Cracked Teeth: Distribution, Characteristics, and Survival after Root Canal Treatment

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Abstract

Introduction: The aims of this study were to analyze the distribution and characteristic features of cracked teeth and to evaluate the outcome of root canal treatments (RCTs) for cracked teeth. The prognostic factors for tooth survival were investigated. **Methods:** Over the 5-year study period, 175 teeth were identified as having cracks. Data were collected regarding the patients' age, sex, tooth type, location and direction of cracks, probing depth, pulp vitality, type of restoration, cavity classification, opposing teeth, and previous endodontic treatment history. Cracked teeth were managed via various treatment methods, and the 2-year survival rate after RCT was analyzed using the Kaplan-Meier method in which significance was identified using the log-rank test. Possible prognostic factors were investigated using Cox multivariate proportional hazards modeling. **Results:** One hundred seventy-five teeth were diagnosed with cracks. Most of the patients were aged 50–60 years (32.0%) or over 60 (32.6%). The lower second molar was the most frequently (25.1%) affected tooth. Intact teeth (34.3%) or teeth with class I cavity restorations (32.0%) exhibited a higher incidence of cracks. The 2-year survival rate of 88 cracked teeth after RCT was 90.0%. A probing depth of more than 6 mm was a significant prognostic factor for the survival of cracked teeth restored via RCT. The survival rate of root-filled cracked teeth with a probing depth of more than 6 mm was 74.1%, which is significantly lower than that of teeth with probing depths of less than 6 mm (96.8%) (P = .003). **Conclusions:** Cracks were commonly found in lower second molars and intact teeth. RCT was a reliable treatment for cracked teeth with a 2-year survival rate of 90.0%. Deep probing depths were found to be a significant clinical factor for the survival of cracked teeth treated with RCT. *(J Endod 2016;42:557–562)*

Key Words

Cracked teeth, Korean population, probing depth, root canal treatment, tooth survival

Cracked teeth may be described as teeth with crack lines present in the vertical plane (1, 2). Many terminologies and classifications have been proposed to describe the characteristics and conditions of cracked teeth (3–5). The American Association of Endodontists (AAE) categorizes cracks into 5 types: craze lines, fractured cusp, cracked tooth, split tooth, and vertical root fracture (VRF) (6). Cracked teeth may result in sharp pain upon biting, unexplained cold sensitivity, pain on release of pressure, or deep probing depths associated with the crack (7–9). The diagnosis of cracked teeth is not straightforward because the symptoms are diverse, and crack lines may be difficult to locate; dye staining, transillumination, or microscopy may be necessary to identify cracks (2, 10). The determination of the severity of a crack is often a prediction rather than an accurate diagnosis, and there are no accurate methods to predict the prognosis of a cracked tooth based on clinical examinations (11).

Cracked teeth represent a restorative dilemma and a source of frustration for both clinicians and patients because of their complicated and vague symptoms and unpredictable prognosis. Treatment plans for cracked teeth depend on the extent and location of the cracks and the severity of the symptoms (12). If the size of the involved portion of the tooth is relatively small and the crack avoids the pulp, the tooth could be restored conventionally using resins, inlays, or crowns (13). If the crack is extensive with prolonged symptoms, thermal hypersensitivity, and pulpal and periapical pathology, root canal treatment (RCT) is required before crown placement. There are some cases in which the crack extends into the pulpal floor, deep down to the bone, or symptoms persist even after RCT; in such situations, extraction is usually the only viable option (13, 14). RCT is among the most important treatment options to salvage symptomatic cracked teeth diagnosed with irreversible pulpitis or pulp necrosis. However, there is a lack of information regarding the endodontic prognosis of cracked teeth; only in 1 study did the authors apply survival analysis to evaluate the outcome of RCT in cracked teeth at a tertiary institute, and the sample size was small (15). The aims of this study were to analyze the distribution and characteristic features of cracked teeth, to evaluate the survival rate of cracked teeth after RCT, and to investigate prognostic factors for tooth survival.

Materials and Methods

This study was approved by the ethics committee of the Ewha Womans University Hospital, Seoul, Korea. Patients who visited the Department of Conservative Dentistry at Ewha Womans University Dental Hospital between 2009 and 2014 and were suspected of having cracked teeth were examined thoroughly by 2 examiners. Examinations by the naked eye, with staining using methylene blue dye, and through the use of microscopy were performed to detect cracks. There were 1977 teeth examined during a 5-year period. Cracks were observed in 175 teeth, and the patients' age, sex, tooth number, location and direction of cracks, crack type, probing depth, pulp vitality, results of

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bite test and percussion test, presence of restoration, type of restoration, cavity classification, opposing teeth, and previous endodontic treatment history were recorded. Four types of cracks described by the AAE were used for classification. Craze lines can easily be mistaken for cracks; however, if a tooth has a craze line, the entire tooth will appear bright under transillumination, whereas only a segment of the tooth will do so when cracks are present. Teeth with craze lines were not included in this study.

The following clinical signs and symptoms of cracked teeth were recorded: probing depths, bite pain, bite tests, percussion tests, and pulp vitality tests. Probing depths were classified along 3-mm intervals (ie, <3 mm, 3–6 mm, 6–9 mm, and >9 mm). Patients were asked if they experienced pain during mastication or the release of food, and the results were recorded as bite pain. The bite test was performed with cotton rolls to reproduce the bite experience. Percussion tests were conducted by tapping teeth with mirror shanks. For pulp vitality, ice sticks were used, and the results were recorded using the following 4 categories: normal pulp, mild cold sensitivity, severe cold sensitivity, and nonvital.

