# Vertical root fracture in endodontically versus nonendodontically treated teeth

## A survey of 315 cases in Chinese patients

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***Objective.*** The purpose of this study was to compare endodontically versus nonendodontically treated teeth with respect to clinical features, including patient age and gender and tooth types of vertical root fractures.
***Study design.*** A total of 315 consecutive cases of vertical root fracture occurring in 274 Chinese patients during a 13-year period were reviewed. Age and gender, as well as tooth type and root distribution of vertical root fractures, were presented and compared in endodontically versus nonendodontically treated teeth.
***Results.*** Most patients (87%) had 1 fractured tooth; the others had 2 or 3 fractured teeth. Of all vertical root fractures, 40% occurred in nonendodontically treated teeth. In comparison with those in endodontically treated teeth, vertical root fractures in nonendodontically treated teeth tended to occur in patients with a higher mean age (55 years vs 51 years) and were more frequent in male patients (78% vs 58%). Vertical root fractures occurred in nonendodontically treated teeth more often in molars (84% vs 53%), less often in premolars (16% vs 33%), and seldom in anteriors (1 tooth vs 27 teeth).
***Conclusions.*** Vertical root fractures in nonendodontically treated teeth are not uncommon and comprise a large proportion of such fractures in Chinese patients. Differences between endodontically and nonendodontically treated teeth in patient age and gender, as well as in tooth types of vertical root fractures, were demonstrated.
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*Vertical root fracture* (VRF) is defined as a longitudinal fracture confined to the root that usually begins on the internal canal wall and extends outward to the root surface.[1] VRF often presents no specific signs and symptoms, and it is therefore difficult for dentists to make a definite diagnosis of the condition. Previous studies[2-5] reported that common clinical symptoms of VRF are the presence of dull pain, swelling, and sinus tract, with a deep localized probing defect. Radiographs may show widening of the periodontal ligament and osseous resorptive defects. The clinical and radiographic findings are related to the extent and location of the fracture. VRF is mostly found in older people.[3]

VRF usually occurs in endodontically treated teeth with or without post insertion.[3,6] Many factors contributing to VRF have been reported, including excessive lateral condensation force during root canal filling procedures, wedging effects of endodontic posts, corrosion, and expansion of posts.[4-8] Considerable loss of tooth structure during instrumentation and excessive pressure during obturation have been reported as the most likely causes of VRF.[6-8]

Root fractures in nonendodontically treated teeth are usually apical extensions of coronal fractures associated with cracked or split teeth.[9,10] VRFs in nonendodontically treated teeth should therefore be differentiated from root fractures that began as coronal fractures (cracked or split teeth). True VRF in nonendodontically treated teeth confined to the root surface is apparently uncommon, the few documented reports being Chinese. Wei and Ju[11] and Yang et al[12] reported 3 cases and 12 cases, respectively, of VRF in nonendodontically treated teeth. All of the fractured teeth reported[11,12] were severely attrited first molars with no or minimal restorations in Chinese males. In a series of 51 cases of root fractures in nonendodontically treated teeth in Chinese patients, Yeh[13] reported that 80% of the fractures were VRFs. Recently we reported 64 cases of VRF in nonendodontically treated teeth in Chinese patients[14]; most (79%) of the patients had intact dentitions with less than 4 teeth missing.

The true causes of VRF in nonendodontically treated teeth are still unknown. Yang et al[12] suggested that these fractures might be related to special diet patterns or chewing habits in Chinese. Yeh[13] proposed that the VRFs might result from an excessive, repetitive and

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**Table I.** Distribution of VRFs in endodontically and/or nonendodontically treated teeth

| | No. of patients (%) | | | |
|---|---|---|---|---|
| *Total no. of fractured teeth* | *Endodontically treated teeth only* | *Nonendodontically treated teeth only* | *Teeth treated both endodontically and nonendodontically* | *Total* |
| 1 | 137 (50) | 100 (36) | 0 (0) | 237 (87) |
| 2 | 21 (8) | 10 (4) | 2 (1) | 33 (12) |
| 3 | 2 (1) | 1 (0.4) | 1 (0.4) | 4 (1) |
| Totals | 160 (58) | 111 (41) | 3 (1) | 274 (100) |

