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Diagnosis and possible causes of vertical root fractures

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Thirty-two cases of vertical fractures were studied in an attempt to identify the causes and diagnostic signs normally present. In all of the patients except two, osseous defects were present and could be probed. The majority (65.63 percent) had only mild pain or a dull discomfort. Seventy-five percent showed diffuse widening of the periodontal ligament space. This study suggests that excessive force during lateral condensation of the gutta-percha caused 84.38 percent of the fractures. A secondary cause was the forcing or tapping of inlays or dowels into place. The majority (78.13 percent) of the patients were over the age of 40. In all but nine of the cases, treatment consisted of the extraction of the involved teeth.

The diagnosis of vertical root fractures associated with endodontically treated teeth can present difficulties for both the endodontist and the periodontist. The periodontist is often the first to see the case. The diagnosis can be made more easily if the dentist alerts himself to certain radiographic and clinical signs present. Horizontal fractures of roots are frequently associated with accidents.[1, 2] A vertical fracture in an endodontically treated tooth was first seen and reported because of a periodontal abscess and vertical bone loss.[3] Polson[4] reported four cases of periodontal destruction associated with vertical root fractures. Reasons given for vertical root fractures are volumetric expansion of endodontic pins or posts due to corrosion,[5–7] excessive pressure during placement of endodontic posts,[8, 9] wedging action of inlays, and excessive pressure during lateral condensation of the gutta-percha during obturation of the canal.[10] Often a definitive diagnosis can be made only when the affected tooth is explored by surgical means and the fracture line is seen. Extraction is normally indicated.[11, 12] The purpose of the present study was to attempt to identify the causes of vertical root fractures and the diagnostic signs normally present.

MATERIALS AND METHODS

Thirty-two cases of vertical root fractures verified by surgery and documented by color photographs were used in the study. Routine probing of the sulcus was accomplished on all the affected teeth, and the vertical bone loss was noted. Full flap procedures were used on all the patients. If the tooth or affected roots were extracted, fractures were evaluated and photographed. Cross sections of four representative teeth having vertical fractures were studied. For the majority of cases radiographs included preoperative, time of fill, yearly recalls, and preextraction (except for the nine cases where the teeth were retained). The patients ranged in age from 21 to 83 years.

FINDINGS

Table I records clinical and radiographic findings. Table II postulates the cause of the fracture. Table III groups the patients according to age.

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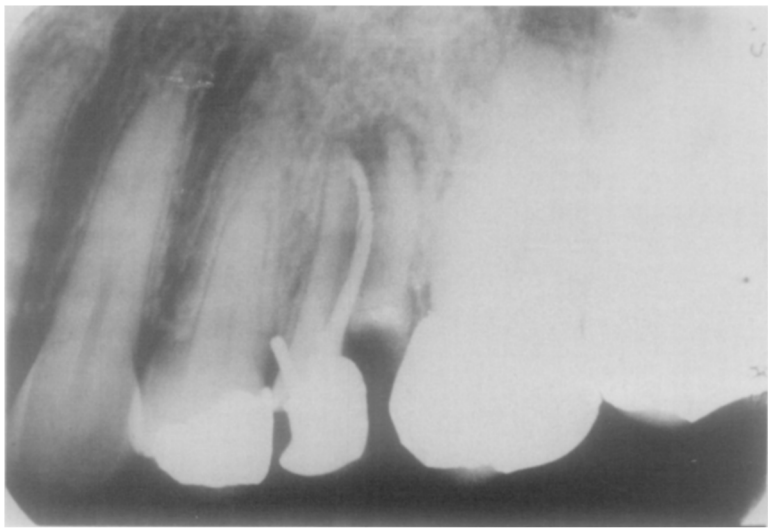

Fig. 1. A radiograph of a vertical fracture where definite displacement of the root has occurred.

Table I. Diagnostic signs from 32 vertical root fractures

Sign	*No. of teeth*	*Percentage of total cases*
Radiographic radiolucency only at root apex	7	21.88
Radiographic radiolucency involving the periodontal ligament (widening)	24	75
Radiographic evidence of displacement of a portion of the root	1	3.13
Probable osseous defect	30	93.75
Severe pain	2	6.25
Mild pain or dull discomfort	21	65.63
Absence of pain or discomfort	9	28.13
Snapping or cracking sound heard at time of obturation of the canal	6	18.75
Presence of a periodontal abscess	9	28.13
Presence of a fistulous tract	4	12.5

Table II. Possible causes of the 32 vertical root fractures

Cause	*No. of teeth*	*Percentage of total cases*
Excessive force used at time of lateral condensation of the gutta-percha	27	84.38
Seating and cementation of inlay on an endodontically treated tooth	1	3.13
Seating and cementation of inlay on a vital tooth	2	6.25
Seating and cementation of post in an endodontically treated tooth	1	3.13
Placement and cementation of pin in an endodontically treated tooth	1	3.13

The time between the canal filling and the onset of symptoms, severe enough for the patient to seek treatment, varied from 3 days to 14 years. The average time between these two intervals was 3.25 years. In two cases endodontic therapy was repeated because the tooth was still "sore." A third case was retreated endodontically because the periapical lesion failed to resolve. Another case had been treated by apicoectomy because the periapical lesion remained. At the time of surgery, bone loss was noted on the buccal aspect of the involved root. A vertical fracture was not seen, probably because the operator did not consider a vertical root fracture as a possible cause of alveolar bone loss. The defect persisted; and when again surgerized, the root fracture was evident and the tooth extracted. In all but nine cases treatment consisted of extraction of the involved tooth. Of these nine cases, five resulted in root amputations and four were treated by apically positioned flap procedures and osseous recontouring. The defects in the last four cases were minimal, and the area was made accessible for oral hygiene procedures.

