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A retrospective study on the prognosis of teeth with root fracture in patients during the maintenance phase of periodontal therapy

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Abstract – Teeth with root fracture generally have a poor prognosis requiring extraction; however, some patients do not wish to have these teeth extracted. Dentists do not have enough information regarding the prognosis of teeth with root fracture. This study retrospectively examined the prognosis of teeth with root fracture in the maintenance phase of periodontal treatment and assessed the factors influencing the prognosis of teeth with root fracture. The clinical records of 100 patients, who had entered the maintenance phase of periodontal therapy in a university hospital and had experienced fracture of tooth root, were analyzed. The following parameters were included in the evaluation: age and gender of the subjects, tooth type, restoration and root-filling of the teeth with root fracture, and number of teeth present. Survival probability was assessed using Kaplan–Meier analysis. The median survival time (95% confidence interval) was 42 months (22–62 months). Teeth with horizontal fracture had a significantly higher survival probability compared with teeth with vertical fracture. No significant differences were found in the survival probability with regard to gender and tooth type. In conclusion, teeth with horizontal root fracture have a better prognosis compared with teeth with vertical root fracture in patients undergoing periodontal maintenance.

Root fracture is one of the major problems that occurs during the maintenance phase of periodontal treatment. Root fracture in endodontically treated teeth fitted with cast posts or screw posts was the main reason for tooth loss during a 30-year plaque control program to prevent dental caries and periodontal disease (1). During a maintenance program of 3–17 years, clinical problems were primarily related to the incidence of root fracture and 48% of teeth extracted were ascribed to root fracture (2). A retrospective study, which examined 120 patients maintained for 10 years or longer, reported that root fracture was the second major reason for tooth extraction (3).

Teeth with root fracture generally have a poor prognosis requiring extraction. Several approaches have been attempted to treat the tooth with root fracture; however, the results were mostly disappointing. A technique which involved extraction of the vertically fractured segments, extra-oral endodontic treatment, recementation of segments, banding and replantation was attempted, but the long-term prognosis remained poor (4). A similar technique was applied to a vertically fractured molar in conjunction with an expanded polytetrafluoroethylene membrane and the tooth remained functional for 1 year (5). Eleven vertically fractured roots were bonded through the root canal and 12 vertically fractured roots were bonded extra-orally and replanted (6). Two roots of the former group and three roots of the latter group were extracted but the remaining roots were retained over a mean period of 33 and 22 months, respectively. A two-stage surgical procedure including ultrasonic cleaning of the fracture, bonding of the fracture with cement, placement of a bone graft material, and application of guided tissue regeneration was performed in six roots with vertical fracture; however, success of the treatment lasted only 1 year (7).

Some patients may not wish to have the fractured tooth extracted or agree to surgical therapy. Others are anxious to know how long the fractured tooth will be kept without any problem, if left untreated. However, dentists do not have enough information regarding the prognosis of teeth with root fracture because no data have been published. In our clinic, we have tried to encourage patients to retain their teeth as long as possible even if the roots of the teeth were fractured and the patients desired to keep the teeth without any treatment. We checked the periodontium of the fractured teeth periodically and instructed patients how to clean the fractured teeth with a toothbrush or interdental brush.

In this study, the prognosis of teeth with root fracture was examined retrospectively from patient records in a university hospital. In addition, factors

influencing the prognosis of teeth with root fracture were also assessed.

Material and methods

Patient population

The sample consisted of 100 subjects (28 males and 72 females), who attended the Department of Preventive Dentistry, Okayama University Hospital for maintenance care of periodontal disease from March 2006 to May 2006 and whose records indicated the occurrence of root fracture of a permanent tooth. Age and gender distribution of the subjects are shown in Table 1.

Data acquisition

One examiner surveyed the location (upper, lower jaw), tooth type, restoration, function (single crown or abutment tooth) and presence or absence of root-filling of the teeth with root fracture, number of teeth present in the patients, and the dates of description of root fracture and extraction from the records. In addition, periodontal parameters of each fractured tooth, including deepest probing pocket depth, clinical attachment level, and presence of bleeding on probing, were also recorded during the visit when root fracture was detected. The dentists who treated the study subjects were interviewed, and radiographic examinations were also conducted.

