

Seven-year Clinical Evaluation of Painful Cracked Teeth Restored with a Direct Composite Restoration

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Abstract

The purpose of this study was to investigate long-term clinical effectiveness of treating painful cracked teeth with a direct bonded composite resin restoration. The hypothesis tested was that cracked teeth treated with or without cuspal coverage showed the same performance. Forty-one patients attended a dental practice with a painful cracked tooth that was restored with a direct composite resin restoration. Twenty teeth were restored without and 21 with cuspal coverage. After 7 years, 40 teeth could be evaluated. Three teeth without cuspal coverage needed an endodontic treatment, of which 2 failed as a result of fracture. No significant differences were found for tooth or pulp survival. Three more repairable restoration failures were recorded. Mean annual failure rate of restorations without cuspal coverage was 6%; no failures in restorations with cuspal coverage occurred ($P = .009$). A direct bonded composite resin restoration can be a successful treatment for a cracked tooth. (*J Endod* 2008;34:808–811)

Key Words

Clinical, composite, cracked teeth, cracked tooth syndrome, cuspal coverage, longevity, posterior

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0099-2399/\$0 - see front matter

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Cracked tooth syndrome was first described by Cameron (1), who defined a cracked tooth as “an incomplete fracture of a vital posterior tooth involving dentin and possibly pulpal tissue.” Patients complain about pain when consuming cold or hot food and beverages and when chewing, especially on hard food (2, 3). In a restored tooth, the crack is often visible in the dentin at the base of the sensitive cusp when the restoration is removed. The presence of pain on loading the cusp is explained by dentinal tubular fluid flow caused by movement between fracture sites (4). Pulp of those teeth might become inflamed because of irritation resulting from microleakage, which will induce thermal sensitivity. Eventually, crack propagation might lead to loss of the cusp or irreversible pulpitis.

A relationship with parafunctional habits such as clenching (5) and damage caused by large preparations are possible etiologic factors. A clinical study by Rattcliff et al. (6) showed that a larger preparation, presence of an amalgam restoration, and parafunctional habits increased the risk for the occurrence of crack lines. However, in another study 60% of teeth with cracks had no restoration (7).

Several therapies have been described as a treatment for painful cracked teeth. Root canal treatment followed by a full crown restoration is recommended by the American Association of Endodontists (8), especially when sensitivity persists with the temporary restoration in place (9). In cases that pulp vitality is to be preserved, a cemented stainless steel orthodontic band to splint the involved tooth is recommended as a temporary and diagnostic treatment before a full crown is placed (10). In a review article the authors advised placement of bonded cast or ceramic restorations with full cuspal coverage (11). Another author suggested placing single appointment, chairside, computer-aided, adhesively bonded porcelain restorations (12). However, these 2 articles expressed only clinical experience and authors' opinions. Few studies report about a successful reduction of complaints as a result of restorative treatment. In one clinical retrospective study (2), cracked teeth were treated with cast restorations or amalgam including cuspal coverage. Also bonded amalgam restorations with cuspal coverage were reported to be successful (13, 14). One study (5) reported a successful treatment of cracked teeth with bonded composite resin restorations after 6 months, with no differences between restorations with or without cuspal coverage.

Long-term clinical studies on the restorative treatment of cracked teeth are still scarce. Signore et al. (15) found that bonded indirect composite onlays were successful, with a 6-year survival of 93%. Failing teeth all needed endodontic treatment. In another study on 127 cracked teeth with reversible pulpitis that received a full crown, 20% of the teeth needed endodontic treatment within the first half year, whereas other teeth remained vital during a period of 6 years (16).

Until now, no long-term data were available on the performance of teeth with cracked tooth syndrome treated with direct bonded composite restorations. The aim of the present study was to document the long-term clinical performance of painful cracked teeth treated with bonded direct composite resin restorations with and without cuspal coverage. The hypothesis (H_0) tested was that painful cracked teeth treated with or without cuspal coverage show the same clinical performance.

Methods and Materials

In the present study, patients presented in a private dental practice with a toothache and were diagnosed to have cracked tooth syndrome including reversible pulpitis. They reported sensitivity when cold food and beverages came in contact with certain

teeth and pain when chewing on hard food. All patients had clinical acceptable amalgam restorations without visible defects and well-maintained dentitions with good periodontal conditions.

