Categorization of Dental Fractures

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Abstract

Categorization of dental fractures should take into account the origin, the location, and the direction of fracture progression. Identifying the fracture category will influence the selection of treatment options. The type of fracture category to be covered in this book will be that primarily occurring in endodontically treated teeth; the fracture is of a *chronic* nature and characterized as having a vertical direction over time and identified as vertical root fracture (VRF). The other two fracture types—crown-originating fractures (COFs) and trauma-related fractures—will be briefly described in this chapter to differentiate them from VRFs.

Introduction

Fractures of bones and teeth can be described as discontinuity in the integrity of these anatomic entities and usually result from either acute or chronic injury [1, 2]. In this chapter, we will categorize dental fractures for the purpose of identifying the various fracture entities involving teeth. To reduce confusion, the term *fracture* will be used when describing these clinical situations rather than the many other terms that have been used such as *cracks* and *infractions.* The term *crack* will be used as the initial minute fracture originating in the dentin and doesn't have clinical relevance (See Chap. 3).

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One of the reasons why dental fractures can be very confusing in their clinical presentation is that teeth consist of several tissues—enamel, dentin, cementum, pulp, and periodontal ligament. Adding to the anatomic complexity is the observation that symptoms alone cannot always be relied on to arrive at a definitive diagnosis and in addition clinical signs may often be difficult to interpret. It is generally recognized that for some dental fractures, pathognomonic signs and symptoms are few and frequently difficult to identify. These complexities have contributed to the difficulty in developing a universally acceptable classification. Efforts that have been made toward classification of dental fractures—such as that by the American Association of Endodontists [3], have not been adopted universally. Treatment of teeth with any type of fracture must be preceded by a accurate diagnosis. As mentioned above, the more complex the fracture situation is, the more difficult it may be to make the accurate diagnosis; such a situation can often be frustrating for both the patient and the dentist. Add to that the fact that treatment options vary considerably depending on the diagnosis, thus it is easy to understand why dental fractures can present some of the more difficult dental problems in the scope of dental practice. Since making an accurate and timely diagnosis is so important in terms of treatment planning and establishing a prognosis, we suggest that developing a practical categorization or classification of the various dental fractures may contribute to more predictable outcomes.

Supporting the value of a generally acceptable classification system is the observation by Andreasen [4] that "because of the increased incidence of medical and dental litigation (See Chap. 8) a necessary aspect of any classification system is the provision of an accurate description of the injury that can be easily understood by individuals with differing educational backgrounds."

Categorization of dental fractures should take into account the origin, the location, and the direction of fracture propagation. Identifying the category will influence the selection of treatment options. The focus in this book will be on the dental fractures that are of a *chronic* nature and characterized as generally having a vertical direction, corresponding to the long axis of the tooth, and having a time component that relates to the fracture line propagating over various time periods [5].

The clinical terms *craze lines*, *fractured cusp*, cracked tooth, and split tooth [3] describe fractures that are all longitudinal or variations thereof and can be categorized into one category. We suggest that category be referred to as *crown-originating fractures* (COFs). They are different from those resulting from *acute* traumatic injuries (trauma-related fractures) and those that are the focus of this book—vertical root fractures (VRFs) (See Table 2.1). The terms *crack* or *root crack* will be used to describe the initial minute fractures originating in dentin as explained previously.

Dental Fractures

The following is a scheme of categorization based on what can be observed with respect to the various dental fracture situations.

Table 2.1 Dental fractures

Categories	Characteristics
Crown-originating fracture (COF)	Spontaneous fracture originating in the crown and may progress into the root in an apical direction
Vertical root fracture (VRF)	A root-originating fracture that may originate anywhere in the root and occur primarily in endodontically treated teeth
Trauma-related fractures	Tooth fractures of acute nature may involve the crown or the root or both

Crown-Originating Fractures (COFs)

These types of fractures typically originate in the tooth crown and are not related to root canal treatment. The fractures progress toward the root; after reaching the coronal area of the root, the fracture lines continue in an apical direction. If not treated, teeth with such fractures will eventually split vertically, or if the fracture line progresses diagonally below a cusp, that cusp may fracture off the tooth. If the cusp fracture does not create a serious periodontal problem, usually this entity can be treated with good prognosis.

Craze lines are fractures limited to the enamel only and may extend over the marginal ridges (Fig. 2.1) in molars and occur in the anterior segments as well (Fig. 2.2) [3]. They are considered benign and require no treatment except occasionally for esthetic reasons.

Some crown-originating fractures (COFs) have been identified as *cracked teeth* [1]; they are found in maxillary and mandibular molars and maxillary premolars. These fractures occur mostly in teeth with vital pulps and have a mesiodistal pattern. They can be observed in intact crowns or may be seen next to a carious lesion or adjacent to a small restoration. The fracture in the crown can at times extend apically to eventually separate the tooth into two parts (*split tooth*) [3] (Figs. 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9).

Crown-originating fractures typically extend to either or both of the marginal ridges through to the proximal surfaces [3]. Very few of these crown fractures have a bucolingual direction. The fractures progress from the marginal ridges through the pulp chambers and eventually may result in a split tooth.

Fractures may be visualized in the tooth crown with transillumination or with the use of dyes absorbed into the fracture lines. The patient's history and symptomatology may include pain in the tooth or pain referred to other oral regions increasing the diagnostic difficulty [6]. Many patients experience a vague discomfort during mastication, often with elevated sensitivity to cold.

Contributing to the diagnostic difficulty may be lack of notable caries or other reasons for pulpal disease. The patient's symptoms may also resemble those in patients with ear aches, TMJ dysfunction, sinusitis and neurological problems [7]. The longer the symptoms are present, the more diffuse they become, and the more difficult the diagnosis becomes [6]. It may be prudent to consider the presence of COF whenever the usual suspects (caries, etc.) are absent. Correct diagnosis and identification of the actual type of fracture involved will help in developing treatment options.

