing a microCT exam and then drying the sample. The limited CBCT performed after the failure of the endodontic surgery had shown the buccal bone loss, which is one of the signs of VRF. In this case, this sign was the only one, which could suggest us the proper diagnosis.

Keywords: Root fractures, Diagnosis, Fracture rim, CBCT.

1. INTRODUCTION

According to Rivera and Walton [1], vertical root fractures (VRF’s) fall within the group of dental longitudinal fractures: they only affect roots without, only and never reaching dental crowns. They are often due to traumas (very fast and sudden events when vertical fractures occur together with horizontal and oblique ones). They can also develop very slowly when the root structures are abnormally loaded with excessive forces, as a result of wrong clinical choices.

VRF’s are very common and extremely compromising for the tooth. Usually they lead to the loss of teeth. Diagnosis is a real challenge for clinicians VRF’s show similar signs and symptoms to those of periodontal diseases or failed endodontic treatments [2-4]. They are often painless or little painful when chewing or pressing the area. Swelling or vestibular fistulae occur very often close to the gingival margin.

Sinus tract in the buccal side is remarkable, even if it can be confused with an endodontic-periodontal disease. However, it does not always occur [5]. Two sinus tracts in both sides of the root are much more important, because they indicate a complete fracture. In 90% of cases an incomplete fracture is detected only on the buccal side [6]. Probing is prevented in case of a large marginal bone or good epithelial attachment. It is, therefore, difficult to detect the fracture.

Conventional 2D radiographic exams are often useless at the beginning, when the bone lesion is the only sign and cannot be seen because of the root overlapped. With time, there will be detected resorption in the cervical area of the root, or resorption with J-shaped, or halo patterns in the apical area [7].

The introduction of CBCT devices [8] has improved the chance of diagnosis of VRF’s, although this is not the opinion of all authors. Fayad et al. [9] have stated that there are five signs, which can favour the diagnosis of VRF’s.

In spite of these new means, diagnosis is often uncertain and the only way to assess VRF is to perform an exploratory flap.

In the case reported below, it has not been possible to detect VRF during two surgical treatments, in spite of the operative microscope and methyl blue staining. The fracture was then seen only with a microCT exam of the extracted tooth.

2. CLINICAL CASE

A female patient, aged 54, was referred by a colleague in July 2014 to perform the surgical treatment of her first and second left upper premolars, which had already been treated endodontically. Her second premolar had been reconstructed using two Dentatus-like screws. Both teeth had been reconstructed with prosthetic crowns. Swelling was seen in the buccal side of the patient’s second premolar (Figure 1). The preop. X-ray showed two periapical lesions in both teeth (Figures 1-2). Periodontal probing indicates sound marginal epithelium. After the elevation of the flap, a long and narrow bone loss of the buccal bone of
the second premolar could be seen. After surgical endodontic treatment of both teeth (Figure 2), we focused on searching for signs of vertical root fracture both in the area of the cut apex (Figure 3) and along the root exposed on the buccal side (Figures 3-4). No vertical root fracture was found despite the use of methylene blue staining. In February 2015 this patient was visited again, and she complained regarding a fistula on the buccal side. A limited Field of View CBCT exam (Carestream 9000 3D, 76 micron voxels) was performed, and it showed that tooth 2.4 had no lesion, but tooth 2.5 still had a periradicular translucency. (Figure 4). The endodontic surgery was performed again. The buccal bone loss was bigger than during the first surgery. After removing the inflammatory tissue both in the buccal and in the apical side, the correct retrograde sealing was checked under the operative microscope (Figure 5). Once again we searched for a VRF, with no success (Figures 5-6). The tooth was then extracted one month after, kept for an hour in a 5.25% Sodium Hypochlorite solution and then we carefully removed some ligament portions with curettes. We

Figure 1: Pre-op X-ray.

Figure 2: X-ray after Endodontic surgery.

Figure 3: View of exposed root after endodontic surgery.

Figure 4: 9-Month control CBCT (axial view).
examined the tooth again under the microscope with 16X magnification (Figures 6-7) but without any results. In order to clarify the reason for the failure of the surgical treatment, the tooth was dipped in a 10% thymol solution and sent to the University of Milan - "Bicocca" for further exams with a microCT.

Figure 5: View of exposed root during the exploratory surgery.