Depending on the type of fracture, the teeth were divided into two groups: vertical fracture and horizontal fracture. Vertical fracture was defined as when the degree between fracture line and long axis of the root was less than 45. Horizontal fracture was defined as when the degree was equal to or more than 45.

Table 1. Age and gender distribution of the subjects

Age group (years)	Male	Female	Total
40–49	3	4	7
50–59	6	12	18
60–69	8	24	32
70–79	10	26	36
80–89	1	6	7
Total	28	72	100

Teeth were categorized as root-filled if they had been filled with a radiopaque material in the pulp chamber and/or in one or more root canals (8).

Treatment of the teeth with root fracture

The patients with fractured teeth were asked to visit the hospital at least once every 3 months for follow-up examination. At each appointment, inflammation of periodontal tissues including redness and swelling of gingiva and suppuration, pain on chewing, and oral hygiene status were assessed. Radiographic examination was performed, when necessary. Oral hygiene instructions were given when plaque was visible around the tooth with root fracture. When a tooth had acute inflammation or pain and the patient agreed to the treatment plan, the tooth was extracted.

Statistical analysis

Survival probability was assessed using Kaplan–Meier analysis. The log rank test ($P = 0.05$) was used to estimate statistically significant differences between two or more survival curves of individual subgroups (e.g., gender, jaw, type of tooth, type of fracture, number of teeth present). Data were analyzed using a statistical package (SPSS 15.0 J for Windows; SPSS Japan, Tokyo, Japan).

Results

A total of 131 teeth were included in this study, of which 105 had records of periodontal examination. Of these 105 teeth, the numbers (%) of teeth with deepest probing pocket depth of ≤3, 4–6, and ≥7 mm were 36 (34%), 49 (47%), and 20 (19%), respectively. The numbers (%) of teeth with clinical attachment level of ≤3, 4–6, and ≥7 mm were 33 (31%), 48 (46%), and 24 (23%), respectively. Thirty-eight (29%) out of 105 teeth had bleeding on probing.

Typical vertical and horizontal root fractures encountered in the present study are shown in Fig. 1. About 20% of the subjects experienced more than one root fracture (Table 2). The number of vertical fractures was relatively greater than that of horizontal fractures (Table 3); however, there was no statistically significant

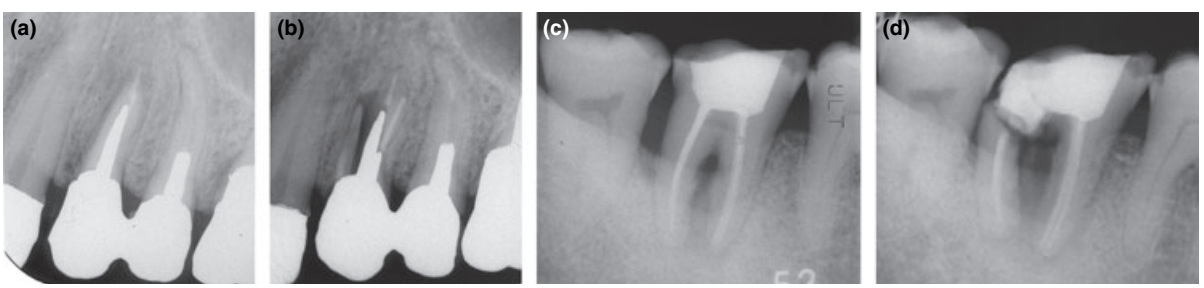

Fig. 1. Radiographs showing typical vertical (a, b) and horizontal root fractures (c, d). the left maxillary first premolar connected with the second premolar showed suspicious vertical fracture (a), was confirmed by open flap as incomplete vertical fracture, and became complete fracture after 1 year of maintenance (b). Incomplete horizontal fracture of distal root of the right mandibular second molar (c) resulted in complete fracture after 3.5 years of maintenance.

