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Clinical Relevance
Crown-root fractures of molars with extensive loss of tooth structure extending well below the alveolar crest can be successfully treated with a conservative method.

SUMMARY
The five cases presented here describe a conservative treatment procedure for complicated crown-root fractures of molars with extensive loss of tooth structure. After the mobile crown-root fragments were extracted, the remaining crowns were restored at the juxtagingival level. The follow-up time ranged from two years, seven months, to four years. At the follow-up examinations, all of the teeth were asymptomatic and had healthy clinical appearances. There was no evidence of pockets related to fractures. The results of these cases show that complete periodontal healing is possible with conservative treatment of complicated crown-root fracture of molars.

INTRODUCTION
A crown-root fracture is defined as a fracture involving the enamel, dentin, and cementum. These fractures may be grouped, according to pulpal involvement, into ‘uncomplicated’ and ‘complicated.’ Crown-root fractures are usually oblique and involve both the crown and root, splitting the crown and extending subgingivally to the root surface, and they are often complicated by pulp exposure and exten-
sive loss of tooth structure. In contrast to other traumatic injuries, in which the posterior teeth are rarely involved, crown-root fractures often include the molars and premolars. In the posterior teeth, the cause of crown-root fractures has been attributed to indirect trauma, including large-size restorations. The treatment strategy for crown-root fractures is complex. It has been recommended that all loose fragments be removed to evaluate the extent of the injury. Restoration of a tooth with a crown-root fracture or a cervical root fracture is unfavorable and can be a difficult procedure when the fracture line extends below the marginal bone level. Such a fractured tooth is often considered hopeless. Restore and functional needs are balanced with the demands of the healthy periodontium. Placing the margin of the restoration in the biologic width frequently leads to chronic gingivitis, the loss of clinical attachment, bony pockets, and gingival recession. Crown-root fractures extending well below the alveolar crest can require surgical repositioning of the tissues to expose the level of the fracture. Either surgical or orthodontic extrusion can also be performed to allow for better restoration of the fractured tooth. The choice of treatment is primarily determined using exact information about the site and the type of fracture, but the cost and complexity of treatment can also be deciding factors. Andreasen and Andreasen described the conservative treatment of various types of crown-root fractures. The most conservative treatment was the following: the loose fragment is removed as soon as possible after the injury, and the remaining crown is temporarily restored supragingivally. Once gingival healing is observed, the coronal portion can be restored at the juxtagingival level. Andreasen and Andreasen noted that this procedure should be limited to superficial fractures that do not involve the pulp. The aim of the present report is to describe a similar conservative treatment procedure for complicated crown-root fractures of molars and to discuss the treatment outcomes.

CASE REPORTS

Case 1
A 47-year-old male patient presented at the endodontic clinic with a cracked mandibular left second molar. He reported that he felt the tooth had cracked four days earlier when he chewed food, and a toothache followed when chewing further. From the dental history, it was learned that the tooth had been treated by pulp mummification (also referred to as “mortal amputation of the pulp,” in contradistinction to vital amputation) previously. The clinical examination revealed a large occlusal-distal amalgam restoration on the mandibular left second molar, with a fracture running mesiodistally along the margin of the restoration (Figure 1). The fracture extended subgingivally, the buccal fragment was mobile in the lateral direction, and there was no mobility of the lingual part. The tooth was nonresponsive to pulp vitality testing. The periodontal examination disclosed an approximately 5-mm pocket on the distal surface of the silver amalgam restoration. Periapical radiography showed no signs of periapical disease (Figure 1). With the patient’s consent, local anesthesia was administered, the mobile buccal segment and the silver amalgam restoration were removed (Figure 1C), and a one-visit root canal treatment was performed. The remaining crown was temporarily restored with zinc oxide–eugenol–based cement applied supragingivally. No antibiotic was administered. Visual examination of the extracted segment showed that the buccal surface comprised the cervical thirds of both the mesial and distal roots, that the fracture of the roots was oblique in pattern, and that the longest distance from the cementoenamel junction of the segment to the apical level was roughly 5 mm (Figure 1D).