The cracked teeth were treated based on symptoms and pulpal and periapical diagnoses (16). For teeth diagnosed with normal pulp or reversible pulpitis (17), resin fillings or inlays were performed. Provisional crowns were placed on teeth with mild cold sensitivity or bite pain. If the symptoms resolved, permanent crowns were placed. If the symptoms did not improve after the placement of a provisional crown, RCT was performed. For cracked teeth diagnosed with irreversible pulpitis or pulp necrosis or that have been previously treated, RCT was performed. The teeth diagnosed with VRF or split teeth were extracted. Of 175 cracked teeth, 88 were treated with RCT. RCT was performed by an endodontist at the Department of Conservative Dentistry at Ewha Womans University Hospital. The teeth that underwent RCT received provisional coronal restoration such as a temporary crown or stainless steel orthodontic band.

Patients were recalled at 3, 6, and 12 months for checkups. Probing depths, bite tests, percussion tests, and periapical radiographic examination were performed in the routine examination. If the tooth was present at the time of checkup, survival was recorded (15).

Statistical Analysis

Statistical analysis was performed using the SPSS software package (SPSS statistics 21.0; SPSS, Inc, Chicago, IL). The 2-year survival rate of cracked teeth after RCT was analyzed using the Kaplan-Meier method, and significance was identified using the log-rank test. Possible prognostic factors were investigated using the Cox multivariate proportional hazards regression model. Backward selection was used to identify the most relevant prognostic factor. The prognostic power of variables was expressed by calculating hazard ratios (HRs) with 95% confidence intervals (CIs). Statistical significance was considered as $P < .05$.

Results

Distribution and Characteristics of Cracked Teeth

Of the 1977 teeth examined, 175 teeth were diagnosed as cracked teeth (8.9%). The majority of patients with cracked teeth were in the age ranges of 50–59 years (32.0%) and >60 years (32.6%) (Table 1). Cracks were more prevalent among men (61.1%) than women. The lower second molar was most frequently cracked (25.1%).

Sixty cracked teeth were intact with no restoration (Table 2). Among restored teeth, gold inlay restorations (25.1%) and class I restorations (32.0%) were common. According to the AAE crack types, of the 175 cracks, 25 were fractured cusps (14.3%), 111 were cracked teeth (63.4%), 21 were diagnosed with VRF (12.0%), and 18 were diagnosed with split tooth (10.3%). Half of the cracks were in the mesiodistal orientation (50.9%), and 150 teeth exhibited a single crack line (85.7%). Cracks frequently extended subgingivally (66.9%). The cracked teeth were mostly occluded natural teeth without restorations (50.9%) followed by teeth with gold crowns (23.4%) and teeth with inlays (18.3%). RCT had been performed previously in 34 of the cracked teeth (19.4%).

Regarding the clinical signs and symptoms of the cracked teeth, 22 had probing depths of >9 mm (12.6%) (Table 3). Most patients experienced bite pain (72.6%) and gave a positive response to the bite test (56.0%). Negative responses to the percussion test were recorded in 99 teeth (56.6%), 15 exhibited severe (8.6%) cold sensitivity, and 74 were nonvital (42.3%).

With respect to treatment for cracked teeth, 10 were managed using resins (5.7%), and another 10 were treated with inlays (5.7%) (Table 4). Of the 38 teeth in which a provisional crown was placed, 27 (71.1%) remained vital and asymptomatic and could be restored using a permanent restoration. Eleven (28.9%) required RCT after provisional crown placement. Of the 175 cracked teeth, 88 (50.3%) were treated with RCT and 40 (22.9%) were extracted. The most common reasons for extraction were VRF (21 teeth) and split tooth (18 teeth). One tooth was diagnosed with a fractured cusp; however, the coronal tooth structure was so scarce that the tooth was extracted for the prosthetic reason. When the tooth was diagnosed as hopeless with a definite split or VRF, the tooth extraction was performed. When there were multiple sinus tracts and J-shaped radiolucency, VRF was strongly

TABLE 1. The Distribution of Cracked Teeth

Location of tooth	Sex		Age (y)					Total, *n* (%)
	Male	Female	20–29	30–39	40–49	50–59	≤60	
Maxillary								
1st premolar	9	0	0	1	1	5	2	9 (5.1)
2nd premolar	17	7	0	2	4	10	8	24 (13.7)
1st molar	19	15	2	6	4	10	12	34 (19.4)
2nd molar	6	19	0	1	10	2	12	25 (14.3)
Total	51	39	2	10	19	27	34	92 (52.6)
Mandibular								
1st premolar	0	1	0	0	0	0	1	1 (0.6)
2nd premolar	3	0	0	0	1	0	2	3 (1.7)
1st molar	21	14	1	3	8	12	11	35 (20.0)
2nd molar	32	12	1	8	9	17	9	44 (25.1)
Total	56	27	2	11	18	29	23	83 (47.4)
Total n (%)	107 (61.1)	68 (38.9)	4 (2.3)	21 (12.0)	37 (21.1)	56 (32.0)	57 (32.6)	175 (100)