ОРИГИНАЛЬНАЯ СТАТЬЯ

# DIFFERENTIAL DIAGNOSIS OF VERTICAL ROOT FRACTURES WITH THE USE OF CBCT: A RETROSPECTIVE STUDY

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**Purpose.** To reveal the important clinical and radiologic characteristics of bony defects developing near vertical root fractures according to cone-beam computed tomography findings, which can be used for the diagnosis and differential diagnosis of root fractures.

**Material and methods.** Eighty clinical cases suggestive for vertical root fractures were analyzed in the study. Teeth with vertical root fractures confirmed after extraction (n = 65) were divided according to tooth group and fracture propagation pattern as well as associated bone resorption according to cone-beam computed tomography. Clinical and radiographic features of vertical root fractures were compared with the mimicking conditions to reveal the differences.

**Results.** From 80 teeth 65 were fractured; the conditions mimicking vertical root fractures included chronic periodontitis (2 cases), periapical pathology (13 cases), strip perforations (5 cases), and accessory canals (3 cases). The characteristic combination of clinical and radiographic features of vertical root fractures included a deep narrow periodontal pocket (52,3%), dehiscence-like defect of the buccal cortical plate with no or a lesser extent of periodontal destruction reflection on the other sites of the dentition and at the proximal surface(s) of the fractured root. Discussion: The differential diagnosis of vertical root fractures is a challenging task. The detection of fracture with cone-beam computed tomography is not always possible. However, this method may be used for the diagnosis of fractures by ascertaining the form and location of the bony defect.

**Conclusions.** The analyses of characteristic features of the bony defect in conjunction with clinical findings allowed for diagnosis of vertical root fractures.

Keywords: cone-beam computed tomography, diagnosis, tooth fractures.

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# ДИФФЕРЕНЦИАЛЬНАЯ ДИАГНОСТИКА ВЕРТИКАЛЬНЫХ ТРЕЩИН КОРНЯ ЗУБА С ПОМОЩЬЮ КЛКТ: РЕТРОСПЕКТИВНОЕ ИССЛЕДОВАНИЕ

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**Цель.** По результатам конусно-лучевой компьютерной томографии выявить клинико-рентгенологические характеристики дефектов костной ткани, образующихся в области вертикальных трещин корней зубов, которые могут быть использованы для диагностики и дифференциальной диагностики.

**Материалы и методы.** В исследование вошли 80 (100%) клинических случаев, в которых предположительным диагнозом была вертикальная трещина корня; 65 случаев, диагноз вертикальной трещины в которых подтвердился после удаления, классифицировали в соответствии с группой зуба, локализацией и характером распространения трещины, а также особенностями костного дефекта по результатам конусно-лучевой компьютерной томографии. Провели сравнение клинико-рентгенологической картины вертикальной трещины корня зуба с другими похожими состояниями.

**Результаты.** В 65 из 80 случаев диагноз вертикальной трещины был подтверждён после удаления зуба; другие состояния включали: хронический пародонтит (2 случая), апикальные периодонтит (13 случаев), ленточные перфорации (5 случаев) и дополнительный каналец (3 случая). Характерная клинико-рентгенологическая картина вертикальной трещины корня включала глубокий узкий пародонтальный карман (52,3%), а также костный дефект наружной кортикальной пластинки по типу дегисценции с менее выраженной деструкцией на остальных участках зубного ряда и с апроксимальных сторон поврежденного корня.

Дифференциальная диагностика вертикальной трещины корня является сложной задачей. Визуализация собственно линии трещины с помощью конусно-лучевой компьютерной томографии не всегда возможна, однако данный метод позволяет в трех измерениях оценить локализацию и форму костного дефекта, прилежащего к трещине.

**Заключение.** Анализ клинических данных в сочетании с оценкой топографии и формы костного дефекта с помощью конусно-лучевой компьютерной томографии позволяет дифференцировать вертикальную трещину от подобных состояний..

Ключевые слова: конусно-лучевая компьютерная томография, диагностика, трещины зуба.

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**Introduction.** Vertical root fractures (VRF) are the fractures originating from the root of the tooth and propagating in the vertical direction [1]. This type of fractures most often occurs in endodontically treated teeth and therefore the formation of a fracture causes the release of bacteria which inevitably invade dentinal tubules of a pulpless tooth. The resulting inflammatory periodontal reaction causes rapid resorption of the adjacent bone. The diagnosis of VRF necessitates tooth extraction as conservative approaches fail to stop further fracture propagation and associated inflammation and bone loss [1].