2.1. MicroCT exam

The extracted tooth was scanned with a micro-CT (Skyscan 1176, Billerica, MA, USA) in order to get initial images necessary for reconstruction and measurement.

Starting from the tomographic images, the cross sections of scans were reconstructed using Windows bitmap format (.bmp). The dataset created was then analyzed with CTAn programme v.1.15 (Bruker, Billerica, MA, USA) and with CTVox v.3.1.1 (Bruker, Billerica, Ma, USA in order to have a graphic representation of the vertical root fracture (VRF).

Figure 6: Extracted tooth: view of the buccal side of the root.

The exam showed a crack from the palatal to the buccal side. This fracture was supposed to be originated where the screw had been inserted in the buccal wall of the palatal canal (Figures 7-8).

The fracture line along the buccal and apical side of the tooth (Figure 7) appeared after dehydrating the tooth kept out of the liquid for a while.
3. DISCUSSION

In terms of correct therapies, there is almost never other solution than extracting the tooth to solve the problems caused by a VRF. It is however very difficult to reach a diagnosis. Fractures mainly involve teeth with a small mesio-distal diameter, therefore premolars, the mesial roots of lower molars and the mesio-buccal roots of upper molars [10]. VRF occur more often in teeth already endodontically treated, with MOD amalgam reconstructions. In case of teeth with prosthetic crowns, 65% of teeth fractured were either terminal abutments or terminal abutments with cantilever [11]. Metal posts increase the risk of fractures both directly and indirectly because of metal corrosion or expansion. Some studies have proved that excessive pressure of prefabricated posts, especially screws, may cause slight cracks bound to become fractures when loaded [12].

Symptoms are often not so clear, with no pain or slight pain, and swelling only after some time.

The time between the endodontic treatment and the diagnosis of fracture is usually very long, in some cases it takes even years.

Fractures usually start from the root canal wall and go towards the root surface. If they affect only one portion of the root they will be incomplete. If they affect both sides of the root they will be complete. Once the fracture reaches the external surface of the root, irritants like bacteria and cements inside the canals will destroy the ligament, causing bone loss and granulation tissue formation.

The final diagnosis is often difficult because there are no specific symptoms and because clinical and radiographic signs may be confused with those of other diseases. Clinically, the main signs are isolated deep periodontal pocket [13] and sinus tract located on the crestal bone [14]. Probing is however not always reproducible unless the bone pocket reaches the margin or if the periodontal attachment is well preserved [15].
The limits of conventional radiographic exams are well known. According to Meister et al. [16], VRF’s may be detected using conventional radiographic exams only if there is a sharp separation of fragments and the X-ray beam hits directly this plane. If this is not the case, we should look for indirect signs, strictly connected to to the periradicular bone loss, such as lateral radiolucency along the root, “halo” or j-shaped radiolucency around the root, or a crest defect in the bone around the root [17].

The same signs can be looked for in a CBCT, in cases where conventional x-ray does not show the separation line [18].

The use of CBCT in the VRF diagnosis has been suggested since a long time ago. In 2007, Mora et al. [19] already underlined that “local computed tomography” could remarkably increase the detection of vertical fractures, as compared to conventional radiographic technologies.

Shortly later, Bernardes et al. [20] confirmed that this kind of exams could give better results than the conventional radiographic ones in the diagnosis of root fractures. CBCT permits to observe teeth and the surrounding tissues using multiple planes and different points of view. Fayad et al. [9] examined the volumetric data and found five signs which could lead to a diagnosis of VRF:

- bone defect in the middle of the root (if the bone is sound in the crestal and apical areas)
- bone lesion of the whole buccal side (in all views and in 3D reconstruction)
- radiolucency area around the root, where a post is inserted
- “tunnel-like” lesion in the medullary bone between the root and the cortical plate
- direct view of the fracture line in every plane

As shown in various papers, the frequent presence of radiolucent materials inside the roots (metal posts, endodontic sealing material, cements, etc.) often causes artefacts preventing a proper reading of diagnostic data, especially the fracture rim in the root, when observing the axial planes.

Several in vivo studies [20-21] had found that the CBCT is much more sensitive and specific than intraoral x-rays to detect VRF’s. However, the studies performed by Mannocci Patel et al. [22], state exactly the opposite. They showed low values both in terms of specificity and sensitiveness in both kinds of exams. The Authors had focused on the difficulties of “ex vivo” and “in vivo” studies, in which it is possible to watch directly only some areas of the root.