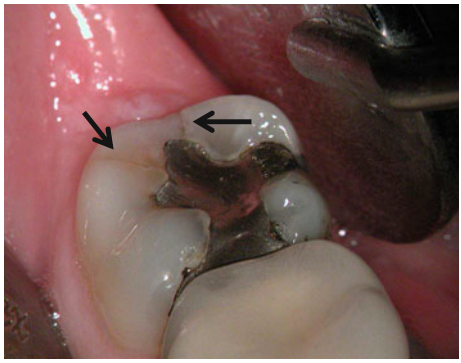

Fig. 2.1 Two craze lines in a mandibular molar. The *two black arrows* point at the craze lines extending from the amalgam filling to the external distal surface of the crown (Courtesy Dr R. Paul)

Fig. 2.2 A *black arrow* pointing at a craze line in a maxillary incisor

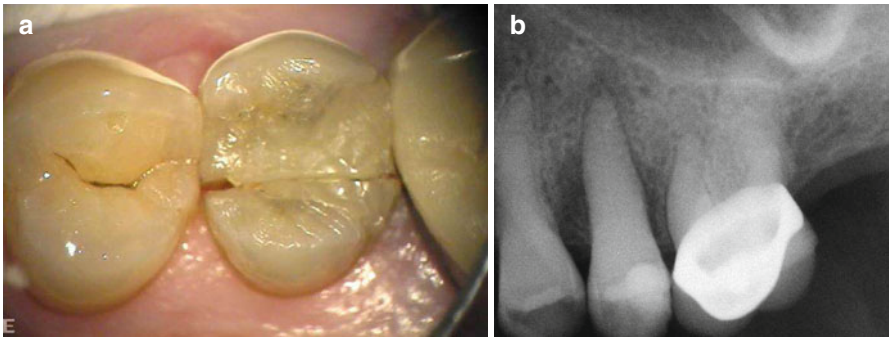

Fig. 2.3 (**a**, **b**) A mesiodistal fracture in a maxillary premolar crown. The crown was previously treated with an esthetic white restoration. The patient's chief complaint was of "problems in brushing the teeth in this area." (**a**) The pulp was diagnosed as necrotic with asymptomatic apical periodontitis. The fracture extends apically creating pockets of 6 mm in the proximal areas. Bone resorption due to the periodontal destruction can be seen mesially and distally (**b**) (Courtesy Dr N. Chivian)

Some patients do present with existing pulp necrosis with or without periapical disease as a result of long-term COF. The term *fracture necrosis* has been suggested for such an entity [8] (Figs. 2.10 and 2.11).

Fig. 2.4 A diagnosis of symptomatic irreversible pulpitis was done in a patient with a class I amalgam restoration in a maxillary premolar. With the use of magnification and illumination, two fractures can be seen extending mesially and distally from the amalgam restoration

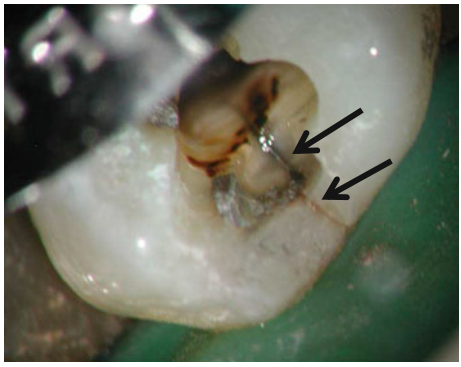

Fig. 2.5 Following local anesthetics and tooth isolation, the fracture is seen clearly (*two black arrows*) after removal of the restoration extending beyond the marginal ridge to the external surface (Courtesy Dr R. Paul)

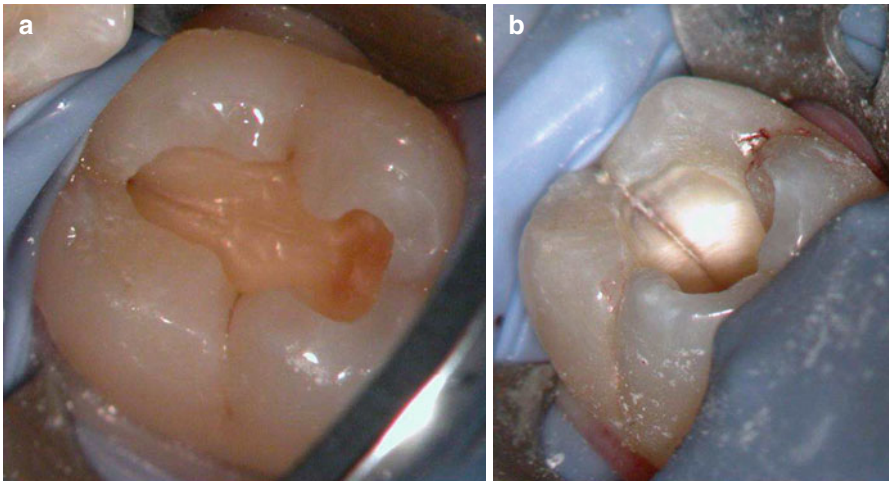

Fig. 2.6 (**a**, **b**) Mesiodistal fracture in a mandibular crown seen in the roof of the pulp chamber after removal of the coronal restoration (**a**). At the pulp chamber level, the fracture can be seen extending to the orifices of the root canal (**b**) (Courtesy Dr R. Paul)

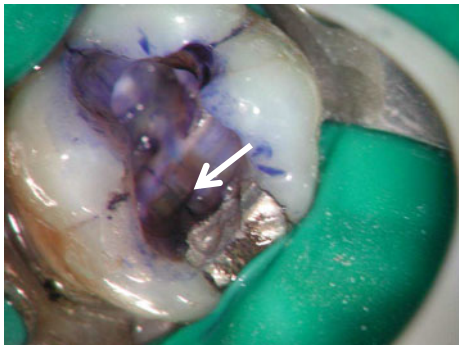

Fig. 2.7 Mesiodistal fracture can be seen at the floor of the chamber (*white arrow*) in mesial distal direction in a mandibular molar using methylene blue dye (Courtesy Dr R. Paul)