The differential diagnosis of vertical root fractures is a complex problem as there are no pathognomonic clinical signs and symptoms. Radiographic examination could be used for the ascertaining of the diagnosis, however, the accuracy of two-dimensional radiography is low, and the detection of a fracture line with cone-beam computed tomography (CBCT) is also not always possible [2-6, 7, 8]. Despite several attempts to increase the accuracy of CBCT for the detection of a fracture line by adapting various scanning regimens and artifact reduction tools, the most accurate method available to date to state the diagnosis of VRF is still surgical revision and visual inspection of the root [9-18]. Sadly, revision is not helpful when the fracture is located on the tooth surface that cannot be directly visualized during surgery [7]. Therefore, the advantages of CBCT imaging, mainly the tridimensional reconstruction of the root and adjacent tissues, could be used in diagnosis and treatment planning, in order to reveal some indirect features characteristic for VRF formation [19]. For example, the results of the study by Komatsu K et al. (2014) have shown that CBCT may be used for the diagnosis of VRF by ascertaining the form and location of the bony defect [20].

In the present article, based on the analyses of a series of clinical cases, we attempted to reveal the important clinical and radiologic characteristics of bony defects developing near VRFs (in different groups of teeth and with a different extent of fracture propagation) according to CBCT findings, which can be used for the diagnosis and differential diagnosis of VRF.

**Material and methods.**

The study was approved by the institutional review board and regional ethical commission. The study was performed in the Department of Therapeutic Dentistry of FMSMU (Sechenov's University) from November 2014 to February 2018.

The cases satisfying the following criteria were included in the study:

• Single tooth with local swelling of the surrounding gingiva and/or pain/discomfort on biting or without stimuli and/or sinus tract involvement and/or presence of deep periodontal pocket.

• Definitive diagnosis uncertain from clinical findings and 2-dimensional radiographic image.

• CBCT obtained to ascertain the diagnosis.

Exclusion criteria included the presence of a fracture as stated clinically (primarily split teeth) or cracked teeth (i.e., fracture initiating from the crown of the tooth and propagating apically; mainly in the mesiodistal direction) as well as uncontrolled diseases and pregnancy.

As a result, 80 clinical cases were analyzed in this study, including all of the clinical findings and the results of CBCT. In cases of confirmed VRF (n = 65), the following clinical parameters were recorded: age, gender, tooth and particular root affected, area of fracture propagation, patient complaints, clinical signs and symptoms, type of restoration used, type of prosthesis, and characteristic features of the patient's occlusion. The teeth were divided according to group and diagnoses, listed as possible by the team of observers. The characteristic features, location, and shape of bone resorption areas were recorded according to CBCT data and used to reveal the characteristic patterns of bone resorption helpful in differentiating between VRFs and other conditions.

(4.6%), the direction of the fracture was mesiodistal.

To reveal the characteristic features of the differential diagnosis of VRFs with similar conditions, each teeth group was analyzed separately.

The upper premolars were among the teeth most commonly affected with VRFs (24 cases, 36.9%). All main types of fracture propagation patterns and associated bone resorption were represented in these teeth (Table 1). The middle third of the vestibular surface was involved in 100% of cases. In 2 cases (3.1%), the fracture line was limited to the middle third of the roots with fenestration-type bone resorption (Fig. 1). Similar bony defects were observed in endodontically treated upper central incisors and rarely in premolars with a wide accessory canal in the middle part of the root, which leads to periodontitis. CBCT examination was useful for the visualization of the accessory canal and exclusion of VRF. In both cases,

**Table №1. The of fracture propagation patterns and associated clinical signs and symptoms in upper premolars.**

| Fracture propagation | Middle third buccal surface | Whole buccal surface | Buccal+palatal surface |
|---|---|---|---|
| N of cases | 2 | 3 | 18<br>1 only palatal surface |
| Clinical signs | Sinus tract/no symptoms | Periodontal pocket >7mm | Periodontal pocket <7mm |
| CBCT bone loss | Fenestration type | Dehiscence type | Dehiscence+infrabony defect; +/-defect in periapical region |
| Differentiate from | Accessory canal in the middle third of the root | Chronic periodontitis | Chronic apical periodontitis |

