

# Preventive Treatment Effects of Posterior Cracked Teeth

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**Abstract:-** Cracks are defects on the tooth surface. The aim of the study is to treat those cracked teeth that are asymptomatic or have symptoms of reversible pulpitis by removal of the crack line and restoration with direct bonded composite resin to prevent further crack propagation and thus splitting of the tooth. A total of 30 patients having 45 mesio-distally oriented cracked teeth were included in the study. During the treatment the teeth were classified into three groups according to the depth of the prepared cavity. Group A included teeth with cavity depth 0.5 to 1mm into dentin (n=12); Group B included teeth with prepared cavity depth 1.1 to 1.5mm into dentin (n=15); and Group C included teeth with prepared cavity depth 1.6 to 2mm into dentin (n=18). Group C was further sub-divided into two groups depending upon the presence (Group C-I) (n=10) or absence (Group C-II) (n=8) of visible crack line at the base of the cavity. All the teeth were restored with light cure posterior composite resin restorative material. Only the teeth in Group C-I were lined with light cure calcium hydroxide lining before restoration. High point corrections were done and final finishing and polishing of the restoration was done. The patients were recalled at 6 months and 12 months, and the condition of restoration, tooth and signs and symptoms evaluated and recorded. Statistical package for social science (SPSS) version 22 was used for statistical analysis. A total of 45 teeth in 30 patients diagnosed with reversible pulpitis due to cracks were included in this study. There was significant difference between the depth of the crack ( $p=0.033$ ) and failure. However, there was no significant difference ( $p=0.388$ ) between the treatment outcome for absence or presence of crack line at the base of the cavity of depth 2mm into dentin. Posterior incomplete cracked teeth can be managed successfully in about 91.2% cases with direct composite resin restorative material for at least a period of 12 months.

## I. INTRODUCTION

Cracked teeth has been described as “a fracture plane of unknown depth and direction passing through tooth structure that, if not already involving, may progress to communicate with the pulp and/or periodontal ligament”.<sup>1</sup> Cracked teeth are a common dental condition that is increasing in frequency as the population ages and their teeth retain longer. In most of the teeth, crack tends to have a mesio-distal orientation but it may run in any direction across the occlusal surface and extend into the facial,

proximal or lingual/palatal surfaces, sometimes dividing the cusps into two halves. Two classic patterns of crack formation exist; one where the crack is centrally located, and following the dentinal tubules may extend to the pulp and the root resulting in a split tooth; and the other where the crack is more peripherally directed and may result in cuspal fracture<sup>2</sup>. In 1997, for consistency reasons, the American Association of Endodontics classified the longitudinal tooth fractures into five types; 1) Craze lines, 2) Fractured cusp, 3) Cracked tooth, 4) Split tooth and 5) Vertical root fracture.<sup>3</sup>

Incomplete fractures may present as asymptomatic fracture lines visible in or through enamel, or be highly symptomatic and either visible or invisible to inspection. If they are allowed to progress to their natural conclusion, such fractures may result in sequelae ranging from cuspal fractures—requiring a cusp replacement restoration—to partial or complete root fractures, the more serious of which will render the tooth non-restorable.<sup>2</sup>

Most of the research on treatment of cracked teeth is based on the treatment with full cuspal coverage. This procedure is destructive in the sense that it requires removal of healthy tooth structure and increases the cavo surface margin area making the tooth more vulnerable to decay if the restoration to tooth interface is not well adapted. The earlier so called less destructive management of cracked tooth involves only the occlusal reduction of the cracked tooth which when undertaken without analyzing the effects on the residual dentition may lead to unwanted occlusal interferences elsewhere on the arch. Furthermore, grinding the tooth out of the occlusion may still cause stress on the tooth with the load of food on it during mastication. Another commonly used procedure of splinting the tooth with copper ring and stainless steel are only temporary procedures for stabilization which are often discomforting for the patient and time consuming and technically challenging.<sup>4</sup>

Cracks are defects on the tooth surface. We know that when a flaw is present in an object it becomes the point of stress concentration and thus leads to further propagation of the defect through it. Removing or sealing off these defects from the tooth might as well remove the point of stress concentration which can thus prevent further propagation of crack and future possible catastrophic fracture of the tooth which would have required a more complex restorative measures or even extraction of the teeth.<sup>3</sup> The cracks on the tooth are also an open route for bacterial ingress towards the

pulp thus further deeming the necessity for its removal or closure.

Thus, the aim of the study is to treat those cracked teeth that are asymptomatic or have symptoms of reversible pulpitis by removal of the crack line and restoration with direct bonded composite resin to prevent further crack propagation and thus splitting of the tooth.

## II. METHODS

The teeth diagnosed as cracked tooth with reversible pulpitis were taken and the tooth surface was checked carefully in a dry field for stained or unstained crack lines. When necessary, the crack lines were stained with iodine dyes and further examined under dental operating microscope (OM) at 14X to 18X magnification. Tooth were checked if they were sensitive to cold or not and the vitality of tooth was tested using electric pulp testing. Only the vital teeth were included. Carious, previously restored crack teeth were not included in the study. Wooden stick was used for the bite test. It was placed on each cusp and patient was asked to bite down with moderate pressure and release. All the cusps were tested. Controls were tested before testing the cracked tooth to avoid false positive results. The tooth with the classic symptom of pain during biting was taken as conclusive evidence. However, the tooth which showed negative bite test results were not discarded as the absence of pain during biting does not rule out the possibility of a crack. The craze lines in posterior teeth that cross marginal ridges or buccal or lingual surfaces were differentiated with transillumination. A fiber optic light source was applied directly to the tooth surface. The light beam was positioned perpendicular to the plane of the suspected crack. The tooth with a craze line transmitting light throughout the crown was not selected for the experiment. Only the tooth with a true crack line which blocks the light was selected.