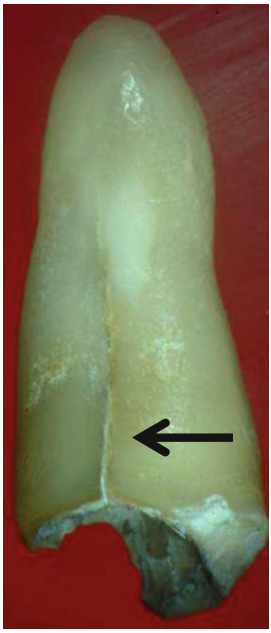

Fig. 2.8 An extracted maxillary premolar showing a VRF that originated in the crown and propagated apically (*Black arrow*)

Fig. 2.9 A fracture in the crown that extended apically to bifurcation area to separate a mandibular molar into two parts (Courtesy Dr. R. Paul)

Fig. 2.10 This radiograph was taken during routine patient examination. The tooth was asymptomatic. A shallow cl I intact amalgam restoration was noted in the crown. A small fracture was seen in the occlusal surface of the crown. The pulp tested nonvital. It caused necrosis of the pulp and as a result damage to the hard tissues. External apical resorption can be seen in the mesial root and bifurcation radiolucency (Fracture Necrosis) (Courtesy Dr R. Paul)

Vertical Root Fractures (VRFs)

Vertical root fracture (VRF) is a frustrating complication associated with root canal treatment in teeth and leads to their extraction [9, 10]. With a few exceptions of VRF in vital teeth [11], they primarily involve endodontically treated and restored teeth [12]; they are longitudinally oriented, thus having an apicocoronal direction. There is an overall prevalence of up to 11 % in endodontically treated teeth [13, 14]. In an incidence study done in a hospital clinic over 1 year [15], a total of 87 new cases of teeth had various types of crown and root fractures with 13 % of them VRFs in endodontically treated teeth.

A VRF can originate at any level in the root [3] although it appears that they commonly begin in the apical part. If they originate away from the apex, such as in the middle of the root, they can propagate in either direction, either apical or coronal. From the horizontal aspect, the fractures originate in the root canal wall and extend to the root surface over time and may involve either one side—buccal or lingual (incomplete)—or both sides (complete fracture) (Figs. 2.12, 2.13, and 2.14).

Fig. 2.11 A patient presented to the dental office with a complaint of "suppuration of pus from the gum." Clinical examination presented with a deep cl 1 amalgam restoration. The pulp tested nonvital, and a sinus tract was presented at the level of the apical part of the attached gingivae. A gutta-percha tracing can be seen in the radiograph all the way to the tip of the mesial root. Radiolucency between the roots can also be noted (Fracture Necrosis)

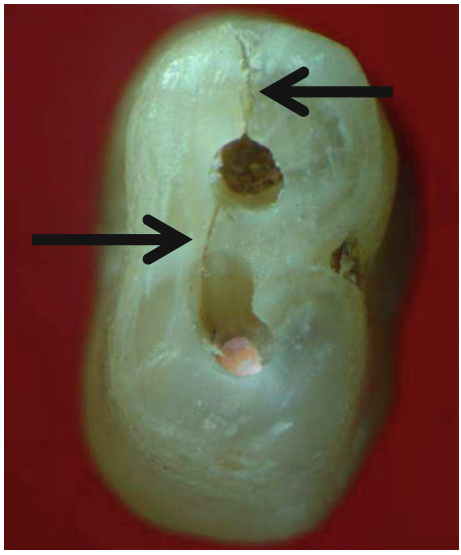

Fig. 2.12 *Two black arrows* are pointing at an incomplete VRF in double-canal single-rooted maxillary premolar. The fracture is not extending to the other root surface

Both in the incomplete and complete fractures, for the most part the fractures have a buccolingual pattern. Very rarely does a VRF have a mesiodistal orientation (Fig. 2.15).

In multirooted teeth, the fracture occurs mostly in one root, but fractured two roots of the mandibular molar (Fig. 2.16) or the two buccal roots of the maxillary molars

Fig. 2.13 A complete VRF in a buccal root of a bifurcated maxillary premolar

Fig. 2.14 An apical view in a complete VRF in a maxillary premolar. Note the typical "hourglass"morphology of these teeth in cross section and the typical mesial concavity in the trunk of the root

Fig. 2.15 A rare mesiodistal oriented VRF from the tip of the root extending to the crown of a maxillary premolar. The coronal restoration was removed for better visualization

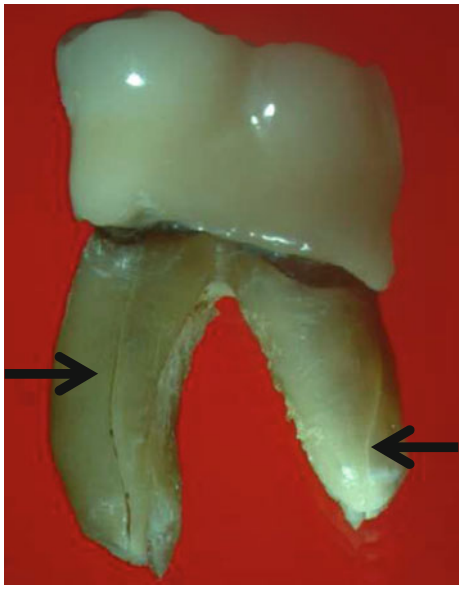

Fig. 2.16 VRFs in mesial and distal roots of a mandibular second molar. Note that the fracture in the distal root does not follow the long axis of the root (*Black arrow*)

(Fig. 2.17) can also be seen. Although VRFs for the most part are longitudinal, they do not always follow the root axis but may progress differently based on the bulkiness of the root and the influence of occlusal forces (Figs. 2.16, 2.18 and 2.19).

Fig. 2.17 VRFs in the two buccal roots of a maxillary first molar

Fig. 2.18 VRF in the mesial root is extending from the external lateral aspect of the root 5 mm coronally to the root tip to the coronal part of the root

In cases 2.16, 2.18 and 2.19 that where the teeth were extracted with their crowns, it is difficult to determine the origin of the fractures. It is possible that the fractures originated in the crowns and progressed apically (crown originating fracture—category 1) or originated in the roots and progressed to the cementoenamel junction.

The signs and symptoms of VRFs in endodontically treated teeth are similar to those of periodontal disease or failing endodontic treatment (see Chap. 4). In addition, they are usually diagnosed years after the endodontic and prosthodontic procedures have been completed [12, 16, 17]. These findings lead to frustration both for the patient and the dentist.