**Results**.

From 80 teeth 65 were fractured and 23 had mimicking conditions (2 – chronic periodontitis, 13 – apical periodontitis, 5 – strip perforations, and 3 – accessory canals in the middle third of the root). The patients' age was from 20 to 75 years (average age = 51.27 years) and occurrence of VRFs was higher in female patients (43 patients, 66.2%) than in male (22 patients, 38.2%). The patients reported pain (49.2%), mild discomfort (46.2%), or the absence of any subjective discomfort (4.6%). Narrow periodontal pockets near the affected teeth were present in 34 cases of VRFs (52.3%). The probing depth near VRFs was 7-12 mm. Sinus tracts were observed in 12 cases (18.5%). The periodontal pockets were located buccally, except for 1 case in which there were 2 periodontal pockets (1 from each side: buccal and palatal) of the mesial root of the first lower molar with a complete fracture. All teeth with VRFs in our study were endodontically treated. In 56 cases (86.2%), fractures propagated in a buccolingual direction; in 6 cases (9.2%), they involved buccal and distal or mesial surfaces; and in 3 cases VRFs caused no symptoms and were found occasionally during the diagnostic procedures for the different pathologies or during the recalls.

In 18 of the VRFs in premolars, the fracture line extended along the full length of the vestibular surfaces up to the level of the cementoenamel junction (CEJ), and in 12 cases, the coronal part of the tooth was not involved. This type of fracture propagation was common in teeth restored with crowns (with a band of safe tissues remaining in the cervical region). The associated bony defect was dehiscence-like vestibular bone loss, causing a formation of a narrow periodontal pocket with a depth of 10 to 12 mm with no or a lesser extent of attachment loss on the other dentition sites. The described bone resorption pattern allowed for differentiation of VRF from chronic periodontitis, in which bone resorption is greater near the proximal surfaces of the root corresponding to the sites of greater plaque accumulation (Fig. 2).

In VRF propagation on the palatal surface, the apical portion of the root may be either affected or intact. CBCT revealed dehiscence-like bone resorption in the buccal cortical plate, continuing

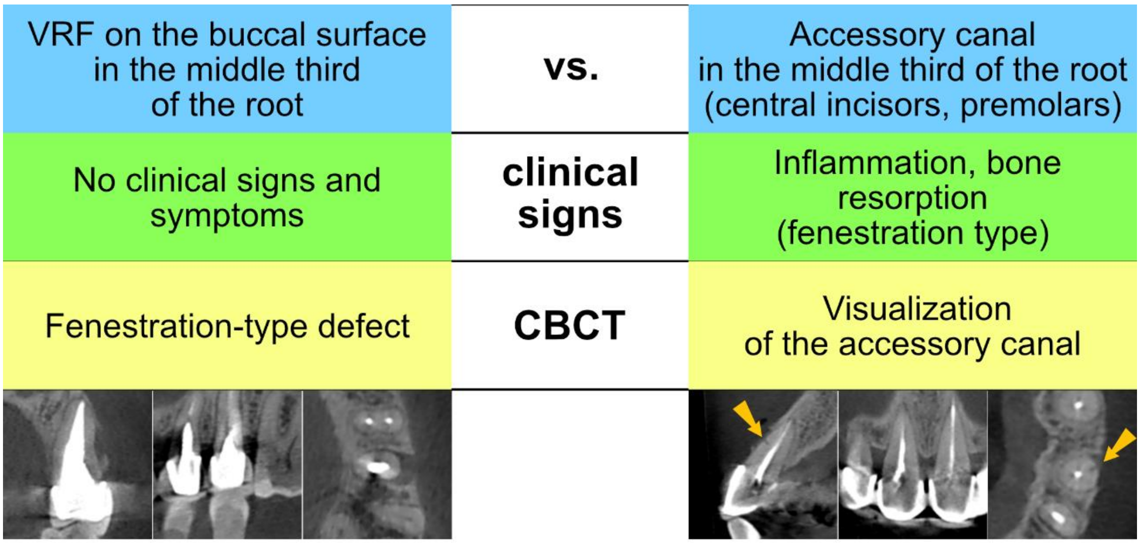


Fig. 1 (Рис. 1)