**Table II.** Age and gender distribution of patients with VRFs

| | No. of patients by age group (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *20-29 y* | *30-39 y* | *40-49 y* | *50-59 y* | *60-69 y* | *70-79 y* | *80-89 y* | *Total* |
| Endodontically treated teeth | | | | | | | | |
| Male | 2 (1) | 16 (10) | 35 (21) | 13 (8) | 20 (12) | 6 (4) | 2 (1) | 94 (58) |
| Female | 0 (0) | 11 (7) | 18 (11) | 21 (13) | 11 (7) | 8 (5) | 0 (0) | 69 (42) |
| Subtotals | 2 (1) | 27 (17) | 53 (33) | 34 (21) | 31 (19) | 14 (9) | 2 (1) | 163 (100)* |
| Nonendodontically treated teeth | | | | | | | | |
| Male | 0 (0) | 5 (4) | 26 (23) | 27 (24) | 21 (18) | 8 (7) | 2 (2) | 89 (78) |
| Female | 0 (0) | 3 (3) | 4 (4) | 8 (7) | 6 (5) | 4 (4) | 0 (0) | 25 (22) |
| Subtotals | 0 (0) | 8 (7) | 30 (27) | 35 (31) | 27 (24) | 12 (11) | 2 (2) | 114 (100)* |

*Includes 3 patients who had VRFs in both endodontically and nonendodontically treated teeth.

heavy masticatory stress; he referred to these fractures as "fatigue root fractures." The clinical features of VRF in endodontically versus nonendodontically treated teeth have yet to be investigated. Comparison of their clinical features may enhance the understanding of the contributing causes or risk factors of VRF. Therefore, the purpose of this study was to present and compare the clinical features, including the age and gender of the patients and the tooth types of the VRFs, in endodontically and nonendodontically treated teeth through a 13-year survey of 315 cases in Chinese patients.

## MATERIAL AND METHODS

Reviewed were 315 consecutive cases of vertical root fractures observed in 274 Chinese patients between January 1985 and June 1998. The final diagnosis of VRF in all uncertain cases was confirmed by surgical exploration. Cases of root fractures that might be related to cracked or split teeth were excluded. Accordingly, only true VRF cases confined to the root were included. Information was collected from each patient's dental history, clinical examination, and radiographic findings. The clinical data recorded were as follows: age and gender of the patient, involved tooth, location of the fracture, history of previous dental treatment (including endodontic and restorative treatments), symptoms and signs, radiographic findings, and final treatment.

Age and gender of the patients, as well as tooth type and root distribution of VRFs (in numbers and percentages), were presented and compared in endodontically versus nonendodontically treated teeth.

## RESULTS

There were 315 cases (teeth) of VRFs documented in 274 patients. The distribution of VRFs in endodontically and/or nonendodontically treated teeth is shown in Table I. Among the 274 patients, 237 (87%) had only 1 fractured tooth; the others (13%) had 2 or 3 fractured teeth. Only 3 patients (1%) had VRFs in both endodontically and nonendodontically treated teeth; each of the first 2 of these patients had 1 fractured tooth, and the third patient had root fractures in 1 endodontically treated tooth and 2 nonendodontically treated teeth.