As noted in Table I, all of these patients except two had osseous defects. In these two cases the teeth were extracted 3 days after completion of endodontic therapy. Evidently sufficient time had not elapsed for the bone loss to occur. In both cases a sharp crack was heard during lateral condensation of the gutta-percha. In the cases where pockets could be probed, the bone loss occurred in the area of the vertical root fracture and extended to the deepest point of the fracture line.

Twenty-one (65.63 percent) of the patients had only mild pain or complained of a dull discomfort in the area, while nine (28.13 percent) had no symptoms. Only two patients (6.25 percent) had severe pain, and both had the teeth extracted 3 days after obturation of the canal. Nine patients (28.13 percent) had a periodontal abscess or reported one that would come and go. Fistulous tracts were present in four cases (12.5 per-

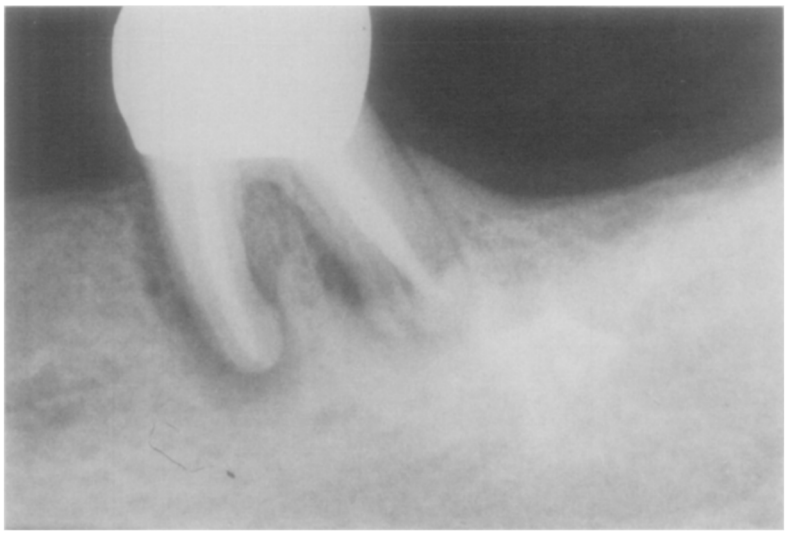

Fig. 2. Typical diffuse widening of the periodontal ligament space seen in vertical fractures.

Fig. 3. A probable osseous defect is present in the area of the vertical root fracture.

cent). Six of the patients (18.75 percent) gave a history of a "snapping" or "cracking"sound at the time the root canal was filled.

Radiographically, 24 of the 32 patients (75 percent) showed diffuse widening of the periodontal ligament space. Seven patients (21.88 percent) showed evidence of periapical pathosis. In only one case could displacement of the root be readily seen (Fig. 1).

Table II shows that the majority (84.38 percent) of the vertical root fractures reported in this study occurred at the time of the root canal filling, the result of excessive force during lateral condensation of the gutta-percha. The fractures were probably due to seating (tapping or forcing) and cementing the inlays, posts, and a pin.

In Table III it is noted that of the 32 cases, 19 (59.38 percent) occurred in patients over the age of 50. When the 40-year age group is included, this figure increases to 78.13 percent.

DISCUSSION

The diagnosis of vertical root fractures can present problems, but there are certain distinctive features that make the diagnosis less difficult. Vertical fractures are usually associated with endodontically treated teeth. Radiographically, a diffuse radiolucent area of the periodontium is often present. Fig. 2 is an almost classic example of the type of radiolucency seen. The defect can be probed (Fig. 3), and the fractures are quite evident at the time of surgery (Fig. 4). Upon

Fig. 4. Vertical root fractures of both roots are evident at the time of surgery.

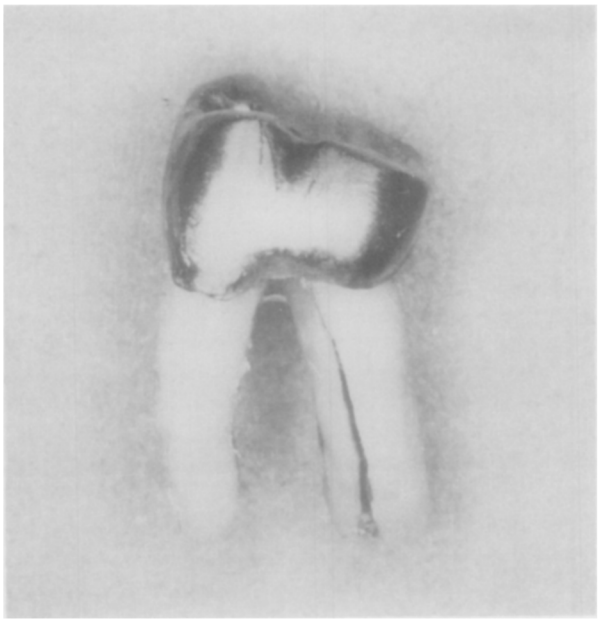

Fig. 5. After extraction of the tooth, the vertical fractures of both mesial and distal roots can easily be seen.