**Fig. 1. Differential diagnosis of VRF and accessory canal in the middle third of the root.**

**Рис. 1. Дифференциальная диагностики вертикальной трещины корня и дополнительного канальца в средней трети корня.**

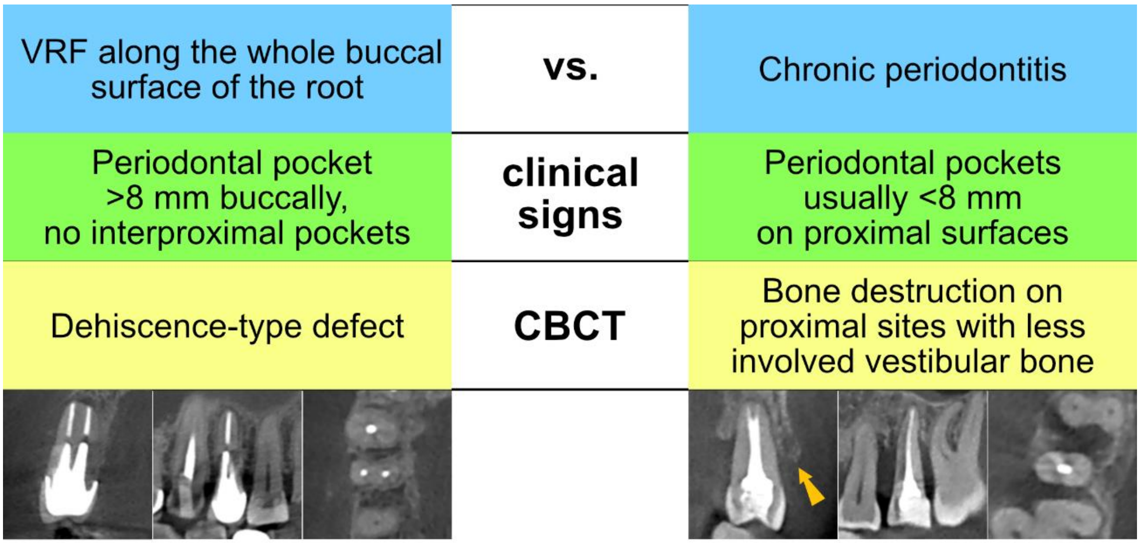


Fig. 2 (Рис. 2)

**Fig. 2. Differential diagnosis of VRF and chronic periodontitis.**

**Рис. 2. Дифференциальная диагностика вертикальной трещины корня и хронического пародонтита.**

to the palatal surface of the root as a substantial widening of periodontal space. At the apical site, the area of bone resorption on CBCT was similar to the one observed in apical periodontitis. However, VRF could be differentiated from apical periodontitis, in which there was no deep narrow periodontal pocket or bony defect on the vestibular/palatal surface of the cortical plate (Fig. 3).

Although the fracture line in most cases (18 of 24) propagated on the palatal surface of the root, the characteristic deep and narrow palatal periodontal pocket was observed in only 1 case.

In all of the cases of VRFs in premolars, surgical revision could clearly confirm the diagnosis before the extraction, because the buccal surfaces were easily accessible for visual examination after the flap reflection.

Clinical and radiographic findings in VRFs in lower molars and premolars were associated with the bone width of the alveolar bone on the buccal site of the tooth. In teeth with thick buccal bone, there was a dehiscence-type bone loss with intraosseous defect apically (18 of 29 cases). Such defects were often (5 cases) accompanied by a "high" (located close to the gingival margin) sinus tract. In patients with thin buccal bone near the