The age and gender distribution of patients with VRFs in endodontically and nonendodontically treated teeth is shown in Table II. Of the 163 patients with VRFs in endodontically treated teeth, the incidence was 1.4 times higher in male than in female patients. Ages ranged from 24 to 84 years, with a mean of 51 years. Most VRFs (89%) occurred in patients 30 to 69 years old. The highest incidence occurred in the 40-to-49–years age group in men and in the 50-to-59–years age group in women. Of the 114 patients with VRFs in nonendodontically treated teeth, the incidence was 3.6 times higher in men than in women. Ages ranged from 34 to 83 years, with a mean of 55 years. Most patients (91%) were between 40 and 79 years old, and the highest incidence occurred in the 50-to-59–years age group. In both male and female patients, the mean age

for VRFs in endodontically treated teeth was lower than that for VRFs in nonendodontically treated teeth.

The distribution of VRF by tooth type varied. Of the 315 fractured teeth, 40% were nonendodontically treated. The incidence of VRF was found to be highest in first molars in both groups. The incidence of fracture in molars was also higher in nonendodontically treated (84%) than in endodontically treated (53%) teeth. For endodontically treated teeth, the incidence of VRF was more than 2 times higher in mandibular first molars than in maxillary first molars, maxillary first premolars (12%), maxillary second premolars (11%), and mandibular second molars (11%). Canines were the teeth least susceptible to fracture and had the lowest incidence. The incidence of fracture in endodontically treated premolars (33%) was double that for nonendodontically treated premolars (16%). VRF was rare in nonendodontically treated anterior teeth; 1 fractured mandibular incisor was noted, in comparison with 27 fractured anterior teeth (14%) that were endodontically treated.

The sites of fractured roots in molars are shown in Table III. Mesiobuccal roots of upper molars and mesial roots of lower molars were most susceptible in both groups. The incidence of fracture in distal roots of mandibular molars was much higher in endodontically treated (24%) than in nonendodontically treated (5%) teeth.

**Table III.** Sites of fractured roots in molars

| *Molars* | *Sites* | *No. of endodontically treated teeth (%)* | *No. of nonendodontically treated teeth (%)* |
|---|---|---|---|
| Maxillary | | | |
| | Mesiobuccal | 20 (71) | 33 (77) |
| | Distobuccal | 4 (14) | 2 (5) |
| | Palatal | 3 (11) | 4 (9) |
| | Fused | 1 (4) | 4 (9) |
| | Subtotals | 28 (100) | 43 (100) |
| Mandibular | | | |
| | Mesial | 53 (75) | 60 (92) |
| | Distal | 17 (24) | 3 (5) |
| | Fused | 1(1) | 2 (3) |
| | Subtotals | 71 (100) | 65 (100)* |

*One tooth had fracture in both mesial and distal roots.

## DISCUSSION

Diagnosis of VRF is a problem inasmuch as the condition is easily misdiagnosed as a periodontal or endodontic lesion. It is possible that many teeth with VRFs are extracted without being identified as such, especially among nonendodontically treated teeth. Though this retrospective clinical study was carried out over a period of 13 years, most of the cases were collected during recent years; this is due both to increasing awareness of VRF occurrence on the part of dentists and to confirmation by flap surgery in all uncertain cases. Although signs and symptoms of VRF are often nonspecific, clinical findings, such as a deep localized periodontal pocket depth and radiographic widening of the periodontal ligament or root canal space, are suggestive.[2-5,12-14] In uncertain cases, surgical exploration is indicated for diagnosis.

Overall, the incidence of VRF in endodontically versus nonendodontically treated teeth is unknown. Through a long-term survey of 13 years and a large collection of 315 cases, our study demonstrates that 40% of VRFs occurred in nonendodontically treated teeth. Apparently, VRFs in nonendodontically treated teeth are common in Chinese patients. This observation may indicate an underdiagnosed clinical entity.

Information pertaining to the question of whether a patient may have VRF in multiple teeth is still limited. Yeh[13] reported that 5 of 46 patients had 2 fractured teeth. In our study, 13% of patients had 2 or 3 fractured teeth; only 1% had VRF in both endodontically and nonendodontically treated teeth. Root fractures occurring in both groups seem to be very rare. Because most patients (99%) had VRF in either endodontically or nonendodontically treated teeth, it is possible that these 2 groups of patients had certain uncommon clinical characteristics or risk factors predisposing them to a particular type of VRF.