Although, the mesio-distal cracks cannot be visualized radiographically, Intra Oral Peri- Apical (IOPA) radiographs were taken to determine the pulp-periradicular status. Crack teeth with presence of any perirapical changes were not included in the study. A thickened periodontal ligament space or a diffuse radiolucency in the apical area with possible indication of crack was noted. They were also taken for comparison with radiographs that will be taken during recall.

45 teeth, from 30 patients were selected. All patients were informed with a detailed explanation of their presenting problem and the proposed management plan. Their written consent to proceed with the treatment was taken and the patient's complete demographic record was documented. Photographs of the crack tooth were also taken recording the crack.

The crack line was completely or partially removed using a diamond fissure bur on high speed handpiece. They were divided into three groups according to the depth of the prepared cavity which ranged from 0.5 mm to 2mm into the

dentin. Group A with cracked teeth depth 0.5 to 1mm, Group B with depth of 1.5mm and Group C with the depth of 2mm. Group C was further sub-divided as Group C-I which included teeth that had crack at the base of the cavity and Group C- II which did not have crack lines at the base of the cavity. The width of the prepared cavity was maintained to be no greater than 1mm. If the crack line was further deeper than 2mm in dentin, then no attempt was undertaken to remove the crack line from the base of the cavity to avoid possible pulpal exposure. Photograph of the prepared cavity was then taken.

The cavities with depth 2mm into the dentin, which still had crack line at the base of the cavity, were lined with light cure Calcium Hydroxide cavity liner (Pulpdent, Lime-Lite) up to the thickness of 0.5mm.

All the cavities were acid etched using 35% phosphoric acid for 5 seconds then washed thoroughly with water. The cavities were blotted to remove excess water but special care was taken so as not to over dry the cavities. Then a bonding agent (3M ESPE, Adper™ Single Bond Plus) was coated according to the manufacturer's instruction and light cured for 10 seconds. The cavities were then restored with light cure composite resin (3M ESPE, Filtek™ P60) following the manufacturer's manuscript and cured for 30 seconds. High points were corrected and final finishing and polishing of the restoration done. Photographs were taken again at the end of the procedure.

Patients were told to contact the doctor immediately if any discomfort was felt and if the tooth remained asymptomatic then they were scheduled for recall every 6 and 12 months for the examination of the tooth.

On the recall appointment all the patients were inquired about their signs and symptoms. Recall examination was done by another dentist to avoid any bias. They were asked if they felt any sensitivity to hot or cold food and or any pain on chewing on hard food. The tooth was also tested clinically for heat and cold test and by electric pulp tester to determine the vitality of the tooth. The opposite quadrant similar tooth and the neighboring teeth were first tested to avoid any bias. Bite test was also done and the response recorded.

The quality of the restoration was examined carefully with naked eye and/or with OM, when necessary, using a sharp explorer. The restoration was checked for its marginal intactness, marginal discoloration, marginal adaptation, and restoration fracture. The chart used for examination of composite restoration is shown in Table 1.<sup>5</sup> The tooth was also inspected for any propagation of crack line in mesio-distal direction. IOPA x-rays and photographs of the tooth were taken. The photographs were further enlarged to view the changes in the restoration and teeth before restoration and after restoration during each visit at 6 months and 12 months. Any new treatment on the affected tooth, if required, was done and recorded.

Table 1 Composite Restoration Evaluation Chart

| <b>Category</b>               | <b>Score</b> | <b>Criteria</b>                                                               |
|-------------------------------|--------------|-------------------------------------------------------------------------------|
| <b>Marginal discoloration</b> | 0            | No discoloration                                                              |
|                               | 1            | Slight staining                                                               |
|                               | 2            | Apparent discoloration                                                        |
|                               | 3            | Recurrent caries                                                              |
| <b>Marginal Adaptation</b>    | 0            | No catch with the explorer, margin is completely continuous with tooth tissue |
|                               | 1            | Slight unevenness detected with explorer                                      |
|                               | 2            | Marginal gap                                                                  |
|                               | 3            | Recurrent caries                                                              |
| <b>Restoration fracture</b>   | 0            | Completely intact restoration                                                 |
|                               | 1            | Slight cracks                                                                 |
|                               | 2            | Subset fracture                                                               |
|                               | 3            | Total fracture                                                                |
| <b>Tooth fracture</b>         | 0            | Completely intact tooth                                                       |
|                               | 1            | Slight enamel cracks                                                          |
|                               | 2            | Crack extends into dentin                                                     |
|                               | 3            | Tooth fracture                                                                |

(Extracted from, the article “Direct resin composite restorations in vital versus root-filled posterior teeth: A controlled comparative long-term follow-up”; Operative Dentistry, 200732-5, 437-442)<sup>5</sup>

The treatment was a success if the patients give negative history of severe spontaneous pain while taking hot or cold food, improvement in the degree of pain symptoms on taking cold food and biting pressure, normal response to heat and cold test during re-examination at each visit at 6 and 12 months, the result of vitality test using electric pulp tester being within normal limits, no or minimum pain during bite test, zero to 1 score in the restoration evaluation chart and no detection of abnormality in the radiograph.