extraction of the tooth, vertical root fractures are seen both on the mesial and distal roots (Fig. 5). Fig. 6 shows a radiograph of a periapical radiolucency. This can be misleading, since only the periapical area seems involved. Upon probing, an osseous defect is present on the buccal aspect of the tooth (Fig. 7), which is visible at the time of surgery (Fig. 8). Since the bone loss was on the buccal aspect of the tooth, the defect was not evident on the radiograph. A somewhat similar case of a periapical radiolucency is seen in Fig. 9, where surgery also revealed bone loss on the facial

Table III. Age groups of patients

Age (years)	*No. in group*	*Percentage of total cases*
20-30	3	9.38
30-40	4	12.5
40-50	6	18.75
50-60	9	28.13
60-70	7	21.88
70-80	2	6.25
80-90	1	3.13
Total No. of patients	32	

(Fig. 10). In this case there was an additional clue that a vertical root fracture may be present because of the thickness of the gutta-percha cone seen at the apex of the root radiographically. The extracted tooth verified this (Fig. 11).

As seen in these patients, probing revealed an osseous defect in the area of the fracture. This bone loss occurs fairly rapidly after the break. In only two early cases of vertical root fractures was an osseous defect not present and, therefore, no pocket present. The probe is one of the diagnostic tools that should be utilized.

Pain was minimal or completely absent for the most part. In only two instances did the patients complain of severe pain, and in both cases a sharp crack was heard at the time of final condensation of the root canal filling. Within 24 hours pain started and became progressively worse. Both teeth were extracted 3 days after the filling. Fig. 12 is the radiograph of an endodontically treated tooth and is essentially normal. Probing revealed no osseous defect. When a full-thickness flap was retracted, no bone loss was evident (Fig. 13). Evidence of a vertical fracture was seen in that portion of

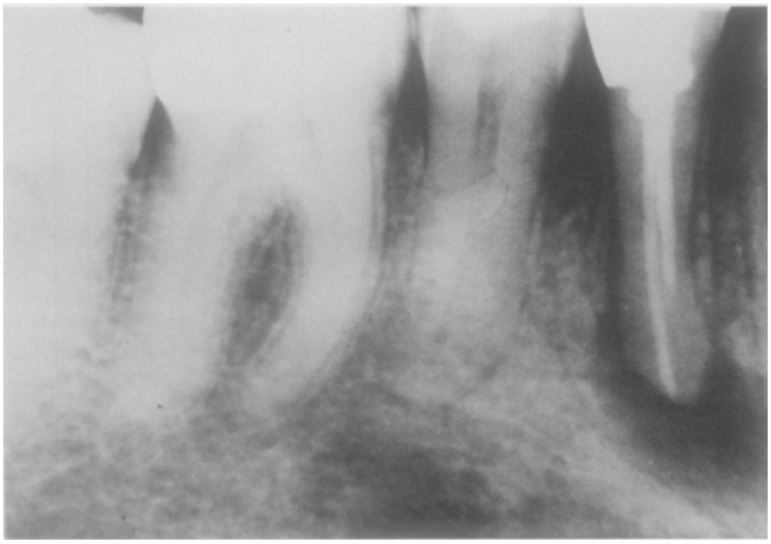

Fig. 6. A periapical radiolucency is present on this case of a vertical root fracture.

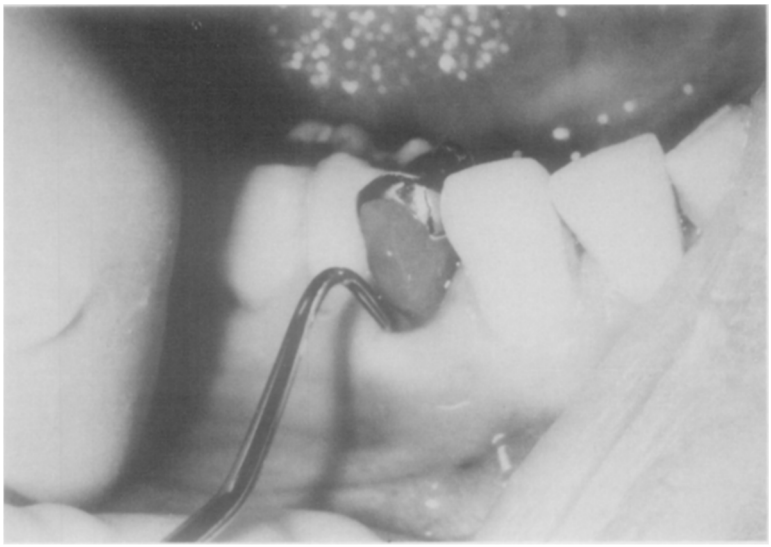

Fig. 7. An osseous defect is probable on the buccal aspect of the tooth which extends to the apex.

the root visible, and upon extraction (Fig. 14) the fracture line was revealed extending the length of the root.