The teeth and roots most susceptible to VRF are those in which their mesiodistal diameter in cross section is narrow compared to the buccolingual dimension (oval, hourglass shaped, kidney shaped, ribbon shaped). Such teeth and roots are the maxillary and mandibular premolars (Figs. 2.12, 2.13, 2.14, and 2.15), the mesiobuccal root of mandibular molars (Figs. 2.16, 2.17, 2.18, and 2.19), the mandibular anterior teeth (Figs. 2.20 and 2.21a, b), and mesiobuccal roots of the maxillary molars (Fig. 2.17) (See also Chap. 3) [18].

From the apical–coronal aspect, the fracture can be limited to the apical area only (Fig. 2.22a, b), limited to the coronal part (Fig. 2.23a, b), both coronal and middle parts (Fig. 2.24a–g), limited only to the middle part of the root (Fig. 2.25a–c), or involving both the middle and apical parts (Fig. 2.26a, b). Often when a VRF diagnosis of an endodontically treated root is made, all the three thirds of the root are involved, i.e., from the tip of the root to the cervical part of the crown, and the fracture is complete from the buccal to the lingual sides. Examples are shown in the premolar teeth (Fig. 2.27a–d) and the mandibular molars (Figs. 2.28a–e and 2.29a, b).

Occasionally, a VRF is confined to the middle part of the root only and not involving the coronal or apical parts (Fig. 2.25). When a tooth with VRF is extracted and a full-length fracture is present, i.e., from the apex to the cementodentinal junction (Figs. 2.19, 2.27, 2.28 and 2.29), it is not possible to determine if the VRF originated in the coronal part of the root or even from the crown itself and progressed

Fig. 2.19 Two VRFs in a mandibular molar. Note that in both roots the fractures in the apical parts are located few millimeters coronally to the root tip

Fig. 2.20 Vertical root fracture can be seen clearly as a radiolucent line parallel to the gutta-percha in an endodontically treated central incisor

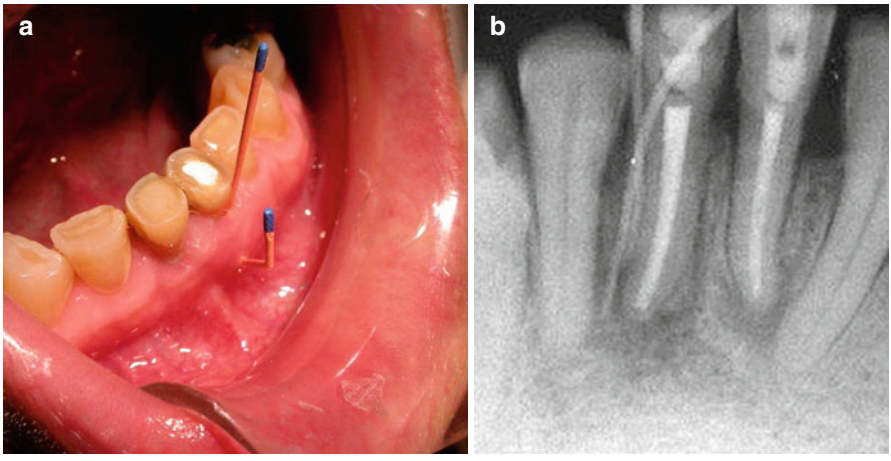

Fig. 2.21 Patient presented to the dental office with a request to restore the two mandibular central incisors. From the patient history, it was revealed that 7 years earlier, two root canal treatments were performed as a result of pulp exposure due to severe bruxism. Clinical examination revealed temporary restoration in the lower left incisor, 8 mm probing defect in the buccal aspect, and a sinus tract in the attached gingivae (**a**). The periapical radiograph (**b**) reveals two large areas of radiolucencies around the tip of the two roots and the two tracings of gutta-percha shown in **a**

apically or was initiated in the apical part and progressed coronally to the cementoenamel junction [17, 18].

The susceptibility of endodontically treated, restored teeth and roots to vertical fractures has been discussed in several publications [13, 15–17, 19]. Current

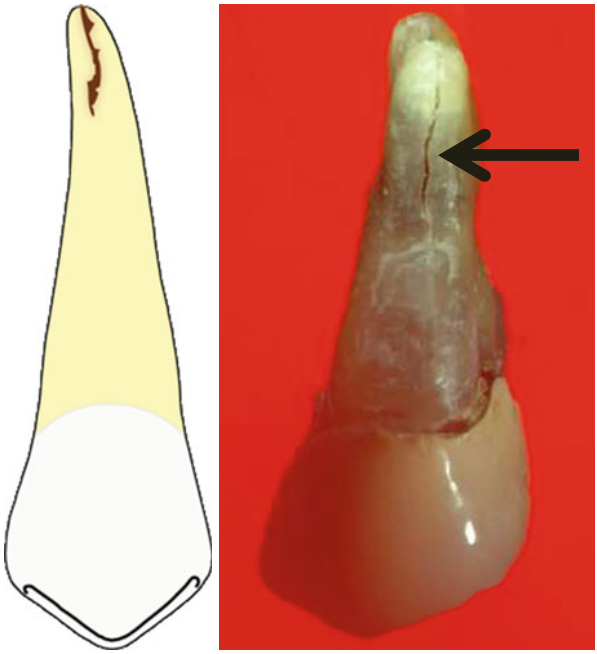

Fig. 2.22 Graphic illustration showing VRF limited to the apical part of a maxillary premolar root. (**a**) Middle and coronal parts of the root are not involved. (**b**) In an extracted maxillary premolar (*black arrow*)