The treatment was a failure if the patient complained of spontaneous, severe, radiating pain on the tooth as with irreversible pulpitis, worsening of the previous symptoms, development of apical periodontitis or periodontal inflammation, non-vital tooth as identified during thermal and electric pulp testing, tooth fracture, score of 2 or 3 in the restoration evaluation chart or detection of any abnormality on the radiograph.

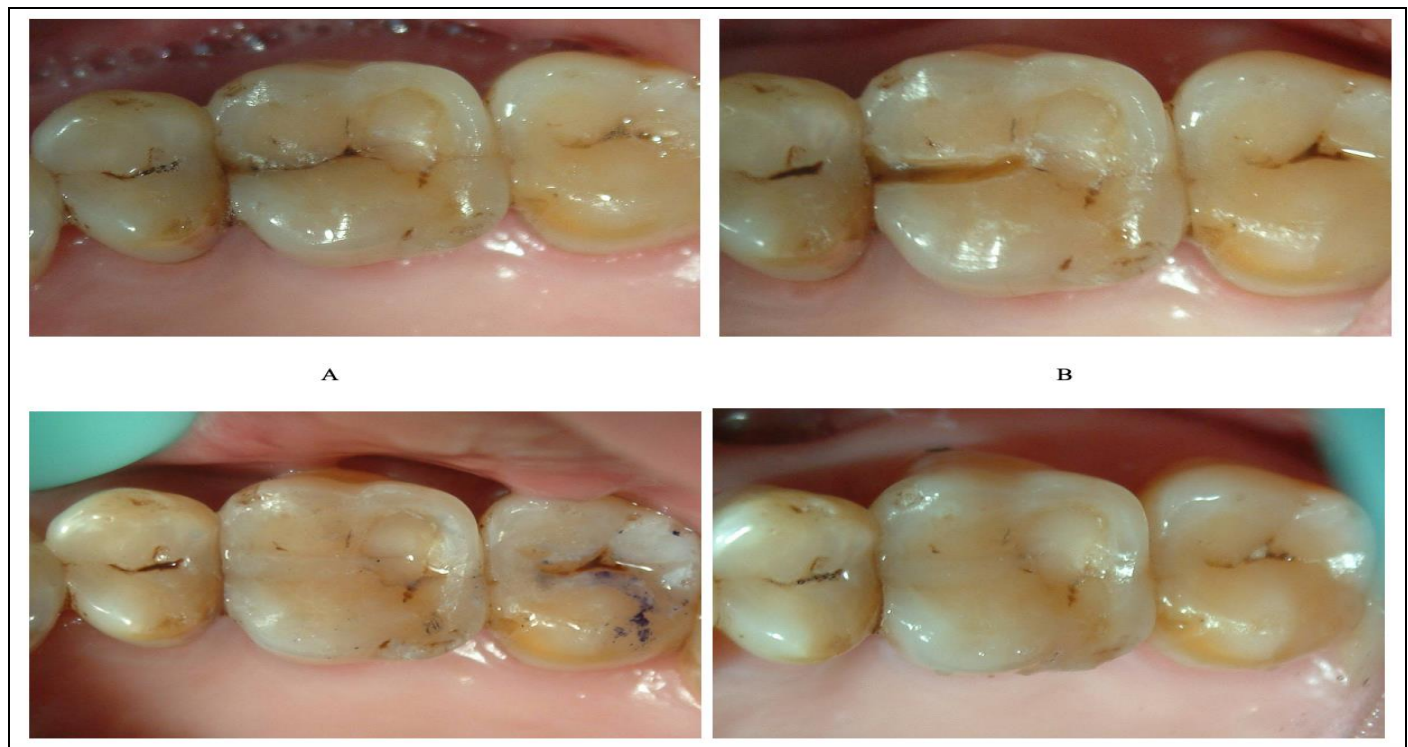


Fig 1A: crack line seen on 16 running from mesial pit towards the mesial marginal ridge. B: Preparation of cavity on 16 (cavity depth=1.5mm into dentin). C: Restoration of the cavity with light cure composite resin. D: 16 at recall after 12 months.