An additional clinical sign of a vertical root fracture may be the presence of a periodontal abscess (Fig. 15). The abscess may come and go, as happened with the tooth seen in Fig. 16. This case was especially interesting, since the canal was obturated 7 years previously. At the time of the first yearly recall (Fig. 17) a slight thickening of the periodontal ligament is noted at the apex of the mesial root, but the distal root was observed to be essentially normal. The tooth was asymptomatic for 6 years until a periodontal abscess developed near the distal root. A radiograph at this time (Fig. 18) revealed a radiolucency around the apex of the distal root extending into the furcation area. Radiographically, the mesial root area was relatively unchanged during the 6-year period. A vertical fracture of the distal root was found at the time of surgery, and the root was amputated. Fig. 19 shows the presence of a fistulous tract. The radiograph presents the typical appearance seen in vertical root fractures (Fig. 20). After surgery and extraction of the tooth, a cross section of the root was photographed (Fig. 21). The fracture line extends from the root canal to the mesial aspect of the root. It extended the length of the root.

As seen in Table II and mentioned in the findings, the majority of fractures (84.38 percent) could be attributed to excessive force when vertically or laterally condensing the gutta-percha. In 1931, Arnold[13] commented after an article on an endodontic filling mate-

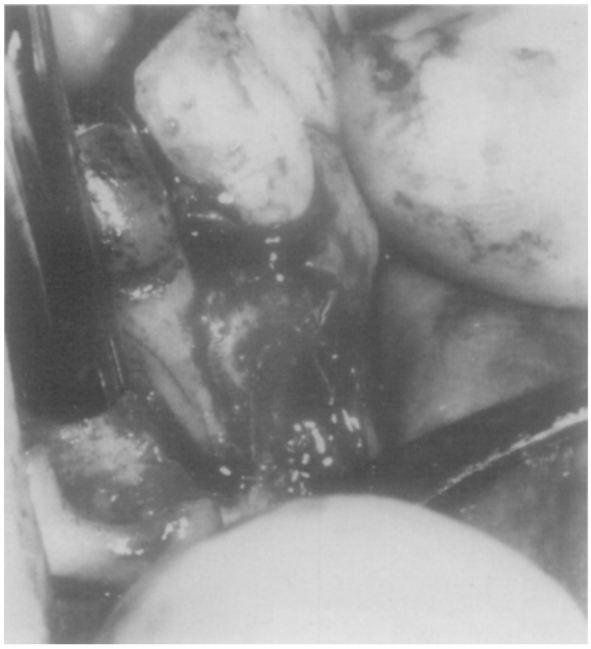

Fig. 8. The vertical root fracture and bone loss are seen at the time of surgery.

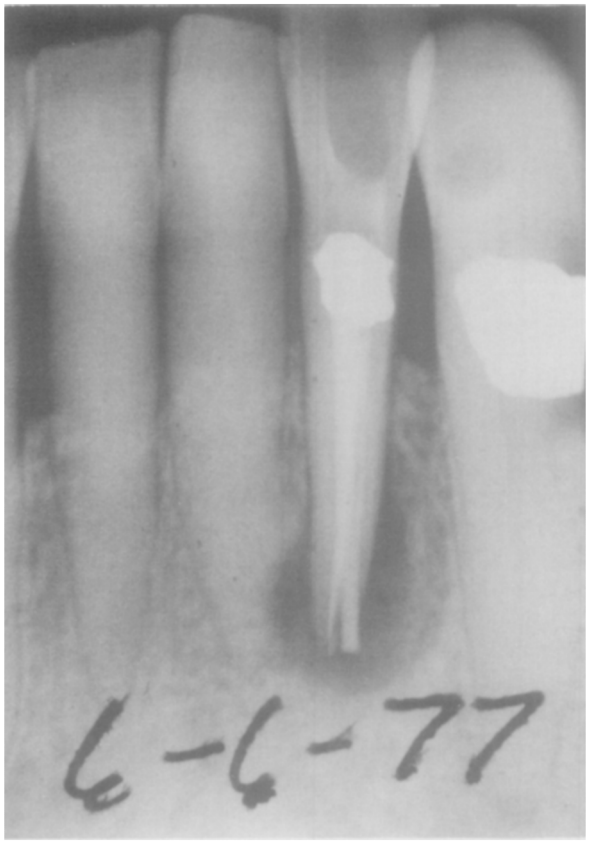

Fig. 9. A radiograph of another vertical fracture. This case had a periapical radiolucency. The gutta-percha cone is very thick at the apex and gives a clue as to the cause of this lesion.

Fig. 10. The vertical root fracture and bone loss associated with it are visualized during surgery.

Fig. 11. The extracted tooth with the large gutta-percha cone is seen.

rial, "It is the packing with solids in canal work that takes time, costs money and also *splits* roots." Much has been written concerning the possibility of root fractures being caused by corrosion of root canal pins and/or posts; but in one article it was also surmised that trauma might be the cause of the fractures.[14] A case which illustrates vertical fractures caused by excessive