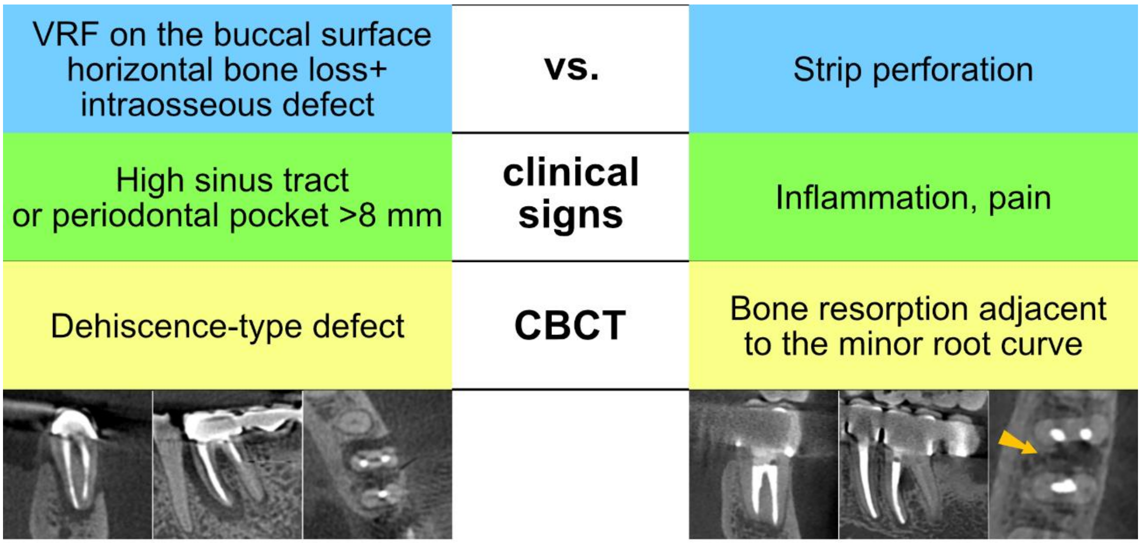


Fig. 3 (Рис. 3)

**Fig. 3. Differential diagnosis of VRF and strip perforation.**

**Рис. 3. Дифференциальная диагностика вертикальной трещины корня и ленточной перфорации.**

tooth with VRF, clinical and radiographic signs were similar to ones described for upper premolars (11 of 29 cases).

In 2 cases of VRFs in the lower molars (out of 17), the fracture line was present not only on the vestibular but also on the approximal surfaces of the root. This caused bone loss in the interproximal area, mimicking localized periodontitis and complicating the differential diagnosis.

Strip perforations caused by substantial mechanical widening of the root canal (especially in the case of retreatment) mimicked VRF (5 cases). However, strip perforations were usually located on a minor curve of the root, and the associated bone defect in that zone was not typical for VRF. The bony defects near VRFs were located buccally, and fractures propagated in the buccolingual direction, where the width of the dentin was greater. On the contrary, strip perforations corresponded to the area with the smallest width of root dentin (Fig. 4).

VRF observed in central incisors (3 cases) were in the middle third of the roots and propagated to the CEJ not involving the palatal surface. Clinical signs included the formation of a periodontal pocket (>7 mm) and mimicked chronic periodontitis complicated with trauma from occlusion. However, the localization of VRFs near the CEJ allowed for direct visualization after retraction of the gingiva.

The VRFs in the mesiobuccal roots of the upper molars (4 cases) had similar clinical and radiographic characteristics to VRFs in the upper premolars. In all VRFs observed in this study, involvement of the vestibular middle part of the roots was observed. The edges of the fracture were toughly bound to one another, except for 1 case, in which the fracture was extended by the gutta-percha coming out during the root-filling procedure. Nevertheless, fractures could involve both buccal and lingual sites of the root without propagation on the apex and cervical portion, leaving safe tissues near the apex and/or at the cervical part of the root.

**Discussion.**

The study dealt with the differential diagnosis of VRFs with similar conditions. Although the prevalence of fractures is comparatively low, each case is a frustrating phenomenon as it necessitated the extraction of affected tooth [1]. In the present study, 65 of 80 teeth suspected to have VRFs proved to be fractured. VRFs occurred mainly in patients older than 40 years. A number of studies have shown that age-related changes in dentin couldn lead to a decrease in fracture resistance [21-23]. The VRFs were more often observed in women, which coincides with the results of previous studies [24, 25]. Premolars and lower molars were the most commonly affected [24, 26].