Table 2. Distribution of subjects based on number of teeth with root fracture

Number of teeth with root fracture	Number of subjects
1	78
2	16
3	4
4	1
5	1

Table 3. Distribution of fractures based on types of teeth

	Type of fracture		
Tooth type	Vertical	Horizontal	Total
Maxilla			
Central incisor	3	1	4
Lateral incisor	9	6	15
Canine	8	6	14
First premolar	5	4	9
Second premolar	7	0	7
First molar	5	9	14
Second molar	8	3	11
Mandible			
Central incisor	0	0	0
Lateral incisor	0	0	0
Canine	1	2	3
First premolar	7	0	7
Second premolar	7	6	13
First molar	9	13	22
Second molar	6	6	12
Total	75	56	131

difference in the frequency of the type of fracture (chi-squared test, $P = 0.27$). Root fracture was most frequent in mandibular first molars and less common in mandibular incisors. About 61% of teeth with root fracture were restored with full-cast crown (Table 4). Only 6% of teeth with root fracture were without root-filling.

Of the teeth extracted, about half of the teeth were extracted within 10 months (Table 5). The reasons for extraction were spontaneous and/or occlusal pain (38 extractions – 57% of extracted teeth), mobility due to severe periodontitis (11 extractions – 16% of extracted teeth), and others (18 extractions – 27% of extracted teeth). The median survival time (95% confidence interval) was 42.0 months (21.7–62.3 months) (Table 6 and Fig. 1). Comparing the type of fracture, the

Table 4. Distribution of root fractures based on function of treated teeth

	Type of fracture		
Type of function of the tooth/root filling	Vertical	Horizontal	Total
Type of function of the tooth			
Full-cast crown	47	33	80
Abutment tooth of fixed bridge	18	17	35
Abutment tooth of removable partial denture	10	6	16
Root filling			
Root-filled	71	52	123
Non-root-filled	4	4	8

Table 5. Distribution of subjects based on duration of maintenance period

Maintenance period (months)	Extracted	Censored	Total
0–10	32	10	42
11–20	13	10	23
21–30	8	11	19
31–40	3	13	16
41–50	3	5	8
51–60	1	4	5
61–70	3	5	8
71–80	0	0	0
81–90	0	2	2
91–100	1	2	3
101–110	0	1	1
111–120	2	1	3
121–130	1	0	1
Total	67	64	131

estimated survival functions revealed statistically significant differences ($P = 0.024$) (Table 6 and Fig. 2). Teeth with horizontal fracture had a higher survival probability compared with teeth with vertical fracture (Fig. 3). The median time period of survival (SD) of horizontal fractured teeth was 117.0 (39.0) months and that of vertical was 27.0 (7.7) months. No significant differences in the survival probability were found with regard to gender, location (upper, lower jaw), tooth type (incisors, premolars, or molars), and the type of tooth function (single crown or abutment tooth) (Table 6).

Discussion

The results of the present study showed that the median survival time of teeth with root fracture was 3.5 years. In addition, the survival time of teeth with root fracture depended on the type of fracture but not on gender, jaw (maxilla or mandible), or tooth type (incisors, premolars, or molars). Teeth with vertical fracture had a higher risk of extraction compared with teeth with horizontal fracture. This information would be useful for dentists not only to explain the prognosis of teeth with root fracture to their patients but also to formulate a treatment plan for the teeth with root fracture.

The median survival time of teeth with vertical root fracture was 27 months, which is within the range of previously reported cases. A study evaluating the method in which teeth with vertical fracture were sealed intra- and extra-orally with a bonding system using a resin showed that 9 of 11 and 9 of 12 teeth were retained over a mean period of 33 and 22 months, respectively (6). A surgical procedure including ultrasonic cleaning of the fracture, bonding of the fracture repair with cement, placement of a bone graft material, and application of guided tissue regeneration was performed on six roots with vertical fracture; however, the treatment was successful for only 1 year (7). These results suggest that periodical examination and oral hygiene instructions might be a treatment option for teeth with root fracture.