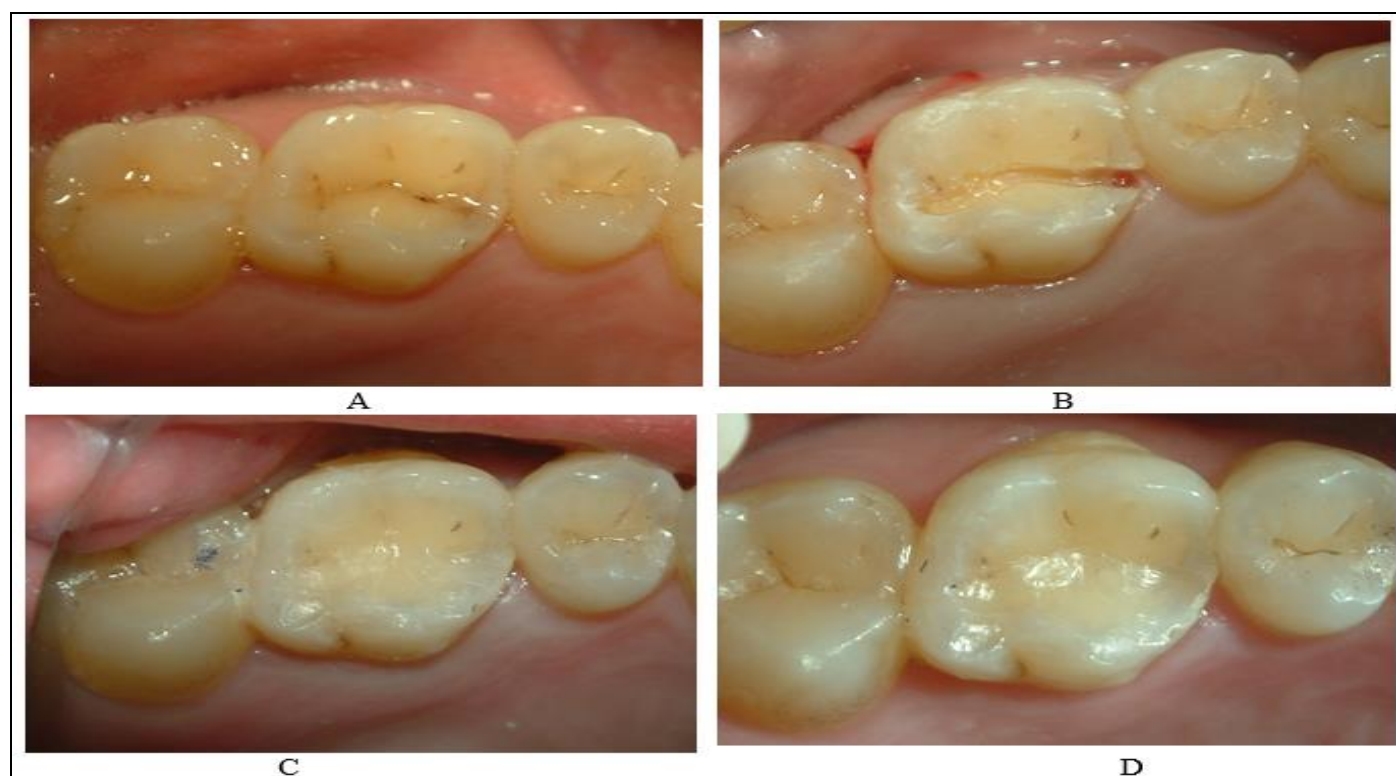


Fig 2 A: Crack line seen on 26 running from distal pit towards the mesial marginal ridge. B: Preparation of cavity on 26(cavity depth=2mm into dentin). C: Restoration of the cavity with light cure composite resin. D: 26 at recall after 12 months.