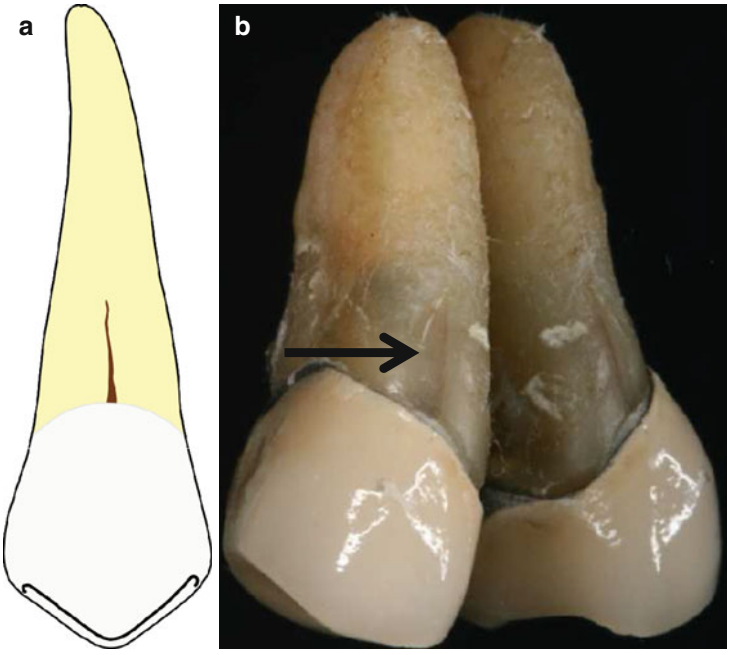

Fig. 2.23 Graphic view of a VRF in the coronal third of a maxillary premolar (**a**). In this case, the fracture originated either in the crown itself or in the coronal third of the root. (**b**) In an extracted single rooted maxillary premolar (*Black arrow*) (Courtesy Dr E. Venezia)

endodontic procedures, such as root canal treatment and retreatment, necessitate the removal of tooth structure to accomplish the procedure. Such loss of tooth structure probably reduces a tooth's resistance to fracture from even normal functional

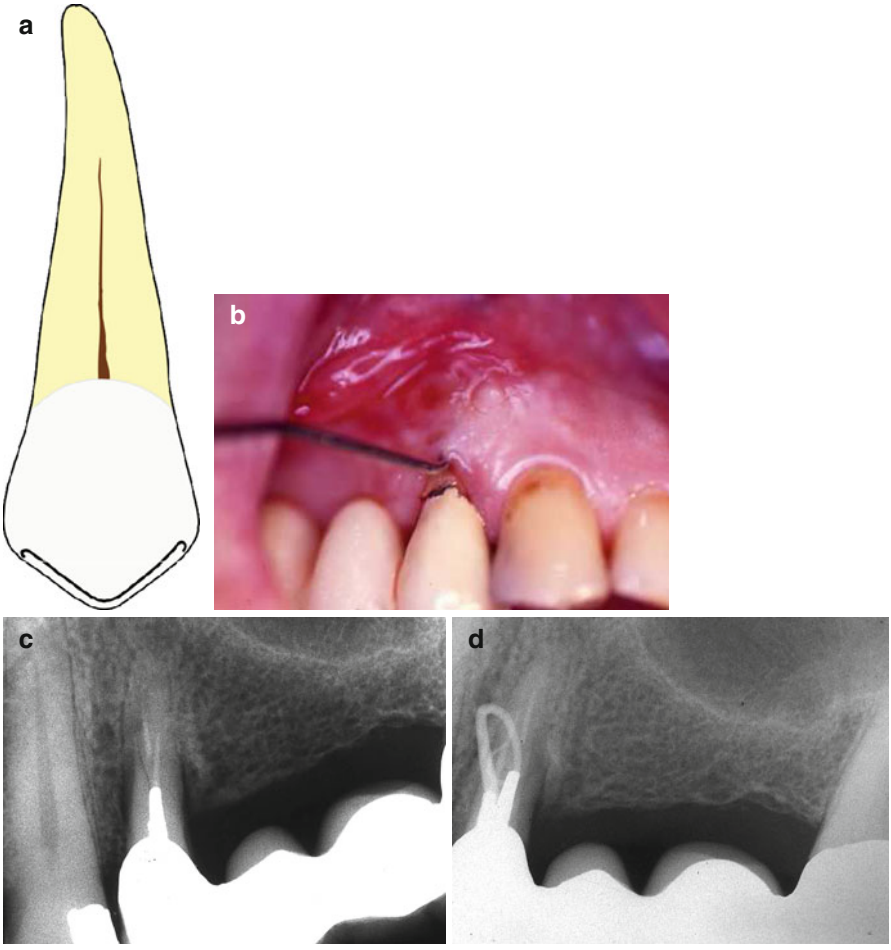

Fig. 2.24 Graphic illustration of a crown-initiated fracture which involves only the coronal and middle parts of the root (**a**). Highly located sinus tract can be seen in the attached gingivae of a maxillary premolar that was used as a mesial abutment for a four-unit bridge. A 7 mm probing defect was measured in midbuccal area (**b**). A periapical radiograph is showing a fracture line from the tip of the dowel diagonally to the mesial aspect. Two isolated radiolucent areas can be seen in the bone in the middle part of the root in the mesial and distal aspects (**c**). Another radiograph taken (**d**) with a gutta-percha tracing. Following a VRF diagnosis, the tooth was extracted (**e**). It can be noted that most likely, the fracture was initiated in the crown and propagated apically and diagonally causing fracture of the root in its coronal and middle parts. Two cross sections of a VRF in a single-rooted maxillary premolar with one canal (**f**, **g**) are showing that a VRF that was initiated in the crown can possibly due to the occlusal forces propagate apically in a diagonal way thus leaving the root canal and terminating at the root surface much more coronal to the apical end

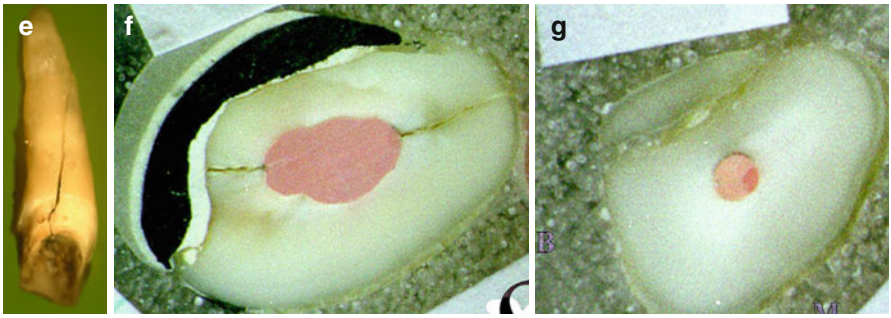

Fig. 2.24 (continued)