We have tried to encourage patients to retain their teeth as long as possible even if the roots of the teeth were fractured and the patients desired to keep the teeth

Table 6. Survival estimates according to Kaplan–Meier analysis

	Number of teeth	Number of teeth lost	Survival median (months)	Standard error (months)	95% confidence interval (months)	*P*-value	
Total data	131	68	42.0	10.4	21.7–62.3	–	
Gender							
Male	39	18	46.0	18.7	9.3–82.7	0.232	
Female	92	50	32.0	10.7	11.1–52.9		
Jaw							
Maxilla	74	39	49.0	16.0	17.6–80.4	0.963	
Mandible	57	29	37.0	9.5	18.3–55.7		
Tooth type							
Incisor and canine	35	20	19.0	22.9	0–63.9	–	
Premolar	35	20	25.0	8.8	27.8–42.2	0.867*	
Molar	61	28	55.5	7.5	40.7–70.3	0.402*	0.169†
Type of fracture							
Vertical	75	44	27.0	7.7	11.9–42.1	0.024	
Horizontal	56	24	117.0	39.0	40.5–193.5		
Type of function of the tooth							
Single crown	88	49	37.0	10.1	17.3–56.7	0.313	
Abutment tooth	43	19	68.0	30.9	7.4–128.6		

*Compared to incisor and canine.
†Compared to premolar.

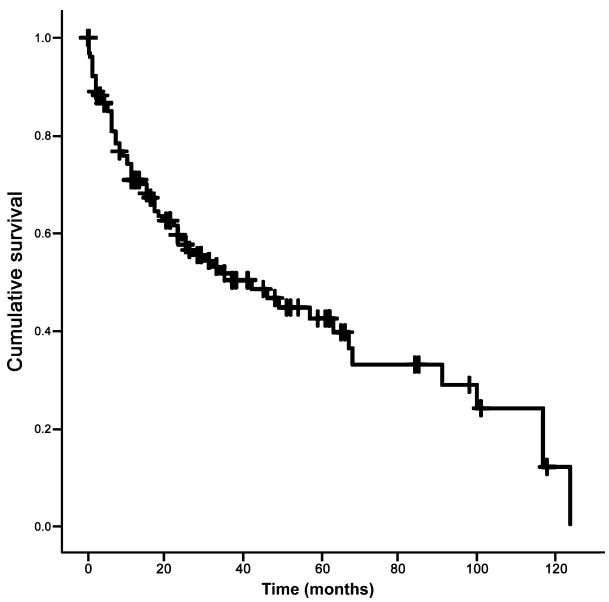

Fig. 2. Kaplan–Meier survival curve for all teeth with root fracture (n = 131). +, censored.

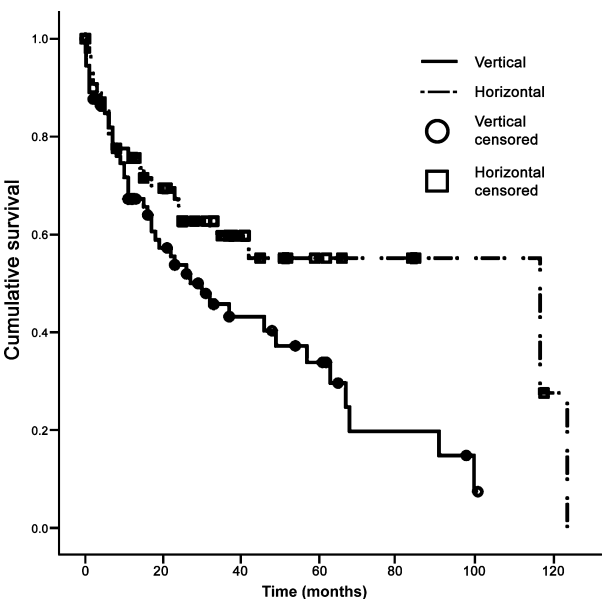

Fig. 3. Kaplan–Meier survival curves for teeth with horizontal root fracture and with vertical root fracture.

without any treatment. However, this approach lacks any scientific basis. Furthermore, there are certain serious concerns in retaining teeth with root fracture. A heavily colonized root surface might lead to microbial translocation within the oral cavity, thus affecting the remaining dentition (9). Furthermore, tolerating large areas of heavily inflamed tissues might affect systemic conditions (10), as increasing evidence points to the transfer of intra-oral pathogens to vital organs via the bloodstream (11). In fact, 57% of the extracted teeth showed spontaneous and/or occlusal pain, indicating the presence of inflammation around the teeth with root fracture.