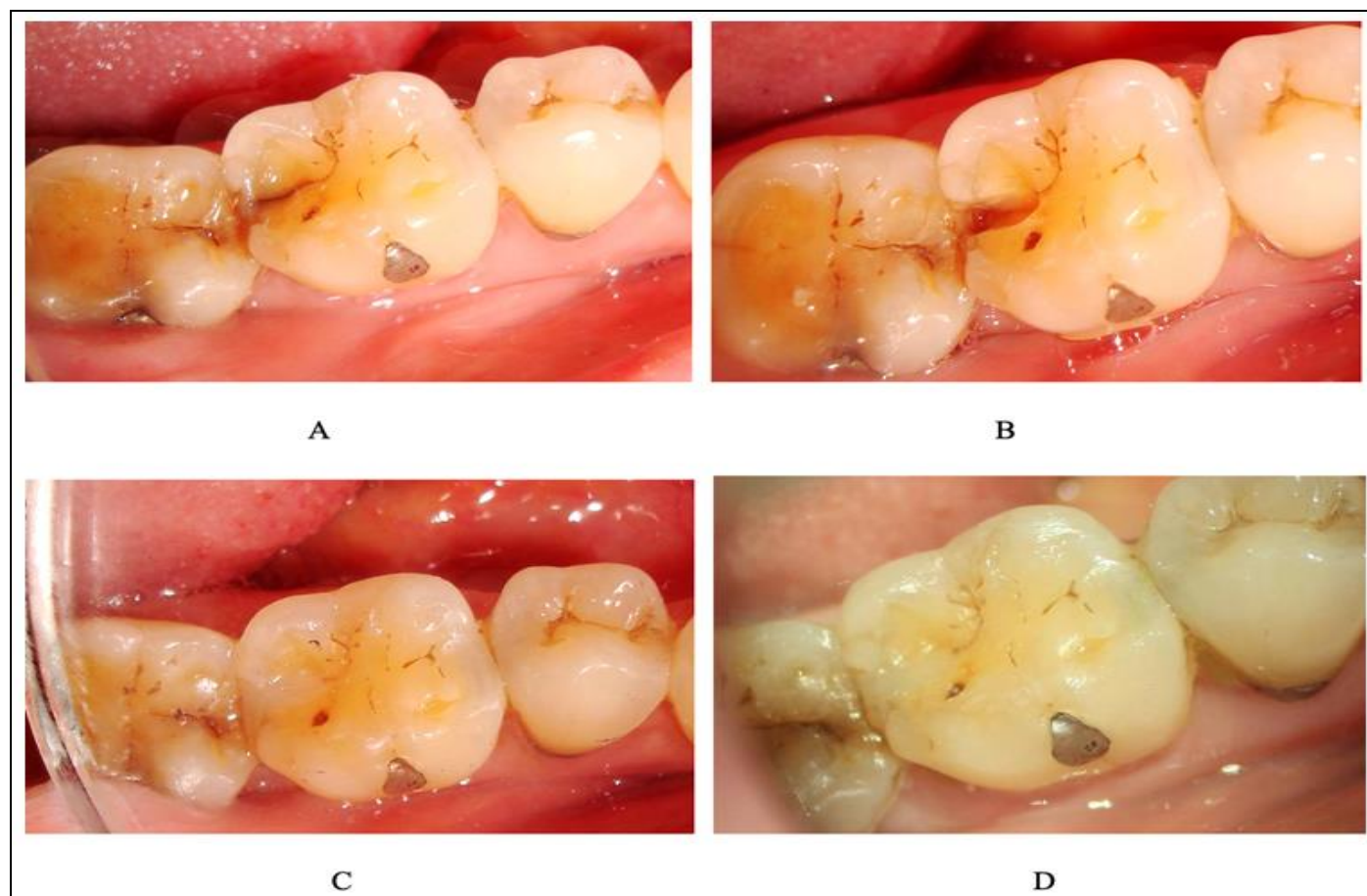


Fig 3A: Crack line seen on 46 running from central pit towards the distal marginal ridge. B: Preparation of cavity on 36(cavity depth=2mm into dentin). Crack line is seen at the base of the cavity C: Restoration of the cavity with light cure composite resin. D: 46 at recall after 12 months.

### III. RESULTS

Statistical package for social science (SPSS) version 22 was used for statistical analysis.

A total of 45 teeth in 30 patients with incomplete mesio-distally oriented crack were included in this study. Three patients who failed to be recalled were excluded from the study. The patients were between 22 to 77 years of age (mean=49.5 years old). The age of the majority (86.5%) of the patient with crack teeth were in the age group of 36-57 years while the number of male and female patients were equal (15 each). The distribution of patient with cracked tooth in respect to age and gender and are shown in Table 2. Majority of the patients had just one tooth treated (46.6%) but some had 2 to 4 teeth treated (Table 3). Molar teeth were the most common tooth involved, maxillary first molar being the most (62.2%) (Table 4).

When the subjective and objective signs and symptoms were compared before treatment and at various time durations, it was found that all percentage of teeth with symptoms decreased greatly, and the percentage of symptomless teeth increased appreciably. Yet, 26.2% of the patients were found to have various signs and symptoms

even at the end of 12 months (Table 5). Since the degree of symptoms was reported to as decreased and patients were willing to observe for a longer duration, no aggressive treatment was performed for them, and they were also listed as successful cases.

The depth of the cavity for 12 of the cracked teeth was 0.5 to 1mm (Group A), for 15 teeth was 1.5mm (Group B) and for 18 teeth was 2mm (Group C). Among the crack teeth with 2mm depth, 10 teeth had crack at the base of the cavity (Group C-I) and 8 did not (Group C- II) (Table 6). Only those in Group C-I were lined with a Ca (OH)<sub>2</sub> cavity liner. Four of the Group C-I cases reported with signs and symptoms of irreversible pulpitis; two within three months, one after a week of restoration and one after 12 months recall period. Root canal therapy followed by restoration with cuspal coverage was advised for them. The rest of the patients were recalled every 6 month and 12 months. On examination at 6 months recall, three of the teeth had marginal adaptation score 1, for which further finishing of the restoration was required and at 12 months recall visits all the 42 teeth had intact restoration which did not need any further repair (Table 5). There were no failures due to restoration fracture or tooth fracture.

Table 2 Distribution of Patient with Respect to Age and Gender

| Age   | Male | Female | Total | Percentage (%) |
|-------|------|--------|-------|----------------|
| 20-29 | 2    | 0      | 2     | 6.6            |
| 30-39 | 4    | 7      | 11    | 36.6           |
| 40-49 | 5    | 3      | 8     | 26.6           |
| 50-59 | 3    | 4      | 7     | 23.3           |
| 60-69 | 0    | 1      | 1     | 3.3            |
| >70   | 1    | 0      | 1     | 3.3            |
| Total | 15   | 15     | 30    | 100            |

Table 3 Number of teeth treated per patient

| Number of teeth treated | Number of patients (%) |
|-------------------------|------------------------|
| 1                       | 21 (70)                |
| 2                       | 5 (16.6)               |
| 3                       | 2 (6.6)                |
| 4                       | 2 (6.6)                |
| 45                      | 30                     |

Table 4 Percentage of teeth types that were treated

| Tooth type      | Maxillary | %    | Mandibular | %    | Total | %     |
|-----------------|-----------|------|------------|------|-------|-------|
| First premolar  | 2         | 04.4 | 0          | 0.0  | 2     | 04.4  |
| Second premolar | 3         | 06.6 | 0          | 0.0  | 3     | 06.6  |
| First molar     | 20        | 44.4 | 7          | 15.5 | 27    | 60.0  |
| Second molar    | 8         | 17.7 | 5          | 11.1 | 13    | 28.8  |
| Total           | 33        | 73.3 | 12         | 26.6 | 45    | 100.0 |