At the seven-day follow-up, the patient was asymptomatic, buccal gingival healing of the tooth was observed, and the zinc oxide–eugenol cement was removed (Figure 1E). A coronal restoration with composite resin (Z250, 3M ESPE, St. Paul, USA) was then placed at the juxtagingival level (Figure 1F). A metal crown was then constructed.

At the three-year follow-up, the tooth was free of clinical symptoms, was functioning normally, and had a healthy clinical appearance (Figure 1G). The pocket probing depth was still approximately 5 mm on the distal aspect of the crown margin. The radiographic examination showed a stable bone level when compared with the prior film, with no signs of periapical disease (Figure 1H).

Case 2
A 46-year-old male patient presented at the endodontic clinic with a cracked mandibular right first molar. He said he felt the tooth had cracked two days earlier when he chewed food. From the dental history, it was learned that the tooth had been treated by pulp mummification previously. The clinical examination revealed a large mesial-occlusal
amalgam restoration on the mandibular right first molar, with a fracture running from the mesiolingual surface to the distal surface along the margin of the restoration, separating the tooth into two distinct components (Figure 2A). The fracture extended subgingivally. The lingual fragment was mobile in the lateral direction, and there was no mobility of the buccal part. The tooth was nonresponsive to pulp vitality testing. No pockets around the tooth were detected. Periapical radiography showed a normal periodontal ligament of the tooth and no signs of periapical disease (Figure 2B). With the patient’s consent, local anesthesia was administered, the mobile lingual segment and the silver amalgam restoration were removed, and a one-visit root canal treatment was performed. The remaining crown was restored temporarily with zinc oxide–eugenol–based cement applied supragingivally (Figure 2C). No antibiotic was administered. The visual examination showed that the lingual surface of the extracted segment comprised the cervical thirds of both the mesial and distal roots, that the fracture of
the roots was oblique in pattern, and that the longest distance from the cementoenamel junction of the segment to the apical level was roughly 5 mm (Figure 2D).

At the ten-day follow-up, the patient was asymptomatic, and the soft tissues were healthy (Figure 2E). The zinc oxide–eugenol cement was removed, a 1.3-mm–thick glass fiber–composite post (Produits Dentaires SA, Vevey, Switzerland) was luted in the mesiolingual canal, and a coronal restoration with composite resin (Z250, 3M ESPE) was then placed at the juxtagingival level (Figure 2F). A porcelain fused to the metal crown was chosen to restore the tooth.

At the two-year, seven-month follow-up, the tooth was free of clinical symptoms, was functioning normally, and had a healthy clinical appearance (Figure 2G). No pockets were observed around the tooth. The radiographic examination revealed a normal periodontal ligament of the tooth and no signs of periapical disease (Figure 2H).
Case 3

A 64-year-old female patient presented with a crown fracture of the maxillary left second molar. She said she felt the tooth had cracked the day before when she chewed food. From the dental history, it was learned that the tooth had been treated by pulp mummification previously. The clinical examination showed a large occlusal-distal amalgam restoration on the maxillary left second molar and a fracture line running mesiodistally along the margin of the restoration, separating the crown into buccal and lingual parts (Figure 3A). The buccal fragment was mobile in the lateral direction, there was no mobility of the lingual part, and the tooth was nonresponsive to pulp vitality testing. No pockets around the tooth were detected. Periapical radiography revealed no signs of periapical disease (Figure 3B). With the patient’s consent, local anesthesia was administered, the mobile buccal segment and the silver amalgam restoration were removed, and a one-visit root canal treatment was performed; two root canals (a buccal one and a lingual one) were detected and filled. The remaining crown was temporarily restored with zinc oxide–eugenol–based cement applied supragingivally (Figure 3C). No antibiotic was administered. The visual examination showed that the buccal surface of the extracted segment comprised the cervical third of the buccal root, that the fracture of the root was oblique in pattern, and that the longest distance from the cementoenamel junction to the apical level of the segment was approximately 5 mm (Figure 3D).
At the seven-day follow-up, the patient was asymptomatic, and the soft tissues were healthy. The zinc oxide–eugenol cement was removed, a 1.3-mm–thick glass fiber–composite post (Produits Dentaires SA) was luted in the lingual canal, and a coronal restoration with composite resin (Z250, 3M ESPE) was then placed at the juxtagingival level (Figure 3E). A metal crown was chosen to restore the tooth.