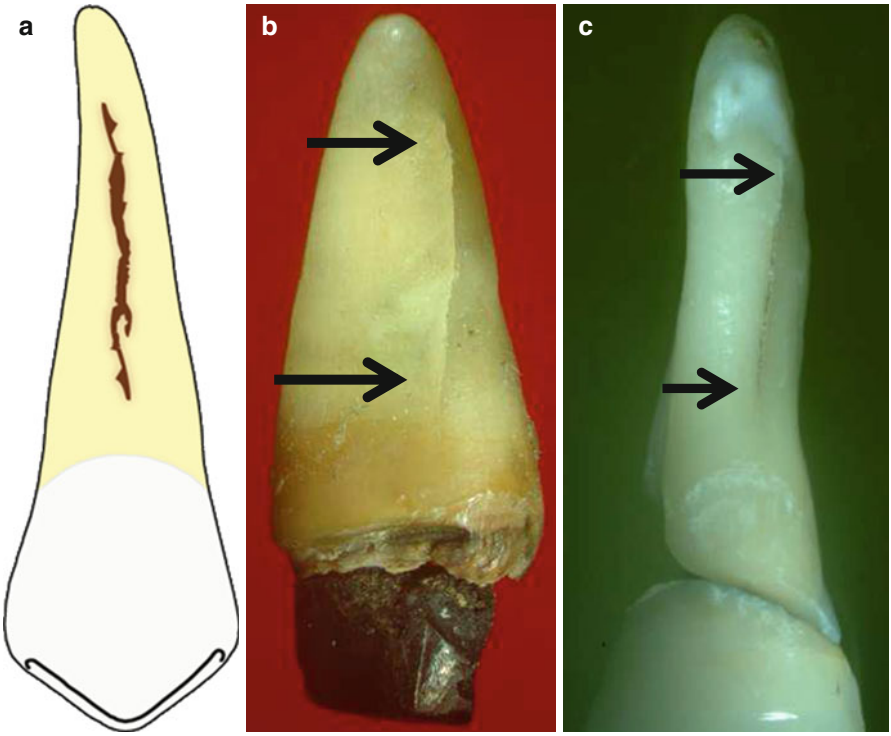

Fig. 2.25 (**a**–**c**) VRF in the middle part of the root of maxillary premolars which is not involving the coronal or apical parts (**a**) Graphic illustration, (**b**, **c**) examples in extracted maxillary premolars with VRFs (*arrows*)

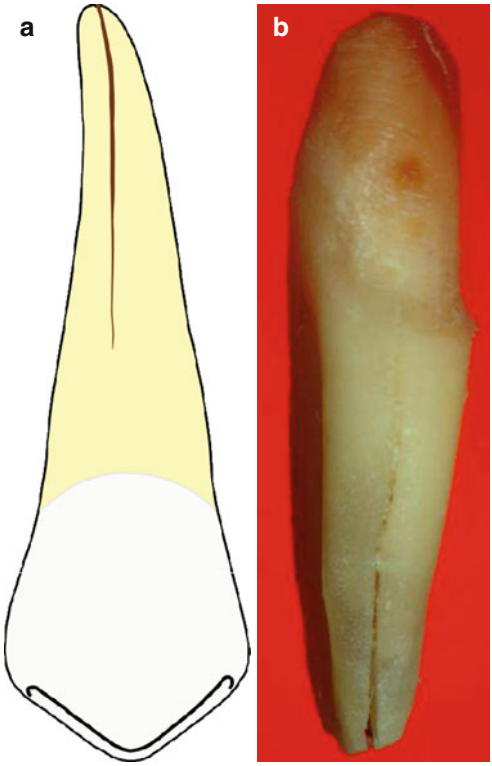

Fig. 2.26 (**a, b**) Graphic illustration of a VRF limited to the apical and middle parts of the root not involving the coronal one. (**a**) Extracted bifurcated maxillary premolar in which the apical and middle parts are fractured leaving the coronal part intact (**b**)

pressure during occlusion. Indeed, many of the VRFs occur in root canal treated teeth [20] where extensive amounts of dentin are removed from the root canal wall. These contributing factors will be discussed in detail in Chap. 3 on VRF Etiology. An example of a crown-originated fracture that progressed to the roots to create vertical fractures in the roots as well is demonstrated in Fig. 2.29.

Trauma-Related Tooth Fractures

Fractures that result from acute-impact trauma that occur mostly in intact as well as endodontically treated teeth are identified as (a) enamel craze lines, (b) enamel fractures (chipped enamel), (c) uncomplicated crown fractures (enamel and dentin, but no pulp exposure), (d) complicated crown fractures (enamel and dentin with exposure of the tooth pulp), (e) crown-root fractures (enamel, dentin, and cementum and may or may not expose tooth pulp), (f) horizontal root fractures (frequently these fractures are diagonally positioned across the root), and (g) cementum chips (cementum that has sequestrated from the root surface) [21] (Fig. 2.30a, b).