The diagnosis of VRF is well known to be a challenge [1, 26]. The conditions similar to VRFs include endodontic and periodontal pathology or both (endoperio lesions). The differential diagnosis requires the knowledge of periodontology and endodontics and experience in interpreting clinical and CBCT findings. Several studies have shown that the accuracy of CBCT for the detection of VRFs in clinical situation is limited and these are the secondary changes that most often lead to the diagnosis of VRF [7, 8]. A systematic review reported that the indirect radiographic findings related to the presence of root include the so-called “halo effect,” a unilateral radiolucency that surrounds the tip of the root in a J-shaped manner

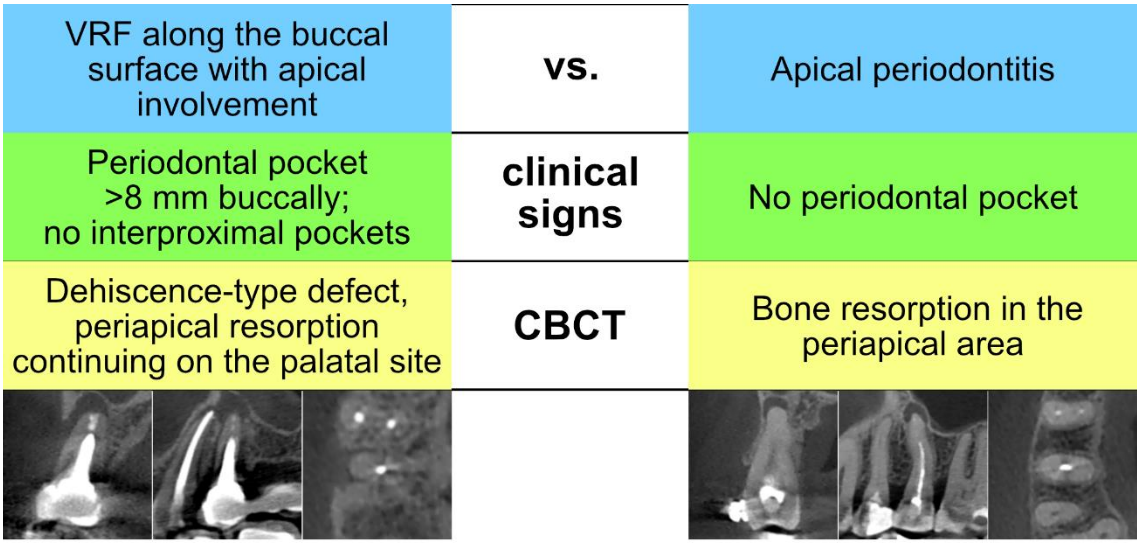


Fig. 4 (Рис. 4)

**Fig. 4. Differential diagnosis of VRF and apical periodontitis.**

**Рис. 4. Дифференциальная диагностика вертикальной трещины корня и апикального периодонтита.**

[1, 26, 27]. One study suggests that it is possible to diagnose VRF on the basis of the analysis of characteristic patterns of bone resorption revealed on CBCT In their study, Komatsu et al. (2014) developed a computerized aid for the diagnosis of VRFs according to the programmed analysis of CBCT data and revealed the horizontal and vertical dimensions of the bony defect. This approach proved to be accurate for differentiating between VRFs from apical periodontitis [20].

In the observation by Walton (2017), most cases of teeth that were suggestive of VRF but proved to not be VRF were failed endodontic therapy [28]. In the present study, VRFs were also more difficult to diagnose in the case of large areas of periapical bone resorption mimicking failed endodontic treatment. However, we found no teeth with fracture present solely in the apical part of the root. In the cases in which the fracture line extended to the apex, it was also present in the middle third of the root, and bony defect was also present either periapically or along the fracture line (most often in the buccal cortical plate). The results of the present study showed that the middle third of the root was involved in 100% of cases with VRFs, suggesting that the middle third is a possible site of fracture initiation. However, this question needs further investigation.

According to the results of the present study, the most typical combination of clinical and radiographic features of VRFs includes deep narrow periodontal pocket, dehiscence-like defect of the buccal cortical plate with the possible involvement of the palatal/lingual site, and no or lesser extent of periodontal destruction on other sites of the dentition and at the proximal surface(s) of the fractured root. In questionable cases, there is an opportunity to perform a surgical revision to visualize the fracture line directly. As the area of bone resorption in all cases was adjacent to the fractured surface of the tooth, CBCT was also helpful in deciding whether the diagnostic flap reflection for the visualization of the fracture line would be helpful.

**Conclusion.**

The characteristic features of the bony defect together with the clinical findings allows for the diagnosis of VRF. In questionable cases, there is an opportunity to perform a surgical revision to directly visualize the fracture line.

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