Table 5 Comparison of signs and symptoms at different time duration

| Signs /Symptoms              |                                                | Before treatment(%) | Immediately after treatment(%) | 6months after treatment(%) | 12months after treatment(%) |
|------------------------------|------------------------------------------------|---------------------|--------------------------------|----------------------------|-----------------------------|
| Subjective                   | Sensitivity to cold                            | 14(31.1)            | Not recorded                   | 5 (11.9)                   | 4 (9.5)                     |
|                              | Pain on biting                                 | 13(28.9)            | Not recorded                   | 3 (7.1)                    | 1 (2.4)                     |
|                              | Both sensitivity to cold and pain on biting    | 9(20)               | Not recorded                   | 4 (9.5)                    | 1 (2.4)                     |
|                              | Symptomless                                    | 9(20)               | Not recorded                   | 30 (71.4)                  | 36 (85.7)                   |
|                              | Total                                          | 45 (100)            | -                              | 42 (100)                   | 42 (100)                    |
| Objective                    | Sensitivity to cold                            | 10(22.2)            | 8 (17.8)                       | 3 (7.1)                    | 4 (9.5)                     |
|                              | Positive bite test                             | 17(37.8)            | 5 (11.1)                       | 5 (11.9)                   | 5 (11.9)                    |
|                              | Both sensitivity to cold and pain on bite test | 14(31.1)            | 5 (11.1)                       | 3 (7.1)                    | 2 (4.8)                     |
|                              | Signless                                       | 4(8.9)              | 27( 60)                        | 31 (73.8)                  | 31 (73.8)                   |
|                              | Total                                          | 45 (100)            | 45 (100)                       | 42 (100)                   | 42 (100)                    |
| Condition of the restoration | Marginal discoloration with score              | 0                   | -                              | 45                         | 42 (100)                    |
|                              |                                                | 1                   | -                              | 0                          | 0                           |
|                              |                                                | 2                   | -                              | 0                          | 0                           |
|                              |                                                | 3                   | -                              | 0                          | 0                           |
|                              | Marginal adaptation with score                 | 0                   | --                             | 45                         | 39                          |
|                              |                                                | 1                   | -                              | 0                          | 3 (7.1)                     |
|                              |                                                | 2                   | -                              | 0                          | 0                           |
|                              |                                                | 3                   | -                              | 0                          | 0                           |
|                              | Restoration fracture with score                | 0                   | -                              | 45                         | 42 (100)                    |
|                              |                                                | 1                   | -                              | 0                          | 0                           |
|                              |                                                | 2                   | -                              | 0                          | 0                           |
|                              |                                                | 3                   | -                              | 0                          | 0                           |
|                              | Tooth fracture with score                      | 0                   | -                              | 45                         | 42 (100)                    |
|                              |                                                | 1                   | -                              | 0                          | 0                           |
|                              |                                                | 2                   | -                              | 0                          | 0                           |
|                              |                                                | 3                   | -                              | 0                          | 0                           |
|                              | Total failed cases                             |                     | 4                              | -                          | 3*(6.6%)                    |
|                              |                                                |                     |                                |                            | 4** (8.8%)                  |

□ Three teeth with marginal score of 1 were further finished and polished to a smooth surface so that marginal adaptation score was 0. □ The failed cases were self reported within \*3 months before recall and at \*\*12 months after the recall. The failure was due to irreversible pulpitis. Please note that at 6 and 12 months total number of teeth examined were 42.

Table 6 Relation between Depth of the Cavity and Failure

| Cavity depth into dentin (mm) |                | Number of teeth | %    | Number of failure (in 12 months) | %  |
|-------------------------------|----------------|-----------------|------|----------------------------------|----|
| 0.5-1.0                       |                | 12              | 26.6 | 0                                | 0  |
| 1.1-1.5                       |                | 15              | 33.3 | 0                                | 0  |
| 1.6-2.0                       | *Crack line +  | 10              | 22.2 | 4                                | 40 |
|                               | **Crack line - | 8               | 17.7 | 0                                | 0  |

\*Crack line+: presence of crack line at the base of the cavity;\*\* Crack line-: absence of crack line at the base of the cavity.

There is no significant difference ( $p=0.388$ ) between the failure of treatment and presence or absence of crack at the depth of 1.6 to 2mm.

There is significant difference between the failure of the treatment and depth of the crack ( $p=0.033$ ).