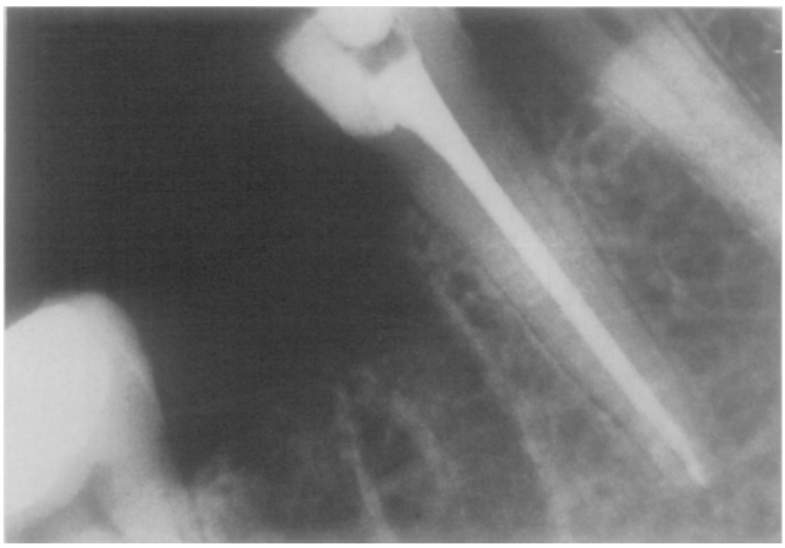

Fig. 12. A case of a vertical fracture with no radiographic signs. The root canal filling has been completed 3 days previously, and the patient had severe pain.

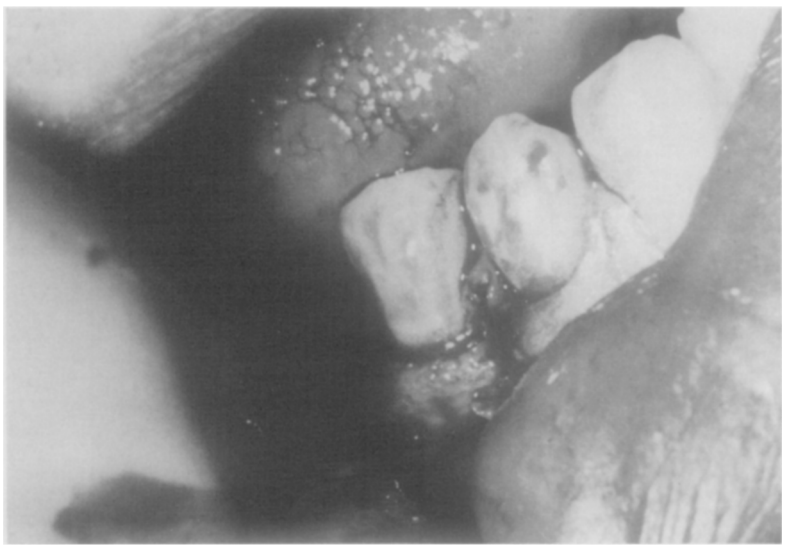

Fig. 13. Bone loss had not occurred as yet at the site of the vertical fracture.

force rather than by corrosion is seen in Fig. 22. This is a cross-section of a two-rooted molar. The distal, larger root, filled with *gutta-percha,* had a fracture extending from buccal to lingual. The mesial root, having two silver cones, presented no fracture line extending to the outer surface, and no corrosive products were visible. Four root fractures in this study could be attributed to seating and cementing of inlays or posts. All were gold, which does not corrode. The last case of a small vertical fracture caused by a steel pin was not extracted nor studied for possible corrosive products. Theoretically it is doubtful that corrosive forces can cause the splitting of roots. It is our conclusion that any corrosion that is seen is due to the fact that the fracture occurred first, allowing the fluids of the mouth access to the metal. Once the fracture has occurred, it becomes a source of chronic inflammation and leads to periodontal breakdown,[15] loss of alveolar bone, and a periodontal defect opening into the oral cavity.

A fracture that occurred while "tapping" an inlay into position is seen in Fig. 23. The fracture line starts at the corner of the inlay at the mesial gingival line angle. After the inlay was "tapped" into place and cemented, the tooth became sore and was treated endodontically. Tight-fitting posts have been known to result in vertical fractures.[8] The use of burs to obtain post room in canals can weaken roots, making them more susceptible to vertical fractures, and may even result in

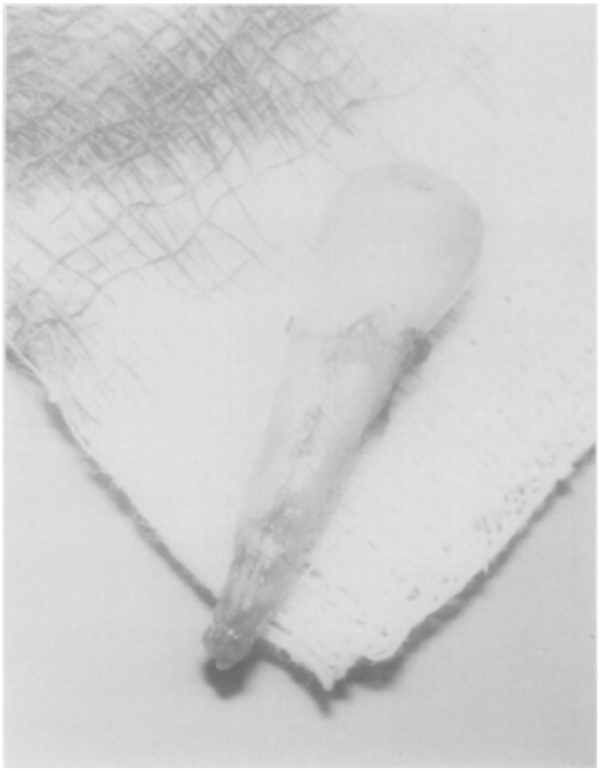

Fig. 14. After extraction, the vertical root fracture is seen extending the length of the root.