The gender distribution of VRF in endodontically treated teeth was not given in previous reports.[2,3,5] VRF differences with regard to patient gender in endodontically versus nonendodontically treated teeth were demonstrated in our study, men being seen more often in cases of nonendodontically treated than in cases of endodontically treated teeth. Other reports[11,12,14] have also shown VRF in nonendodontically treated teeth to occur more frequently in males. However, Yeh,[13] reporting that most of the patients in his study were betel nut chewers with severely attrited dentition, noted no gender difference. The higher incidence of VRF in nonendodontically treated teeth in males may be related to factors such as stronger masticatory force, increased attrition, habitual chewing of hard food, and less pliable supporting bone. These risk factors may have less influence on endodontically treated teeth, in which the incidence of VRF in males is only slightly higher.

As in previous reports,[3,5,13,14] most of the VRFs in our study were found in patients 30 to 69 years of age. We also showed that the mean age was lower in patients with VRF in endodontically treated teeth. This suggests that endodontic treatment and post insertion could result in significant loss and weakening of tooth structure and could increase the risk in younger patients.

Posterior teeth seem to be more susceptible to VRF. Testori et al[3] reported premolars to have the highest incidence of VRF in endodontically treated teeth; however, we showed first molars to be the teeth most frequently fractured in both groups. This may be related to the heavier masticatory force associated with first molars, to thin or flat roots in first molars, or to the habitual use of first molars in the chewing of hard food.[14]

Differences in VRFs with respect to tooth distribution were demonstrated in endodontically versus nonendodontically treated teeth in our study. VRF in nonendodontically treated anterior teeth seldom occurred, possibly because of the direction of the masticatory force, which is usually more lateral than vertical and thus more likely to cause horizontal or transverse, rather than vertical, root fracture. In both endodontically and nonendodontically treated teeth, flat or thin roots of smaller mesiodistal diameter are more susceptible to fracture. Despite having more ovoid root shapes, endodontically treated teeth—including the distal roots of mandibular molars, premolars, and anterior teeth—showed a higher tendency to fracture than did nonendodontically treated teeth. This may be related to weakening of the root structure by endodontic treatment or post insertion.

The differences that have been described in patient and tooth distribution of VRF between endodontically and nonendodontically treated teeth suggest that they have certain uncommon contributing factors, such as endodontic treatment and post insertion in endodontically treated teeth and moderate to severe attrition in nonendodontically treated teeth. Biologic or anatomical variations of the endodontically treated and the nonendodontically treated tooth are therefore important contributing factors of VRF. Grippo[15] suggested that the mechanical loading factors affecting the teeth are the magnitude, direction, frequency, location, and duration of the force. The stress induced on the tooth structure may therefore result in different patterns of fracture, depending also on the biologic or anatomical conditions of the crown, root, or supporting bone. For a nonendodontically treated tooth, possibly excessive and repetitive masticatory force, exerted vertically on an attrited occlusal surface, may concentrate the stress at the weaker apical areas. Cracks or fatigue are thus initiated, with eventual coronal propagation of the fracture.[14] However, VRFs on endodontically treated teeth may have a different pattern of crack initiation and propagation. Because of the weakening of root structure by endodontic treatment or post insertion, the apical point may not always be the weakest part of the root or point of crack initiation. The fracture may then begin at the apex or midroot or at some other position.[1,8]

The reason for the racial predilection of VRFs in nonendodontictically treated teeth in Chinese patients is still unknown. Yang et al[12] suggested that the predilection may be related to certain diet patterns or chewing habits, such as the chewing of bones in meat. These may be regarded as damaging habits of which the patients are not aware. It is not known whether this risk factor related to the fracture of nonendodontically treated teeth[12,14] also increases the tendency of endodontically treated teeth to fracture.

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