Inclusion criteria for participation included the following: (1) There was a pain response when a cotton pellet with chloraethyl was applied on the tooth. The pain reaction had to be more severe compared with adjacent teeth, but it disappeared after a few seconds. (2) There was a pain response after loading 1 or more cusps of the tooth by using a Tooth Slooth (Professional Results, Inc, Irvine, CA). (3) After removal of the restoration, a fracture line had to be visible inside the preparation in the dentin of cusp(s) tested positively at (2).

Informed consent was obtained, and before treatment was started, randomization took place. Each new case was alternately assigned to 1 of 2 protocols. According to the first protocol, the restoration was removed, and the cavity was restored with a 3-step etch-and-rinse adhesive system (Clearfil SA primer/PhotoBond; Kuraray Co, Tokyo, Japan) and direct composite resin (Clearfil PhotoPosterior; Kuraray Co). In the other group, involved cusps were reduced, and a cusp-covering restoration was placed with the same materials. Forty-one patients were treated, 14 men (range, 24–68 years) and 27 women (range, 20–56 years), of whom one had 2 cracked teeth located in both upper first molars. Treatments took place between August 1999 and January 2001. More details about the restorative protocol are described in the 6-month report (5).

Patients visited the dental practice regularly for check-up. Treated teeth were examined clinically, and every treatment performed on the teeth during the observation period was recorded. At 6 months and the end of the observation period, patients were asked explicitly whether treated teeth were still painful. In addition, these teeth and both adjacent teeth were clinically tested on sensitivity for a cold stimulus and for a painful reaction after loading the individual cusp by using the Tooth Slooth. Teeth were tested in random order so that patients were unaware whether the involved tooth or a control tooth was tested. When experimental teeth appeared to be more sensitive than control teeth, they were evaluated as sensitive.

A Kaplan-Meier survival analysis was applied on the results to calculate the survival of the groups with and without cuspal coverage. The survival was evaluated on 3 levels: tooth survival, pulp survival, and restoration survival. A log-rank test was used to test for differences between groups at $P < .05$.

Results

Forty of 41 cases (97%) could be evaluated at 7 years. In Table 1, distribution of cracked teeth among the treatment groups is shown. All teeth had an amalgam restoration: 3 occlusal, 10 two-surface, and 28 three-or-more surface restorations. Of the 18 involved maxillary teeth, 15 showed fracture lines in buccal cusps, whereas 18 of the 23 involved mandibular teeth had fracture lines in lingual cusps. Wear facets and indentations of opposing cusps in central fossae were frequently observed, indicating presence of bruxism in these patients.

At the end of the follow-up period, 3 endodontic treatments (7%) were needed as a result of irreversible pulpitis, one after 2 weeks, the second after 5 weeks, and a third after 7 years and 5 months. No significant differences between the groups were found for pulp survival (log-rank test, $P = .065$).

The molar that was endodontically treated after 2 weeks was extracted after 1 year and 9 months because of a vertical mesiodistal root fracture. The molar that was endodontically treated after 5 weeks received a hemisection after vertical fracture of the mesial root after 6 years and 7 months. Therefore, 2 of 40 recalled teeth (5%) did not survive, at least completely. The Kaplan-Meier graph of the survival of teeth in both groups is shown in Fig. 1. No significant differences between the groups were found for tooth survival (log-rank test, $P = .147$).

In Table 2, the results for failures and presence of sensitivity are presented. At 6 months, 39 teeth with vital pulps were evaluated; 31 teeth (75%) functioned without any complaints according to the patients. However, during clinical testing only 21 teeth (50%) were symptom-free.

At the end of the evaluation period, 40 teeth could be evaluated. Of the 37 vital teeth, 1 tooth was occasionally slightly sensitive when contacting cold food. After clinical testing, 30 teeth (75%) were free of symptoms, as patients reported that 7 teeth were more sensitive than adjacent teeth on testing with chloraethyl.

Three more restorations required repair as a result of fracture of a marginal ridge (1 tooth after 7 years and 1 month), secondary caries (1 tooth after 6 years and 9 months), and erosive wear next to the restoration resulting in sensitivity of exposed dentin (1 tooth after 6 years and 1 month).

At 7 years, no failures were recorded in the group with cuspal coverage, whereas restorations without cuspal coverage showed a mean annual failure rate of 6.0%, which was significantly different from the group with cuspal coverage (log-rank test, $P = .008$).