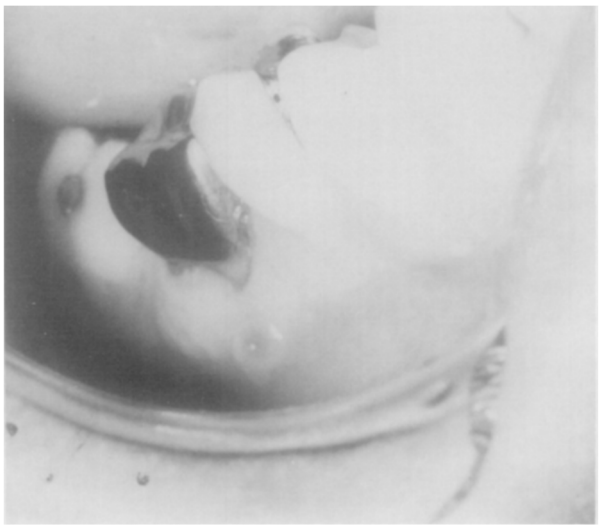

Fig. 15. A periodontal abscess is present by a tooth with a vertical root fracture.

perforations through the side of the root. Gerstein and Burnell[16] presented a technique using prefabricated precision dowels that reduces the possibility of fractures or perforations. Another case of a tooth that had a vertical root fracture due to excessive pressure of condensation and then was further damaged at the time when the post was seated follows. Fig. 24 is the radio-

Fig. 16. A fistulous tract in the area of a vertical root fracture. This patient told a history of a periodontal abscess that would "come and go."

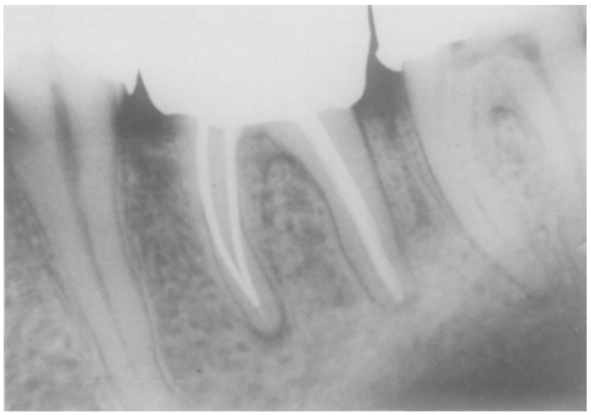

Fig. 17. A radiograph of a case of vertical root fracture at the first yearly recall after endodontic therapy had been completed. The tooth was asymptomatic.

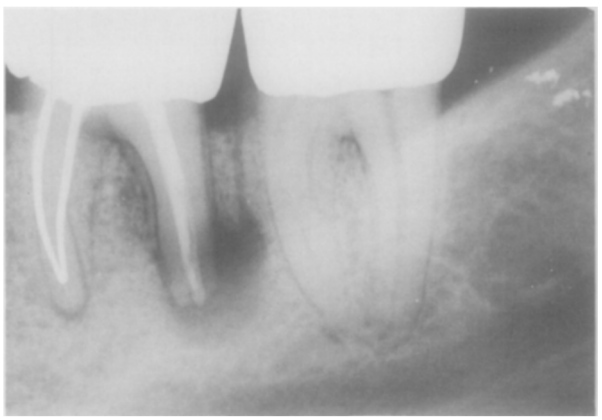

Fig. 18. Six years after completion of endodontics, the patient now was having periodontal abscesses. The radiograph shows a radiolucency at the apex of the distal root and evidence of pathosis extending into the furcation area.

Fig. 19. A case of a vertical fracture that has a fistulous tract and a probable defect present.

Fig. 20. Radiograph showing the typical findings of vertical root fractures.

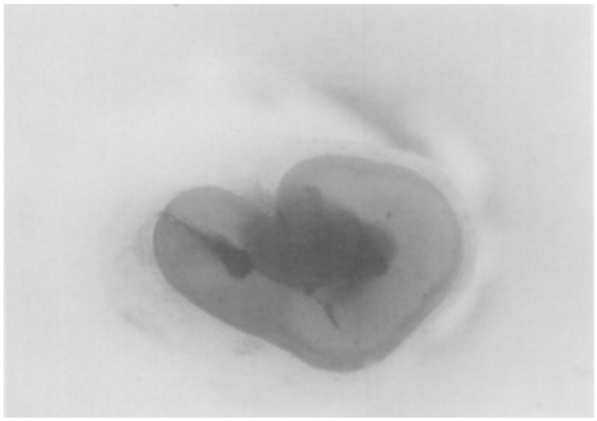

Fig. 21 A cross section of the root. The fracture line extends from the canal to the mesial facial aspect of the root.

