CASE REPORT

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Rehabilitation of Mandibular Molar Teeth with Single Crown Prosthesis After Root Resection and Hemisection Applications Due to Vertical Root Fracture: Two Case Reports

Dikey Kök Kırığına Bağlı Mandibular Molar Dişlerde Kök Rezeksiyonu ve Hemiseksiyon Uygulamaları Sonrası Kuron Protezi ile Rehabilitasyonları: İki Olgu Sunumu

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ABSTRACT

Objectives: Root resection and hemisection are multidisciplinary treatment methods that might be considered on mandibular molars with single root fractures before extraction.

Case report: In this present case report, two mandibular first molars were treated with root resection and hemisection due to the vertical root fracture on one of the roots. Fractured roots were separated from the furcation area and extracted. Three months were waited for each case for the recovery of extraction sites. Both cases were planned as single crowns, one of the superstructure was metal-porcelain and the other was a zirconia crown. During the one year follow up period, no clinical or radiographic problem was found related to the root resection and hemisection method.

Conclusion: Mandibular molar teeth with vertical root fracture, if the fracture is limited to one root only, can be successfully treated with root resection and hemisection methods and restored with a single crown prosthesis. These methods might be considered prior to extraction.

Keywords: *Molar, Tooth fracture, Crown*

ÖZET

Amaç: Kök rezeksiyonu ve hemiseksiyon; tek kök kırığı olan mandibular molar dişlerde, dişlerin çekimi öncesi düşünülebilecek multidisipliner tedavi yöntemleridir.

Olgu sunumu: Bu olgu sunumunda dikey kök kırığı olan iki mandibular molar diş olgusu kök rezeksiyonu ve hemiseksiyon yöntemleriyle tedavi edilmiştir. Dikey kök kırıkların tek kökte sınırlı olması nedeniyle her iki olgu da yönteme uygun bulunmuştur. Dikey kök kırığı bulunan kökler furkasyon bölgesinden ayrılarak çekilmiştir. Çekim yerlerinin iyileşmesi için her olguda üç ay beklenmiştir. Her iki olgunun protetik rehabilitasyonunda da tek kuron protezi planlanmış, üst yapılardan biri metal-porselen, diğeri ise zirkonyum olarak tercih edilmiştir. Bir yıllık takip sürecinde kök rezeksiyonu ve hemiseksiyon yöntemine bağlı klinik ve radyografik bir soruna rastlanmamıştır.

Sonuç: Dikey kök kırığı olan mandibular molar dişleri, eğer kırık tek kökte sınırlı ise kök rezeksiyonu ve hemiseksiyon yöntemlerini takiben kuron protezi ile başarılı bir şekilde tedavi edilebilir. Bu yöntemler, dişin çekiminden önce düşünülebilir.

Anahtar kelimeler: *Azı dişi, Diş kırıkları, Kuron protezi*

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Introduction

The importance of minimally invasive interventions and conservative therapeutic techniques has been increasing as patients desire to age with their teeth. Root resection and hemisection applications appear as multidisciplinary and conservative alternatives to tooth extraction. According to The American Association of Endodontics root resection is ‘’sectioning and surgical removal of one or two roots and the adherent soft tissues of a multirooted tooth leaving the crown of the tooth intact and supported by remaining roots’’ and hemisection, in other words bicuspidization, is “the vertical surgical separation of a multirooted tooth, usually a mandibular molar, through the furcation in such a way that a root and the associated portion of the crown may be removed or retained”.[1,2]

A vertical root fracture, which is one of the many indications of root resection and hemisection, is a longitudinally oriented fracture of the root extending from the root canal to periodontium. Vertical root fractures usually occur in endodontically treated teeth due to the loss of moisture and structural integrity, exhibiting specific clinical and radiographic signs that should alert the practitioner to the possibility of a root fracture. Local chronic infection formation around the vertical fracture line represents itself as mild pain upon mastication, swelling of surrounding soft tissues, and narrow isolated periodontal pockets on its’ early stage. When patient neglects initial subjective signs, radiographically slight widening of the periodontal ligament space turns into unexplained bone loss around the furcation area and V shaped bone loss along the vertical axis of the related root.[3-6] Treatment of vertical root fracture in endodontically treated teeth is often extraction but root resection and hemisection offers an alternative in such cases which root fracture is concentrated on one root only.[7] The root that is considered to be preserved and the associated crown are kept in place at the level of furcation preserving the tooth’s integrity.[8] Right case selection for root resection and hemisection is the key to the long term success of this treatment method which is based on extend and the pattern of bone loss, root trunk and root length, ability to eliminate the osseous defect, and endodontic and restorative situation of the remaining root.[1] Factors related to long-term prognosis in a review article are defined as: contouring and quality of root canal therapy and the final restoration of the retained root, and the ability to maintain the integrity of the supporting periodontal hard and soft tissues.[9]