#### IV. DISCUSSION

In this study, 30 patients with 45 cases of cracked teeth were analyzed and treated with direct composite resin restoration. Forty-one teeth were symptomatic among which, 5 of the teeth were found to have signs and symptoms of reversible pulpitis during examination only without prior

complaint, and the rest 4 teeth were completely asymptomatic. Unlike in other studies, treatment was done on cracked teeth without caries and without previous restorations. The previously restored teeth with underlying crack and carious teeth, as have already lost part of the tooth structure due to caries or during restorative procedure, can possibly weaken the remaining tooth structure and might require full cuspal coverage rather than simple filling<sup>1,6,7</sup>. Only those teeth that have crack on the occlusal surface running mesio-distally with or without diversion in facial or palatal/lingual surface were selected due to their higher frequency<sup>8</sup> and to avoid bias in the study. There has been conflict regarding the occurrence of incomplete cracks on anterior teeth. Some searchers believe that only craze lines

can be seen on anterior teeth<sup>9</sup> whereas some believe that these craze lines can deepen to form an incomplete crack, even in anterior teeth, which eventually results in split tooth<sup>10</sup>. The force of mastication is also lesser in anterior teeth than in posterior teeth<sup>11</sup>. Thus, to avoid this difference to occur in our study only posterior teeth were included. Although molars and premolars are anatomically and positionally different and also the force of mastication is not same, our study did not find any significant difference ( $p=1.00$ ) in the treatment outcome due to this variation.

There have been contradictory results of incidence of cracked teeth in male and female patients. Some studies<sup>12,13</sup> have shown women to be affected more than men by cracked teeth, others<sup>9</sup> show the higher incidence of male and yet in other studies there seems no significant difference. In the present study, the frequency of cracked teeth in male and female was equal. Cameron<sup>12</sup> and Homewood<sup>13</sup> in their studies presumed the reason for the higher incidence of female patients as the higher oral awareness and increased demand for dental care among females and less tendency of male patients to report; and in our study, since patients were screened for the cracked teeth even when they did not complain of any symptoms, frequency of cracked teeth among male and female patients was same. However, our study had various criteria for inclusion because of which the number of cases cannot be labeled as incidence and thus compared with other study results on incidence.

The majority of the patients belonged to 36 to 57 years age group, which is comparable with other studies<sup>1,7,9</sup>. The susceptibility of the older patients to CTS may be because of the less elasticity of dentin and less pliable supporting tissues usually seen with increasing age as explained by Udoe<sup>9</sup>.

In our study, 44.4% of cracks were found in maxillary first molar. Conversely, many authors reported that mandibular molars were the most common tooth with cracks<sup>2,12,22,27,29-44</sup>. Most of these studies have included complete cusp fractures and fractures in previously restored teeth. In our study only intact teeth with incomplete mesio-distally oriented cracks (symptomatic and asymptomatic) were included. Moreover, in a study<sup>7</sup> done in Korean population, maxillary molars were found to be the most commonly involved tooth similar as in our study. It was stated that Koreans have more lingually tilted molars and smaller and shorter teeth than Caucasians. The buccal cusp of the lingually tilted lower molars could act as plunger cusp to the maxillary molars. Smaller amounts of dentin and the surface area of the roots absorbed less occlusal stress and transferred less occlusal forces to the alveolar bone. Furthermore, the prevalence of the C-shaped root canal in the mandibular second molar is higher in Asians than in Caucasian. C-shaped canal joined the mesial and distal root, which may provide the additional resistance to the lower second molar.

The patients were screened for the cracked teeth even when they did not complain of any symptoms to detect the crack in its earliest stage. Various diagnostic tests were

performed rather than a single test to confirm the diagnosis of cracked tooth. When discussing the symptoms of these patients, most had sensitivity to cold food, tenderness to biting or both. 20 % of the teeth were reported symptomless by the patient but during examination only 8.9% did not have any symptoms. Most of the patients who did not complain of any symptoms were found to have positive bite test. The pain is produced with movement of dentinal fluid when the crack is opened by pressure on the cusp, and it also explains the short sharp pain as the fluid moves back on releasing the pressure. It was also found that due to the presence of other carious lesion, the symptoms reported by the patient did not match the symptoms during clinical examination. As most of the teeth had mild to moderate attrition, in some teeth the sensitivity to cold might also have been caused by dentinal hypersensitivity. Due to scanning of all the teeth during examination, in some patients, the cracks were detected in the early stage and thus the depth of the crack into the dentin was not very deep (0.5mm) which might have been the reason for the tooth be completely asymptomatic.

After investigation of the teeth, the crack line was completely removed till the depth of 2mm into the dentin. In the teeth with crack depths beyond 2mm, complete removal of the crack line was not done to prevent accidental pulp exposure. Instead, a light cure calcium hydroxide liner (Pulpdent, Lime-Lite) was used to cover the crack line to prevent possible pulpal trauma during the composite restorative procedure. Lime-Lite is a light cure, fluoride releasing, radiopaque cavity liner specially formulated for use with adhesives and composites. It contains hydroxyapatite in a urethane dimethacrylate resin. It chemically bonds to composites and micromechanically bonds to dentine. It is said to release favorable calcium ions, hydroxyl ions, fluoride ions and phosphate ions which are known to be beneficial to tooth structure, to stimulate secondary dentin formation and to have a cariostatic properties.