At the two-year, eight-month follow-up, the tooth was free of clinical symptoms, was functioning normally, and had a healthy clinical appearance (Figure 3F). The pocket probing depth did not exceed 3 mm. The radiographic examination showed a stable bone level when compared with the prior film and no signs of periapical disease (Figure 3G).

Case 4

A 69-year-old male patient presented with a crown fracture of the maxillary right second molar. He reported that pain on mastication in the tooth had persisted for approximately 1.5 months. From the dental history, it was learned that the tooth had been treated by pulp mummification previously. The clinical examination showed that a previous filling was absent, resulting in a large cavity of the maxillary right second molar. Some discharge of purulence was present in the lingual region of the tooth, and there was a fracture line running from the mesial surface to the distal side of the cavity of the tooth (Figure 4A). The lingual fragment was mobile in the lateral direction, and the tooth was nonresponsive to pulp vitality testing. No pockets around the tooth were detected. Periapical radiography revealed no signs of periapical disease. With the patient’s consent, local anesthesia was administered, and the mobile lingual segment was removed; this was followed by a one-visit root canal treatment. The files could not reach working length because the pulp canal space was totally obliterated, and the root canals were underfilled. The remaining crown was temporarily restored with zinc oxide–eugenol–based cement applied supragingivally. No antibiotic was administered. The visual examination showed that the lingual surface of the extracted segment comprised the cervical third of the lingual root, that the fracture of the root was oblique in pattern, and that the longest distance from the cementoenamel junction of the segment to the apical level was roughly 5 mm (Figure 4B).

At the fourteen-day follow-up, the patient was asymptomatic, and the soft tissues were healthy. The zinc oxide–eugenol cement was removed, a 1.1-mm titanium post (Anthogyr Company, Sallanches, France) was luted in the lingual canal, and a 0.75-mm stainless-steel post (Xihu Biomaterials Compma-
ny, Hangzhou, China) was luted in the distobuccal canal (Figure 4C). A coronal restoration with composite resin (Z250, 3M ESPE) was then placed at the juxtagingival level. A full metal crown was chosen to restore the tooth (Figure 4D).

At the three-year, six-month follow-up, the tooth was free of clinical symptoms, was functioning normally, and had a healthy clinical appearance (Figure 4E). No pockets around the tooth were detected. The radiographic examination revealed a normal periodontal ligament of the tooth and no signs of periapical disease (Figure 4F).

Case 5
A 68-year-old male patient presented with a crown fracture of the mandibular left second molar. He reported that pain on mastication in the tooth had persisted for approximately one month. From the dental history, it was learned that the tooth had been treated by pulp mummification previously. The clinical examination showed a large occlusal-lingual amalgam restoration on the mandibular left second molar and a fracture line running buccolingually along the distal margin of the restoration, separating the tooth into two distinct components (Figure 5A). The distal fragment was mobile in the lateral direction, and the tooth was nonresponsive to pulp vitality testing. No pockets around the tooth were detected. Periapical radiography revealed no signs of periapical disease (Figure 5B). With the patient’s consent, local anesthesia was administered, the mobile distal segment and the silver amalgam restoration were removed, and a one-visit root canal...
treatment was performed (Figure 5C). The remaining crown was temporarily restored with zinc oxide–eugenol–based cement applied supragingivally (Figure 5D). No antibiotic was administered. The visual examination showed that the distal surface of the extracted segment comprised the cervical third of the distal root, that the fracture of the root was oblique in pattern, and that the longest distance from the cementoenamel junction of the segment to the apical level was roughly 5 mm (Figure 5E).