According to Weine, the indications for hemisection can be divided into periodontal indications, restorative and endodontic indications. Periodontal indications are severe vertical bone loss confined to one root of a tooth with multiple roots, grade IV through and through furcation destruction, root exposures and dehiscence, and when a root of the adjacent teeth is too close to maintain hygiene within the same quarter. Restorative and endodontic indications are prosthetic failure of abutments within a periodontal splinting, when a root canal cannot be instrumented, perforation of the furcation area or one of the roots, trauma resulting in a vertical root fracture, or deep dentin caries involving root dentin. Although vertical root fracture is listed under endodontic and restorative indications, according to Weine, it results in severe bone loss around the related root and can also be considered a periodontal indication. The advance of the fracture line should be well determined, and it should be ensured that the fracture is limited to one root only. On the other hand, the presence of strong adjacent teeth available for bridge abutment, root canals that cannot be instrumented, and root fusions are considered contraindications for the method.[9-11]

After root resection and hemisection, the distribution of occlusal force and the force that is going to be directed on the resected/hemisected tooth alter, leaving the remaining root and the associated crown withstanding the functional loads placed on them, such as bridge abutment. The frequent reporting of root fractures in resected/hemisected molars with higher occlusal loads proves that the amount of occlusal force is significant for the long-term success of the fixed bridge. When the tooth has lost part of its crown and root support, it will necessarily require a restoration in order to function. Unfavorably, a restoration may contribute to periodontal destruction, or an incorrectly shaped occlusal contact region might increase the risk of destructive forces and predispose trauma resulting in failure of root resection/hemisection. As a whole, root resection and hemisection treatment protocols integrate principles from prosthodontics, oral surgery, endodontics, periodontics, and restorative dentistry and should be carried out with precision.[1,10-12]

The aim of this case report is to indicate that successful clinical and radiographic results can be obtained if the root resected and hemisected mandibular molar teeth are prosthetically rehabilitated a with single crown prosthesis after vertical root fractures occurring in a single root.

Case Report 1

A 35-year-old female patient attended our clinic with the chief complaint of swelling on the lower left side; she also mentioned pain upon mastication. The patient was systemically healthy, a non-smoker, and didn't indicate regular medication use during medical anamnesis. On clinical examination, swelling was observed between teeth 35 and 36. The patient mentioned having a root canal treatment in the related area three years ago. A periodontal probe was carefully inserted parallel to the long axis of tooth 36; nearly 11 mm of pocket depth and bleeding were noted from the mesio-buccal side. Probing depths on the disto-buccal sides of teeth 35 and 36 were 4 mm and 3 mm, respectively. During the radiographic examination, the orthopantomogram showed slight bone loss at the furcation area and around the coronal one third (1/3) of the mesial root. Early-stage furcation involvement (Grade I) was noticed for tooth 36. A CBCT was taken, and a 3D image showed circumferential bone destruction around the mesial root.

Both clinical and radiographic evidence led to the diagnosis of a vertical root fracture on the mesial root of tooth 36 (Figure 1). Treatment options were explained to the patient; hemisection and a single crown, as a more conservative and economic option compared to an implant, or a fixed partial denture was decided. Informed consent was obtained before any interventions.