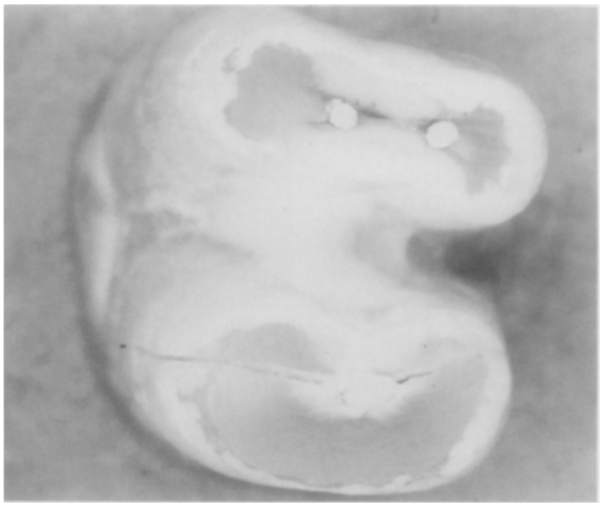

Fig. 22. The mesial canals were filled with silver cones and no fracture lines are evident. The distal root which is thicker has a fracture line from the canal to the outer aspects on both the buccal and lingual. This canal had been obturated with gutta-percha.

graph taken at the first yearly recall, and a periapical radiolucency is present. The patient complained that the tooth was sore from the time the root canal filling was first completed. Fig. 25 is the radiograph taken 3 years after cementation of the post and crown. An enlargement of the radiolucent area at the apex has occurred during the 3-year interval. At the time of surgery (Fig. 26), vertical and horizontal fractures are evident which can be attributed to both the endodontic treatment and cementation of the gold post. It is conceivable that even a pin can result in a small fracture if the hole prepared for it is too small, or if too much force is used

Fig. 23. A vertical fracture is seen extending in an apical direction from the mesial gingival line angle of the inlay. The gutta-percha filling is seen through this fracture.

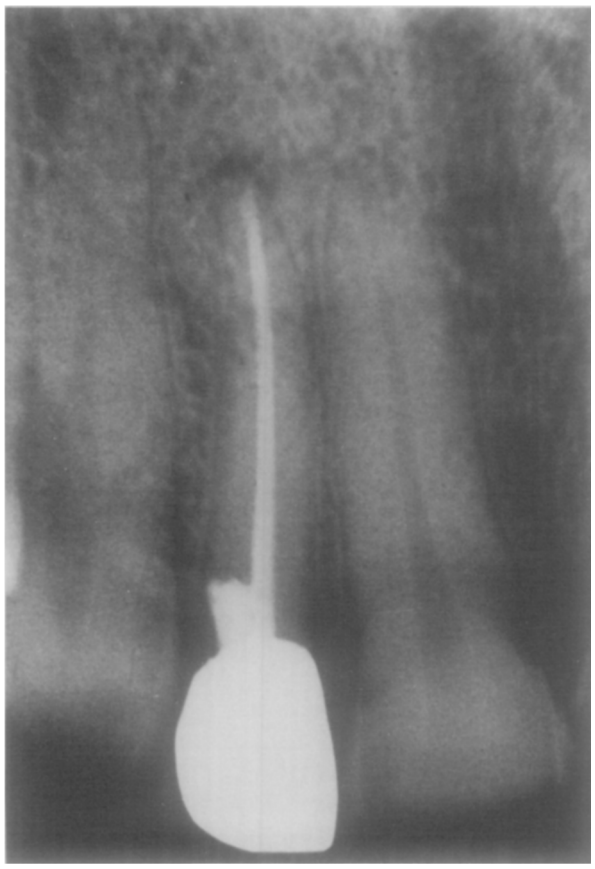

Fig. 24. Radiograph of a vertical root fracture seen at the first yearly recall. A radiolucency is seen at the apex of the tooth.

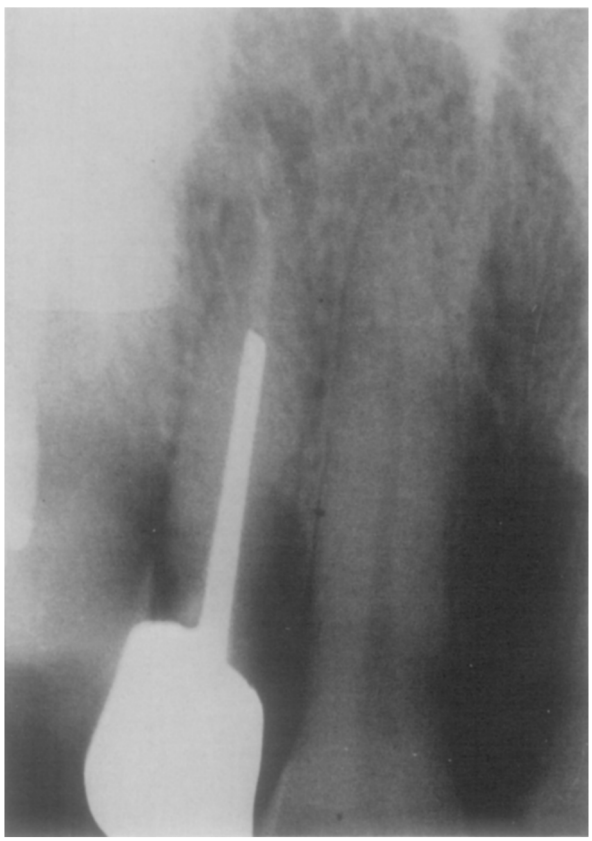

Fig. 25. Radiograph taken 3 years after cementation of the post and crown. The periapical radiolucency seen in Fig. 24 has enlarged.