The depth of the prepared cavity was measured from dentino-enamel junction for consistency reasons because most of the teeth showed mild to severe degree of attrition. In our study, 26.6% of the teeth had crack lines up to 0.5 to 1mm deep into dentin, 33.3% up to 1.5mm, 17.7% up to 2mm and 22.2% more than 2mm. The cavity was prepared up to the depth of the crack line until 2mms; beyond which the crack was not removed. However, the width of the cavity was maintained to 1mm in all cases. All the cavities were restored with light cure posterior composite resin, Filtek P60 (3M ESPE, USA), since the compressive strength of this resin was found to be the highest<sup>14</sup> and is claimed to have low polymerization shrinkage thus causing less stress on the tooth and less sensitivity potential to the patient. But among the successful cases, four of the patients continued to have some sensitivity to severe cold at both recall visits (6 months and 12 months). It has been shown in clinical follow up study<sup>15</sup> that the post operative sensitivity in resin composite restorations was not related to the absence of protective layers but increased with the depth of cavities restored with resin composite. The type of dentine-bonding

agent could also be responsible for post-operative sensitivity. Since all the cavities were restored using same bonding agent and composite resin by one operator following the manufacturer's instruction the latter is not the case in our study. The objective and subjective signs and symptoms were slightly different. The reason could be because the substance used during test and that used by the patient being different and because of bias shown by the patient toward the affected teeth. Moreover, there were other symptomatic carious teeth in the same side of the oral cavity which might have caused the symptoms, but patient failed to identify them. Also, the cracked teeth had various degrees of attrition and gingival recession exposing the root surface which might have led to the sensitivity of the teeth. During examination we excluded those causes and made sure that the abnormal sensitivity to cold was just due to presence of crack to remove any bias in the study.

It is said that the bonded resin composite restoration with or without cuspal coverage as definitive restoration has the potential to connect the weakened cusp with restorative material and that adhesive procedures may prevent microleakage along the crack line<sup>16</sup>. In vitro studies suggest that adhesive bonded resin composite restoration can improve the strength of structurally compromised teeth<sup>85</sup>. In a six-month clinical investigation, Opdam and Roeters<sup>17</sup> found no statistically significant difference in the results of teeth treated with a bonded restoration composite restoration with and without cuspal coverage. Direct and indirect bonded resin composite has been described as a successful restorative treatment of cracked teeth.<sup>17, 18</sup> However, some authors do not agree with this and recommend that the cracked teeth with wide cavities should be protected and strengthened by full cuspal coverage.<sup>16, 19</sup> Since the cavity width is maintained to 1mm width, which is less than 1/3 of inter-cuspal width, we have believed that it would not compromise the strength of the tooth. Thus, a more aggressive treatment like placement of crown requiring removal of healthy tooth structure was not done in our study.

All the patients were recalled at 6 months and 12 months' time. The recall examinations were performed by another competent operator to avoid any bias in the study. The success and failure were based according to the evaluation criteria. Those cases where the patients were symptomatic even after 12 months of restoration were also regarded as successful cases because signs and symptoms were reported to be mild and infrequent. They also stated that the symptoms had improved to their comfort level. At 6 months recall, 3 of the restoration had marginal adaptation score 1. The reason possibly is due to inadequate finishing of the composite restoration because in 12 months recall all the scores for condition of restoration were found to be zero. Had it been due to inability of the composite resin to bind the crack surface leading it to movement of the separated fragments, the marginal adaptation score would not have been zero.

The rise in percentage of symptomless teeth after treatment is considerable from 8.9% before the treatment to 60% immediately after the treatment and 73.8% after 6 months. The percentage remained same at 12 months recall. The reason for the immediate rise in symptomless teeth is apparent. The composite restoration splinted and sealed the crack and prevented movement of individual cracked surfaces thus the occurrence of signs and symptoms. The further decline at 6 months might be due to wearing off of post operative sensitivity, the inherent effect of composite resin restoration which also explains the maintenance of the 73.8 percentage at the end of 12 months.

During the evaluation period, four total failures were recorded. One of the patients returned to the office after 4 days of treatment, the other two within three months and one after 12 months recall visit. All patients had developed signs and symptoms of irreversible pulpitis for which root canal therapy was performed and a full coverage crown advised. None of the teeth failed due to complete fracture of teeth or restoration. The failed cases were all from Group C-I where the cavity depth was 2mm and had crack line at the base of the cavity. Interestingly these were all maxillary molar teeth and the crack length was long in all cases crossing the oblique ridge. One of the possible reasons of failure may be explained by the study done by Kahler<sup>20</sup> in which he used SEM to investigate the cracks in the teeth and found it to be contaminated with bacteria. Three of these were stained cracks. Furthermore, since all of the crack line was not removed from the base of the cavity, the exact extension of the crack beyond 2mm was not known during the procedure. The failure to bind the crack beyond 2mm into dentin might have been reason for further propagation and it is possible that the pulp was highly stressed (as shown by signs and symptoms of reversible pulpitis) before the treatment that finally gave up. However, although all the failures were seen in the teeth with presence of crack line at the base of the cavity, we did not find any significant difference in the success or failure of the treatment due to the presence or absence of the crack at the cavity depth of 2mm into dentin ( $p=0.388$ ). But there was significant difference between the failure of the treatment and depth of the crack into dentin ( $p=0.033$ ). All the cases that failed were symptomatic before the treatment and were symptomatic at all recall visits. This means that the other symptomatic cases which have not yet shown signs and symptoms of irreversible pulpitis needs further recalls at longer duration to know the success of the treatment on such cases.

## V. CONCLUSION

Posterior incomplete cracked teeth without caries or previous restoration and with a mesio-distal orientation, if is either asymptomatic or have signs and symptoms of reversible pulpitis, can be managed successfully in about 91.2% cases with direct composite resin restorative material for at least a period of 12 months.

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