Discussion

In the present practice-based study the treatment of patients visiting a dental practice with a painful cracked tooth was evaluated. The patients received a bonded direct composite resin restoration to replace the amalgam restoration. A relatively small number of restorations were placed by one operator, which is a limitation of this study, because it is unclear whether operator skills might have influenced the results. The randomization process was done in a simple way before treatment started and was not influenced by the details of the case. Because the type of tooth treated was not included in the randomization, this might have led to an unbalanced number of types of teeth in the 2 groups. From Table 1 it can be seen that this is not the case because among both treatment groups, all types of teeth are equally presented.

The outcome of the study can be interpreted in different ways. The clinically most relevant events in this study related to the cracked teeth were the 3 endodontic treatments that had to be started and, subse-

TABLE 1. Distribution of Cracked Teeth and Involved Cusps over the Two Treatment Groups

	Maxilla			Mandibula		
	2nd Premolar	1st Molar	2nd Molar	2nd Premolar	1st Molar	2nd Molar
Teeth without cuspal coverage						
number of teeth	1	3	4	1	7	4
buccal cusps with cracks (n)	1	3	4	0	3	0
lingual cusps with cracks (n)	0	2	0	1	7	5
Teeth with cuspal coverage						
number of teeth	2	6	2	1	5	5
buccal cusps with cracks (n)	1	9	2	1	3	0
lingual cusps with cracks (n)	1	1	0	0	4	6

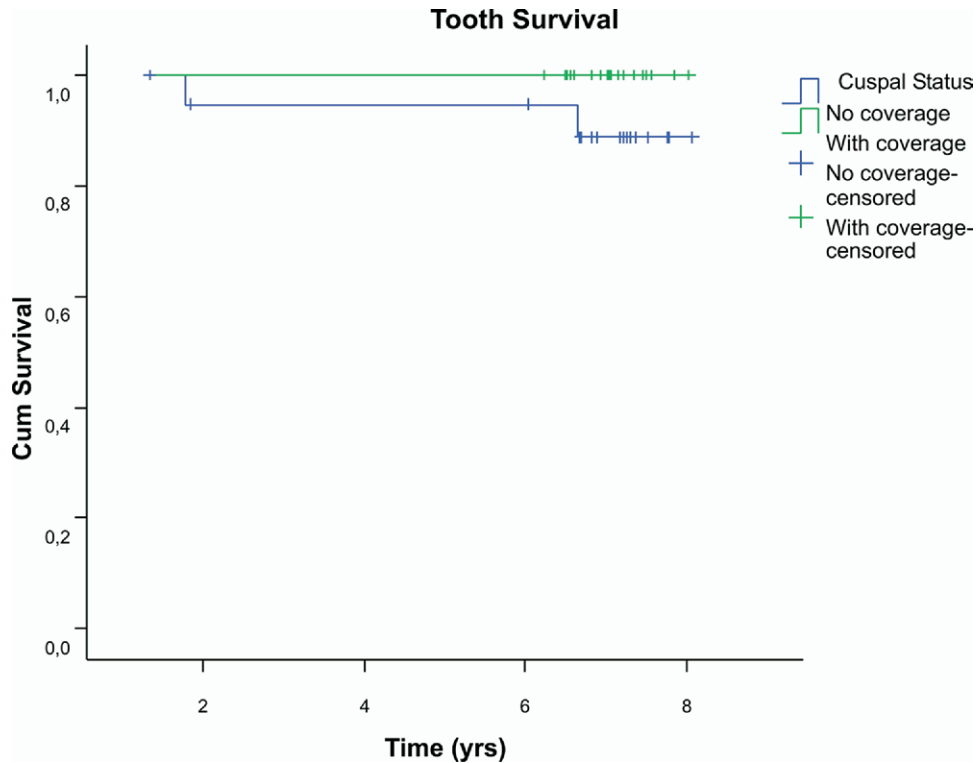


Figure 1. Kaplan-Meier graph showing the survival of cracked teeth treated with or without cuspal coverage.

quently, the 2 molars that fractured vertically. No significant differences between the 2 groups were found on those failure levels. This might be partly due to the low power because the number of included teeth was relatively small. Moreover, as mentioned in the first report about this research project, in both teeth that were extracted later, a fracture line in the pulpal wall was observed after endodontic opening (5). The location of the fracture was no part of the randomization process, which might have played a role. Therefore, it is doubtful that the fact that both teeth with vertical fracture were in one group can be contributed solely to the absence of cuspal coverage, also because endodontic treatment took place after only a short period of clinical service.