As a matter of fact, the endodontic surgery cannot reach the palatal/lingual surfaces of roots to detect any fractures and the conventional endodontic treatment permits only to detect the internal aspect of the root,
close to crown. Therefore these Authors deem valid only those studies with direct observation of the entire root surface and this is only possible either extracting the tooth or at least the fractured root.

In our opinion, CBCT is an excellent diagnostic device, in spite of all these limits, if it is used as an auxiliary means during a clinical and instrumental visit (6 During the 3D instrumental diagnosis, it should be recommended to look for one or more signs among those detected by Fayad and Colleagues [9].

There is a certain agreement that an absolutely correct diagnosis is only possible through an exploratory flap, which permits to see the fracture rim [2,23-24].

In the case we are showing, probing was not remarkable because the periodontal attachment was good and the initial x-ray could not let us see any bone losses because of the root overlapped. After reflection of the flap, the kind of bone loss could suggest a fracture, but we could not see it either under the operative microscope or using methylene blue staining. Therefore it was decided to perform the endodontic surgery, as suggested by Tamse [5]. The buccal bone dehiscence is a usual sign of periodontal diseases or of failed endodontic treatments. This suggestion, however, was not confirmed by any lesions in other areas or by periodontal problems [25]. The CBCT exam performed prior to the second intervention, showed the loss of the entire buccal bone plate, as reported by Fayad and Colleagues (second point) [9]. As soon as the flap was elevated, the bone loss appeared higher than what detected during the first surgery, and it was developing exactly as described by Tamse [5].

However, it was not yet possible to detect the fracture under the microscope or after methylene blue staining. The fracture was not visible even examining the extracted tooth under the operative microscope with 25x magnification. The tooth was then examined using a microCT [26-27], as the quality of retrograde sealing needed to be checked, and it was crucial to understand why the surgical endodontic treatment had failed. Micro CT showed in fact ability to detect in details anatomy of root canal and modifications generated by nickel titanium instruments [27-28].

The microCT exam was able to prove that there was a crack originating in the area in which the screw tip was inserted in the buccal wall of the lingual root canal. After dehydrating the sample, kept in a 10% thymol solution until some hours before the exam, it was possible to see the fracture on the root surface.

In this situation, however, it was difficult to explain why a loss of the bone plate had occurred.

We can assume that the crack had almost reached the buccal root surface. The portion of root surface preserved should have been so thin to let intracanal irritants out. All this had caused the chain of pathological events causing the buccal plate bone loss and the growth of inflammatory tissues.

Another assumption was that the fracture was so small to be not visible even with high magnification values or stained. If this second assumption were true, however, the fracture would have increased in the lapse of time between the two surgical flaps.

The reason for suspecting a vertical root fracture came in the first place as this was a premolar endodontically treated and restored with screws. It also showed a sinus tract very close to the gingival margin. This condition is often associated with VRF’s. Buccal bone dehiscence, usually associated with other clinical aspects, was not a sufficient sign in a patient without diffused periodontitis. The intraoral x-ray did not show any signs because of the root overlapping the bone lesion area; the CBCT exam let us see the complete loss of the buccal plate, which usually, but not exclusively suggests VRF’s. It was however not possible to identify fractures examining the axial sections.

No cases like the one presented are described in the literature: this could be explained because teeth similar to the one reported in our case, are usually extracted and then no further specific exams, like microCT are performed, in order to understand why the endodontic treatment had failed. Cracks which do not reach the root surface and which lead to the loss of the buccal plate may not be so rare. They may simply have not been investigated further.

4. CONCLUSIONS

Buccal bone losses, which often occur in several endodontic/periodontal diseases, may occur even before the root crack becomes an incomplete vertical root fracture. The CBCT exam appears to be the only diagnostic means suggesting VRF’s. This case seems to deny the statement that a definitive diagnosis of VRF is best attained by an exploratory flap.
Further studies on the samples gathered under similar clinical conditions should be performed to confirm this assessment.

ACKNOWLEDGMENTS

We would like to thank Mrs. Roberta Penna and Prof. Simone Grandini for their help translating and reviewing our paper.

REFERENCES