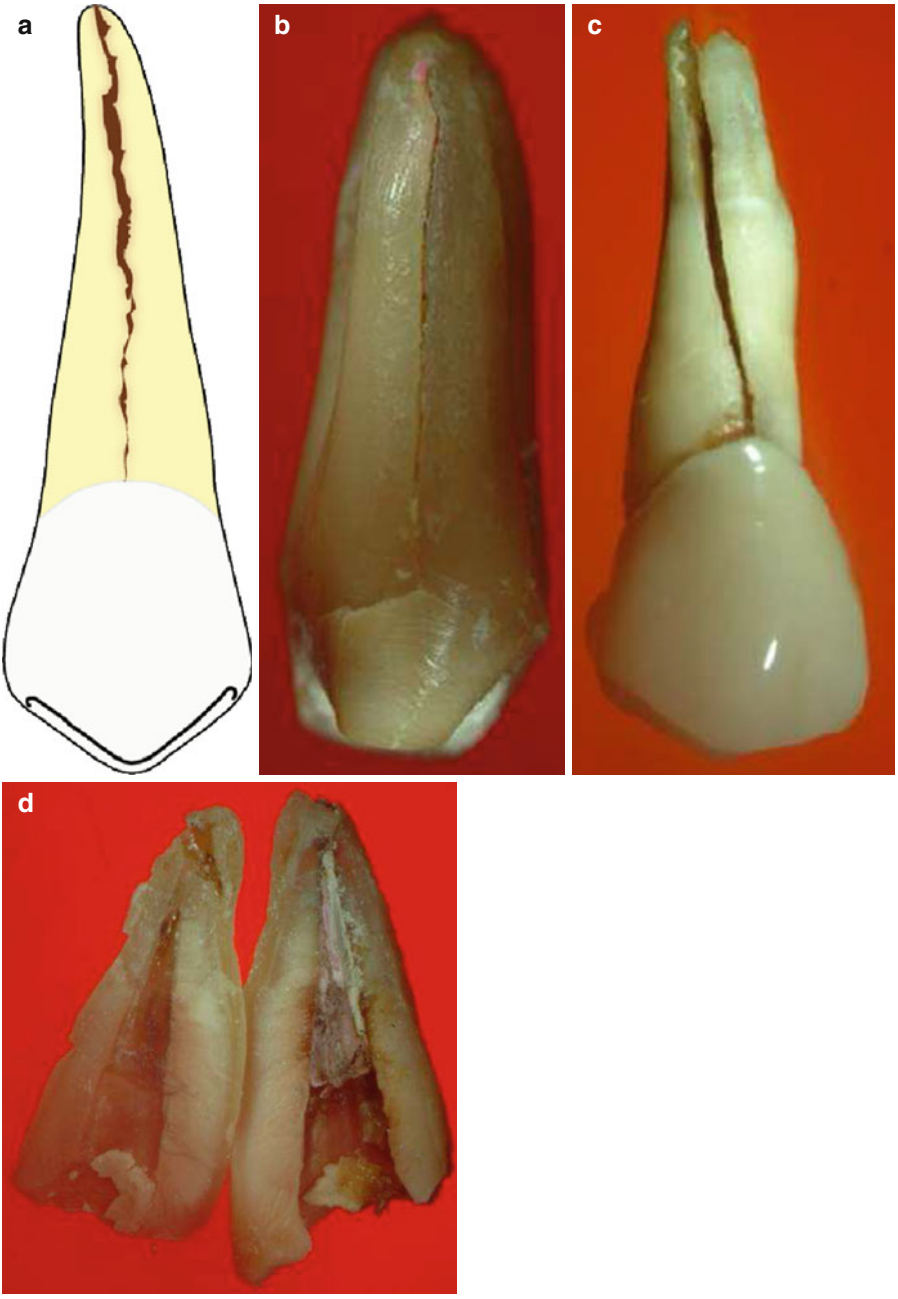

Fig. 2.27 (**a**–**d**) Graphic illustration of VRF that involves the three parts of the root (**a**) VRF in all the three parts of an extracted maxillary premolar tooth (**b**) The two parts of the fracture were not separated when extracted. Another extracted maxillary premolar where the parts are separated (**c**) showing the very typical buccal–lingual fracture of the root (**d**)