At the twenty-one-day follow-up, the patient was asymptomatic, and the soft tissues were healthy. The zinc oxide–eugenol cement was removed, a 1.3-mm–thick glass fiber–composite post (Produits Dentarires SA) was luted in the mesiobuccal canal and mesiolingual canal individually, and a coronal restoration with composite resin (Z250, 3M ESPE) was then placed at the juxtagingival level. A full metal crown was chosen to restore the tooth.

At the four-year follow-up, the tooth was free of clinical symptoms, was functioning normally, and had a healthy clinical appearance (Figure 5F). No pockets around the tooth were detected. The radiographic examination revealed complete bone healing around the distal marginal surface of the tooth and no signs of periapical disease (Figure 5G).

**DISCUSSION**

In the present article, the teeth are pulpless, and since the fractures involved the chamber, we grouped these fractures into the ‘complicated’ category. The cause of these complicated crown-root fractures in molars could be attributed to large-size restorations without proper cuspal protection. A conservative treatment was presented, by which the fragments were removed to allow for proper healing of the periodontal tissues, and root canal treatments were performed; afterwards, the coronal portion could be restored at the juxtagingival level. There was good marginal adaptation, and the simple technique presented here seemed to be effective. The advantages of this treatment method include the rapid and conservative nature of the treatment and the simplicity of the procedure; in addition, there are economic advantages as well as a greater likelihood of cooperation from the patient.

Crown-root fractures have immediate implications for the endodontic, restorative, and periodontal prognoses as a result of the line of fracture, which is subgingival. The treatment objective must be aimed at exposing the fracture margins, juxtagingivally or supragingivally, so that all of the clinical procedures can be managed with strict moisture and bleeding control. The first clinical procedure involves retrieving the fragment of the traumatized tooth. This step will indicate the level of fracture and whether the pulp is involved. Only then should a treatment plan be determined.

An appropriate treatment plan after an injury is important for a good prognosis. A tooth with a complicated crown-root fracture presents many problems with regard to coronal restoration when the fracture line extends below the marginal bone level. The treatment of complicated crown-root fractures in molars is dependent on the extent, duration, and location of the fractures. According to the recommendations of the International Association of Dental Traumatology, various treatment approaches to complicated crown-root fractures have been indicated: 1) fragment removal and gingivectomy (sometimes ostectomy); 2) orthodontic extrusion of apical fragments; 3) surgical extrusion of apical fragments; 4) decoronation; and 5) extraction. However, reports on the treatment of crown-root fractures of molars are limited in number. Theodossopoulou described a case of a crown-root fracture of the mandibular first left molar in which the tooth was treated by combining orthodontic extrusion and effective endodontic and prosthetic therapy.

Preservation of the gingival biologic width is critical for the long-term success of the treatment. We intentionally selected these cases to be reported because the extent of the injuries was nearly the same. We demonstrated that healing of the periodontal tissues occurred in all of the cases, despite the different locations of the fractures. The gingiva reattached to the exposed dentin after the loose fragments were removed, and none of the teeth exhibited signs of pathology at follow-up; in addition, bone healing was observed around the incomplete root surface of the tooth (case 5). This study was confirmed, and it is concluded that the indication for conservative treatment of complicated oblique crown-root fractures of molars may be greater than previously has been thought.

There are many ways of managing crown-root fractures of a molar, and the clinician may have difficulties deciding on the appropriate treatment option. In these cases, the patients wish to preserve their own teeth. If complications occur with the conservatively treated teeth, all other treatment options, such as a fixed partial denture or a dental implant, are still possible.
CONCLUSION

These case studies demonstrate that molars with complicated crown-root fractures can be managed using an uncomplicated method, which can result in satisfactory periodontal healing.

Acknowledgement

This study was supported by the National Nature Science Foundation of China (Grant 81070832).

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

(Accepted 14 December 2012)

REFERENCES