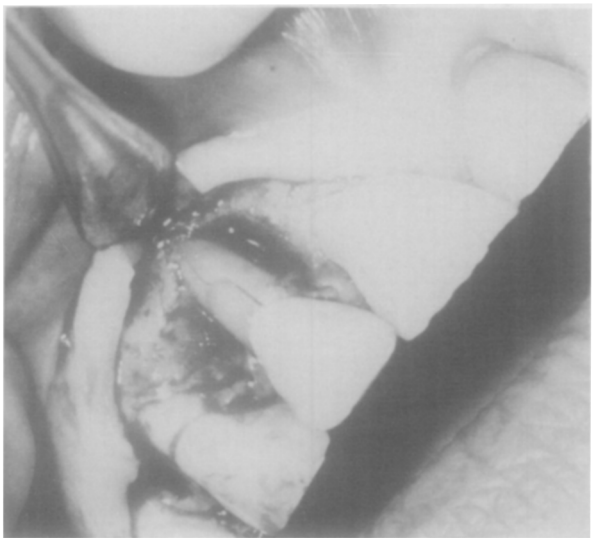

Fig. 26. At the time of surgery both vertical and horizontal root fractures are visible, which can be attributed to both the endodontic treatment and the cementation of the gold post.

to seat it. It is well known that friction grip of self-threading pins can cause crazing and stress cracks in dentin.[17]

To avoid vertical root fractures, the practitioner should avoid the use of excessive force with possible torque during lateral or vertical condensation of gutta-percha. All intracoronal compound case restorations, amalgams, and even pins can increase the possibility of fracture. All dowels should show a passive fit and not be "tapped" into position. In older patients it is reasonable to assume that teeth may have become more brittle with age. Also, after root canal treatment the teeth become more brittle[18] and therefore are more likely to fracture from a given amount of force.

SUMMARY AND CONCLUSIONS

Thirty-two cases of vertical root fractures were studied as to possible causes and for distinctive diagnostic features. Reasons for the fractures occurring were presented. Radiographic and clinical signs, which include routine probing, were presented to help facilitate the diagnosis of vertical fractures.

This study suggests that excessive force during lateral condensation of the gutta-percha and excessive force in seating Silver cones are the major causes of vertical root fractures. Forcing or tapping inlays or dowels into place and overpreparation of dowel space are suggested as secondary causes.

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REFERENCES

1. Sibley, L. C.: Management of Root Fracture, ORAL SURG. **13:** 1475-1484, 1960.
2. Epstein, L. I.: Traumatic Injuries to Anterior Teeth in Children, ORAL SURG. **15:** 334-344, 1962.
3. Meister, F., Jr., Lommel, T. J., and Davies, E. E.: A Periodontal Abscess Associated with Vertical Root Fractures—Case Report, J. Wis. State Dent. Soc. **52:** 562-563, 1976.
4. Polson, A. M.: Periodontal Destruction Associated with Vertical Root Fracture—Report of Four Cases, J. Periodontol. **48:** 27-32, 1977.
5. Peterson, K. B.: Longitudinal Root Fracture Due to Corrosion of an Endodontic Post, J. Can. Dent. Assoc. **37:** 66-68, 1971.
6. Angmar-Mansson, B., Omnell, K., and Rud, J.: Root Fractures Due to Corrosion 1. Metallurgical Aspects, Odontol. Revy. **20:** 245-265, 1969.
7. Rud, J., and Andreasen, J. O.: A Study of Failures after Endodontic Surgery by Radiographic, Histologic and Stereomicroscopic Methods, Int. J. Oral Surg. **1:** 311-328, 1972.
8. Davies, E. E., Meister, F., Jr., and Lommel, T. J.: Panoramic Versus Periapical Surveys: A Comparison of Findings on Freshman Dental Students, Dent. Radiogr. Photogr. **50:** 41-47, 1977.
9. Wechsler, S. M., Vogel, R. I., Fishelberg, G., and Shovlin, F. E.: Iatrogenic Root Fractures: A Case Report, J. Endodon. **4:** 251-253, 1978.
10. Lommel, T. J., Meister, F. Jr., Gerstein, H., Davies, E. E., and Tilk, M. A.: Alveolar Bone Loss Associated With Vertical Root Fractures, ORAL SURG. **45:** 909-919, 1978.
11. Weine, F. S.: Endodontic Therapy, ed. 2, St. Louis, 1976, The C. V. Mosby Co., p. 300.
12. Michanowicz, A. E., Michanowicz, J. P., and Abou-Rass, M.: Cementogenic Repair of Root Fractures, J. Am. Dent. Assoc. **82:** 569-579, 1971.
13. Arnold, L. H.: Discussion, J. Am. Dent. Assoc. **18:** 483, 1931.
14. Rud, J., and Omnell, K.: Root Fractures Due to Corrosion. Diagnostic Aspects, Scand. J. Dent. Res. **78:** 397-403, 1970.
15. Linaburg, R. G., and Marshall, F. J.: The Diagnosis and Treatment of Vertical Root Fractures, J. Am. Dent. Assoc. **86:** 679-683, 1973.
16. Gerstein, H., and Burnell, S. C.: Prefabricated Precision Dowels, J. Am. Dent. Assoc. **68:** 787-791, 1964.
17. Dilts, W. E., Welk, D. A., Laswell, H. R., and George, L.: Crazing of Tooth Structure Associated with Placement of Pins for Amalgam Restorations, J. Am. Dent. Assoc. **81:** 387-391, 1970.
18. Helfer, A. R., and Schilder, H.: Determination of the Moisture Content of Vital and Pulpless Teeth, ORAL SURG. **34:** 661-670, 1972.

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