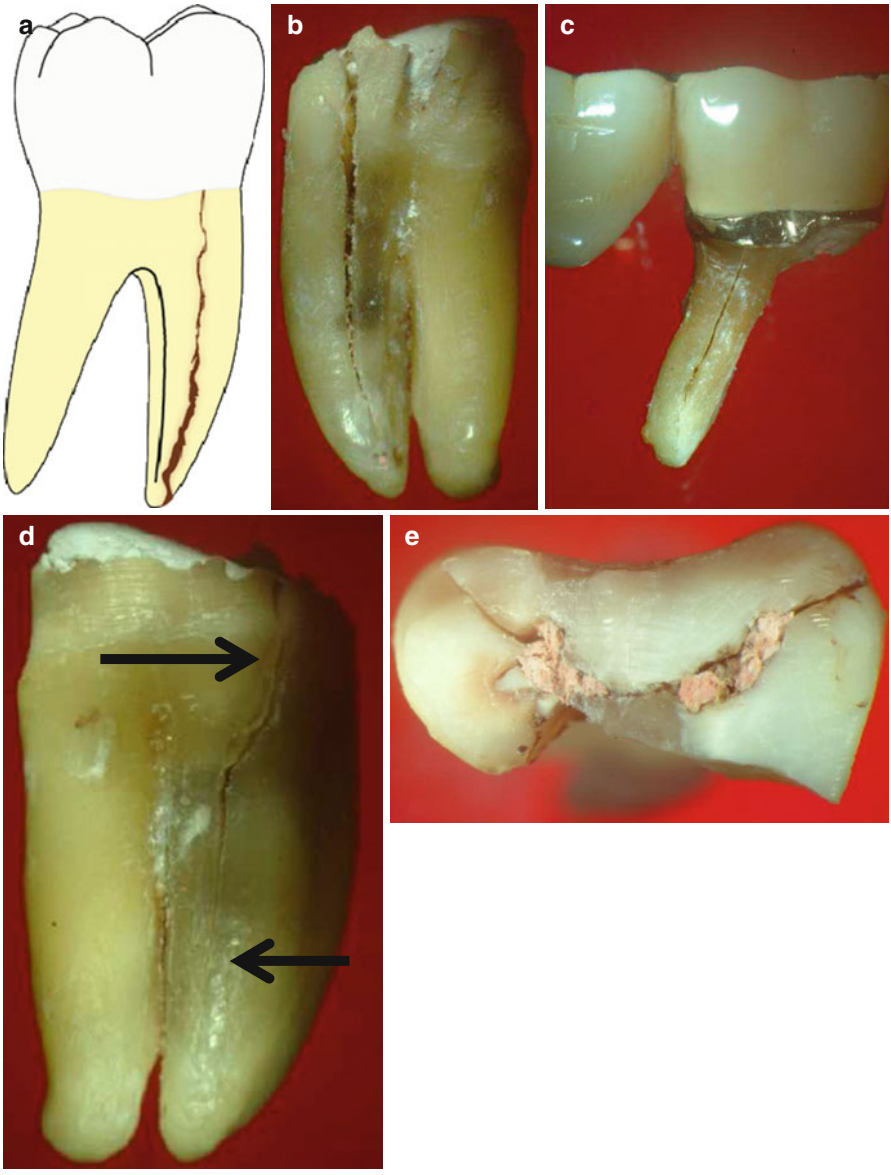

Fig. 2.28 (**a**–**d**) Graphic illustration of a typical VRF involving the three thirds of an endodontically treated mesial root of a mandibular molar (**a**). A complete fracture in the mesial root of a mandibular molar that follows a straight axis from the tip of the root to the crown (**b**). A straight line VRF that involves the three parts of the root (**c**). Note that in figure (**d**) of another VRF case in a mandibular molar, most likely the fracture was initiated in the crown mesiodistally (crown-originated fracture—*top black arrow*) and propagated from the mesial aspect of the crown, turning diagonally and apically to form a buccal–lingual fracture which is typical for a VRF (*Bottom Black arrow*). A complete VRF in a cross section (**e**) of endodontically treated mesial root of a mandibular molar. The complete fracture involved the two root canals in the root and most likely through the isthmus between the canals

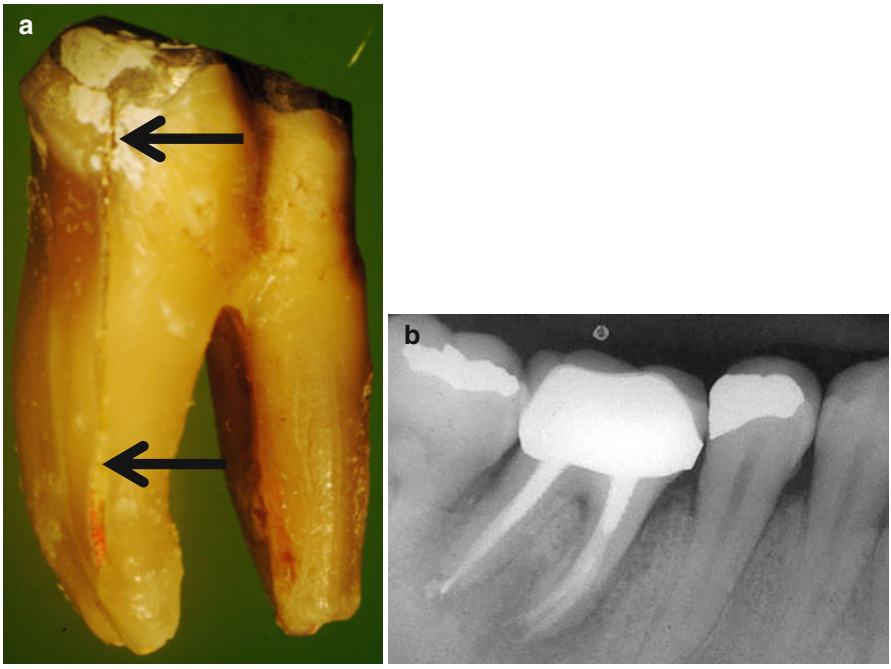

Fig. 2.29 (**a, b**) The patient presented to the dental office with a history of acute exacerbation in the right side of the mandible. Three years earlier, the root canal treatment was retreated and a new PFM crown placed. On clinical examination, there was redness at the attached mucosa adjacent to the mandibular first molar, sensitivity to percussion, and 8 mm probing defect at the MB site. The periapical radiograph (**b**) revealed well-obturated root canals and two dowels in the mesial and distal roots. Large "halo"-type radiolucency combined with a lateral one on the mesial aspect of the mesial root can be seen in the radiograph. Although the radiographic appearance and the probing hinted that there may be a VRF in this case, the diagnosis that was done was symptomatic apical periodontitis. The tooth was extracted because the prognosis for a new retreatment was poor. The extracted tooth (**a**) shows a VRF in the mesial root (*arrows*) that extends from the coronal area to the apical third of the root and a vertical root fracture in the bifurcation aspect (mesial) in the distal root as well. Most likely, this is a case of crown-originated fracture that progressed to the two roots as well

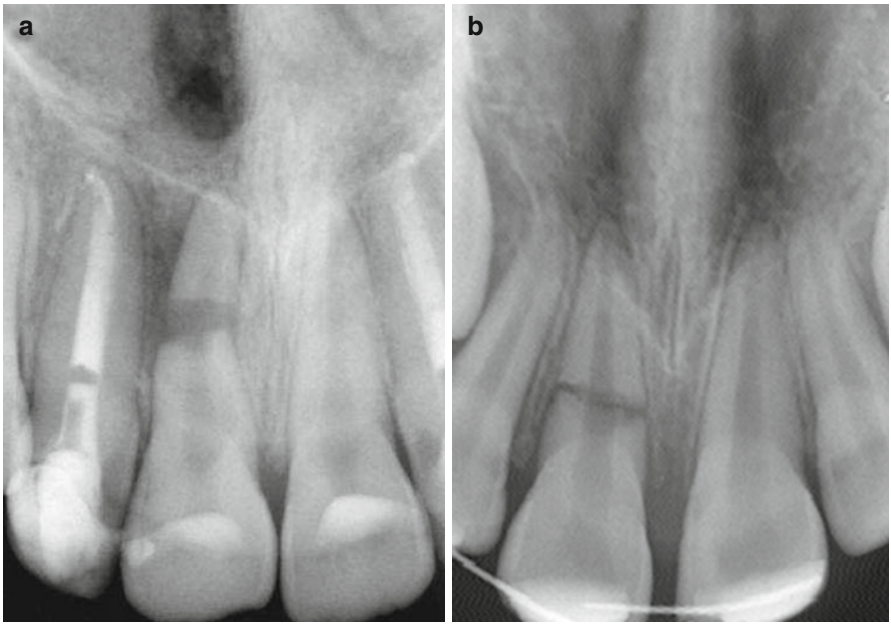

Fig. 2.30 Two examples (**a**, **b**) of acute-impact trauma to the maxillary central incisors causing fractures of the roots

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