In this study, 20% of subjects had two or three fractured teeth, and 2% of subjects had four or five fractured teeth. The percentage of patients who had root fracture in multiple teeth in the present study was higher than those in other studies. A study which examined 46 Chinese patients with root fracture occurring in 51 non-endodontically treated teeth reported that 11% of patients had two fractured teeth (12). Another study reviewing a total of 315 cases of vertical root fractures in 274 Chinese patients during a 13-year period reported that 13% of patients had two or three fractured teeth (13). The survey method may explain the difference in percentage of patients who had root fracture in multiple

teeth among the studies. The present study examined not only vertical fractures but also horizontal fractures; however, the previous studies examined only vertical fractures. Another reason for the disparity in results of these studies may be the difference between Japanese and Chinese subjects. Prevalence of root-filled teeth, which have a higher risk of root fracture (14), is higher in Japan than in other countries, including China (8, 15).

Our study demonstrated that the majority (94%) of teeth with root fracture had been endodontically treated. This result is in agreement with other studies. A study examining 36 patients who had vertical root fracture, revealed that 2 out of 36 fractured teeth were vital and 34 were non-vital (that is, endodontically treated) (13). Another study using human extracted teeth found that the force required to fracture the instrumented mandibular premolars was 30% lower than that required to fracture their uninstrumented counterparts, suggesting that instrumented mandibular premolars had a higher risk of fracture than the uninstrumented mandibular premolars (16). It is generally accepted that the amount of dentin remaining is directly related to the strength of the root (17). Loss of coronal tooth structure by endodontic treatment might decrease fracture resistance of endodontically treated teeth (18).

Posterior teeth seem to be more susceptible to vertical and horizontal root fracture and the findings in patients undergoing periodontal maintenance agreed with the results of studies using general dental patients. A 2-year retrospective study using 100 fractured teeth in 98 patients showed that 67% were molars (19). A study in 135 Chinese patients reported that the incidence of vertical fracture in molars was 84% in non-endodontically treated teeth and 53% in endodontically treated teeth (13). Another 2-year retrospective study found that molars were most often affected by vertical root fracture (20). This may be related to the heavier masticatory force associated with molars (21).

All the fractured teeth in the present study had full-cast crowns or were abutment teeth of fixed bridges or removable partial dentures, and about 60% had full-cast crowns. A retrospective study of vertical root fracture found that 91% of the teeth with fractures were crowned or fixed-bridge abutments (22). No correlation was found between root fracture and the function of the tooth (single unit or abutment) in a study using 303 patients with 460 endodontically treated teeth (23). The findings of the present study agreed with the abovementioned studies.

The results of this retrospective study suggest that survival probability of teeth with root fracture depends on the type of fracture (horizontal or vertical) but not on jaw (maxilla or mandible), tooth type (incisors, premolars or molars), or the type of function of the teeth (single crown or abutment tooth). However, the following limitations must be considered. Presence or absence of post, and kinds and length of post, which are considered to affect the risk of root fracture (20, 23), were not examined in the present study. Root fracture is diagnosed with various tests, such as interview, percussion test, microscopy, probing, X-ray and flap operation; however, we did not investigate how the root fractures were definitively diagnosed in this study.

In conclusion, 131 teeth with root fracture in 100 patients in the maintenance phase of periodontal treatment were retrospectively examined from patient records, and it was found that the survival probability of teeth with horizontal root fracture was higher than that of teeth with vertical root fracture. The jaw (maxilla or mandible), tooth type (incisors, premolars or molars), and the type of function of the teeth (single crown or abutment tooth) did not affect the prognosis of teeth with root fracture.

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