Looking at the survival on pulp and tooth levels, the H_0 hypothesis was therefore accepted. However, when all 3 levels of failure were combined, H_0 was rejected, because after 7 years, teeth with cuspal coverage showed a significantly higher survival rate (100%) than teeth without cuspal coverage (annual failure rate of 6%). Under the restriction of the limited power of the present study, as already mentioned, an

explanation for this finding might be that in absence of cuspal coverage, loading of either the remaining cusp or restoration will stress the adhesive layer. This loading might be severe in the investigated group of patients, showing clear signs of bruxism. Because of the crack, the cusp will be supported less, which might increase the load applied to the adhesive layer. In cases of cuspal coverage, stress on the weakened cusp will be less, whereas the composite resin might have a shock-absorbing effect. An *in vitro* study also showed that premolar teeth with composite restorations and cuspal coverage were significantly more fracture-resistant than teeth without cuspal coverage (17).

Sensitivity data were recorded on a yes/no basis and not by visual analogue scale. It is doubtful whether this would have enhanced accuracy of the sensitivity measurements, which were done partly by phone and partly by live interview. Moreover, intervals between measurements were several years.

At the end of the study, most of the teeth were symptom-free. Occasionally slight sensitivity was reported by one patient and was also

TABLE 2. Clinical Performance of Cracked Teeth Treated with (cc) or without (nc) Cuspal Coverage

Time of Evaluation	Baseline		6 Months		6-7 Years					
	Method of Evaluation		Clinical Testing		Interview		Interview		Clinical Testing	
Cuspal Coverage	nc	cc	nc	cc	nc	cc	nc	cc	nc	cc
Failure, endodontic treatment followed by extraction/hemisection	0	0	0	0	0	0	2	0	2	0
Failure, endodontic treatment Sensitive	0	0	0	0	2	0	1	0	1	0
No symptoms	20	21	20	21	6	4	1*	0	3**	4**
lost to follow-up	0	0	0	0	14	17	15	21	13	17
Failure of the restoration, repairable	0	0	0	0	0	0	3	0	3	0

* tooth occasionally sensitive on cold.

**Teeth more sensitive than adjacent teeth on testing.

References

recorded when teeth were clinically tested, but in absence of spontaneous complaints by the patients, these findings were not considered as failures. However, one should consider that painful cracked teeth, as treated in the present study, often show a long postoperative period of persisting but gradually reducing sensitivity. This might be an indication for a higher risk for pulpal complications in the long term as illustrated by the case that was endodontically treated after more than 7 years.

In another study, cracked teeth that were temporally restored with a direct composite restoration followed by an indirect composite onlay with cuspal coverage showed a 6-year survival of 93% (15). All failed teeth (7%) needed endodontic treatment, which is in accordance with the number of endodontic treatments (7.7%) found in the present study.

This study and the study by Signore et al. (15) suggest that a bonded composite restoration can be an effective treatment for a painful cracked tooth, resulting in more than 90% of the teeth maintaining pulp vitality in the long-term. Although it is difficult to compare the results of different studies, a full crown seems to be less effective in preserving the pulp's vitality, because in the study by Krell and Rivera (16), 20% of 127 symptomatic cracked teeth needed endodontic treatment within 6 months of service. Further clinical studies comparing these direct and indirect treatment options are required, also on the need to cover the cusps because this study is not entirely conclusive on this aspect. However, loss of pulp vitality might have a poor effect on the prognosis of the tooth because endodontically treated cracked teeth showed a survival of only 85.5% after 2 years (18). Obviously, a more invasive treatment option might be accompanied by a higher loss of teeth as a result of extraction in the long-term. Therefore, the recommendations by the American Association of Endodontists and other authors to do a root canal treatment on a cracked tooth exhibiting thermal sensitivity (8, 9) might be subject to reconsideration because maintaining the vitality of the dental pulp might improve the long-term prognosis of the tooth. From that point of view, a direct bonded composite resin restoration might be a good choice to treat a painful cracked tooth.

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