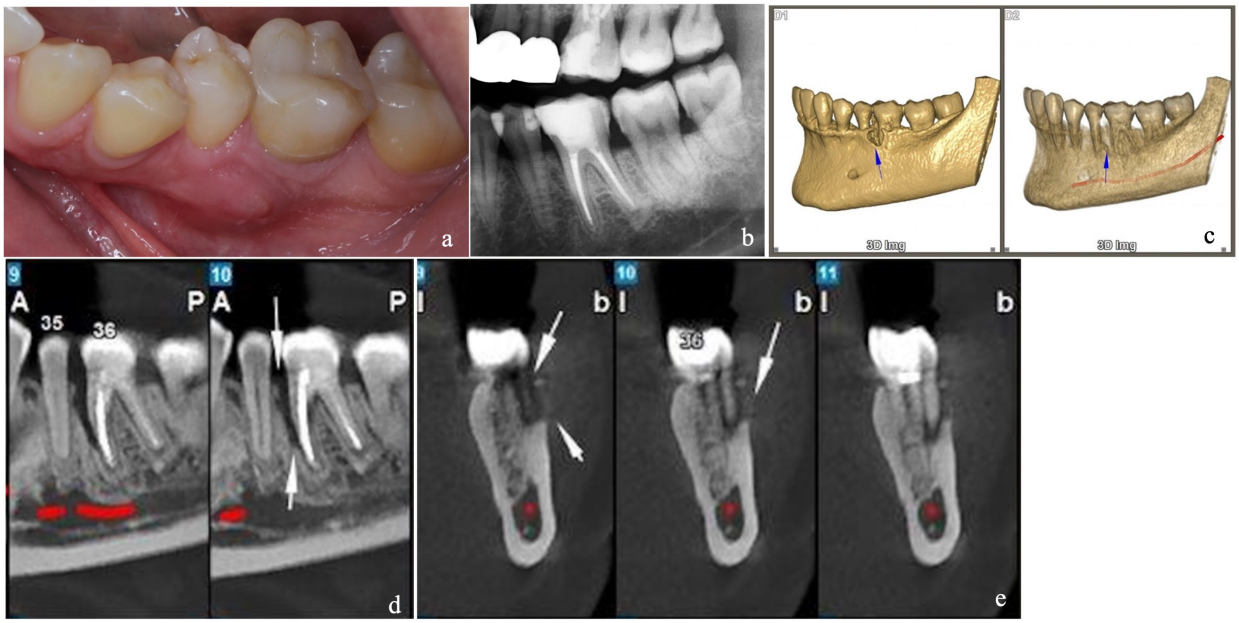

Figure 1. Preoperative diagnostic images.
(a) Clinical image showing swelling between teeth 35 and 36
(b) The orthopantomogram showing slight enlargement of lamina dura around the coronal 1/3 of the mesial root and the furcation area
(c, d, e) CBCT images showing bone loss around the mesial and buccal sides of the mesial root

Current root canal treatment of the related tooth was examined through CBCT sections, and it was decided that there was no need for a retreatment of the root canal on the distal root. In order to avoid further progressive bone loss around the furcation area and the supporting bone around the distal root of tooth 36, an appointment was given to the patient for the extraction of the mesial root. Five days of antibiotic prophylaxis was prescribed prior to the surgical intervention. During the surgical procedure, an inferior alveolar nerve block and buccal infiltration anesthesia were applied. Without raising a flap, the mesial root and its' associated crown were separated from the distal root and its' associated crown at the level of furcation. The mesial root and its' associated crown were extracted, and the granulation formation was curetted for better healing of the extraction site. A control radiograph was obtained after the surgical procedure. Scaling and root planning of teeth 35 and 37 were also performed as surgical access was provided. The extraction socket was left for secondary healing. The patient was advised to continue brushing her teeth while paying attention to the intervention area and informed to contact us in case of swelling or pain after three days of extraction. A NSAI analgesic (Brufen 400 mg 3x1) was prescribed for post-operative pain. Three weeks after the extraction, initial periodontal therapy of the whole mouth was performed. A total of three months were spent waiting for the maturation of the bone at

the extraction site before the prosthetic phase. In the prosthetic phase, feather edge preparation was used on the remaining crown. An impression was obtained using Zhermack Elite HD+ type A silicon. Keeping the patient's esthetic concerns in mind, the hemisected mandibular molar was restored with a single zirconia crown. CEREC MTL medi A2 zirconia block was used for this restoration. It was ensured that the interproximal contacts were tight enough to prevent food impaction, were suitable for dental floss use, and reflected the patient's natural contact anatomy. Also, occlusal contacts were arranged carefully to prevent the hemisected root from withstanding excessive loads. On centric occlusion, contacts were limited to the functional cusps, and there was no contact during lateral movements of the mandible (Figure 2).

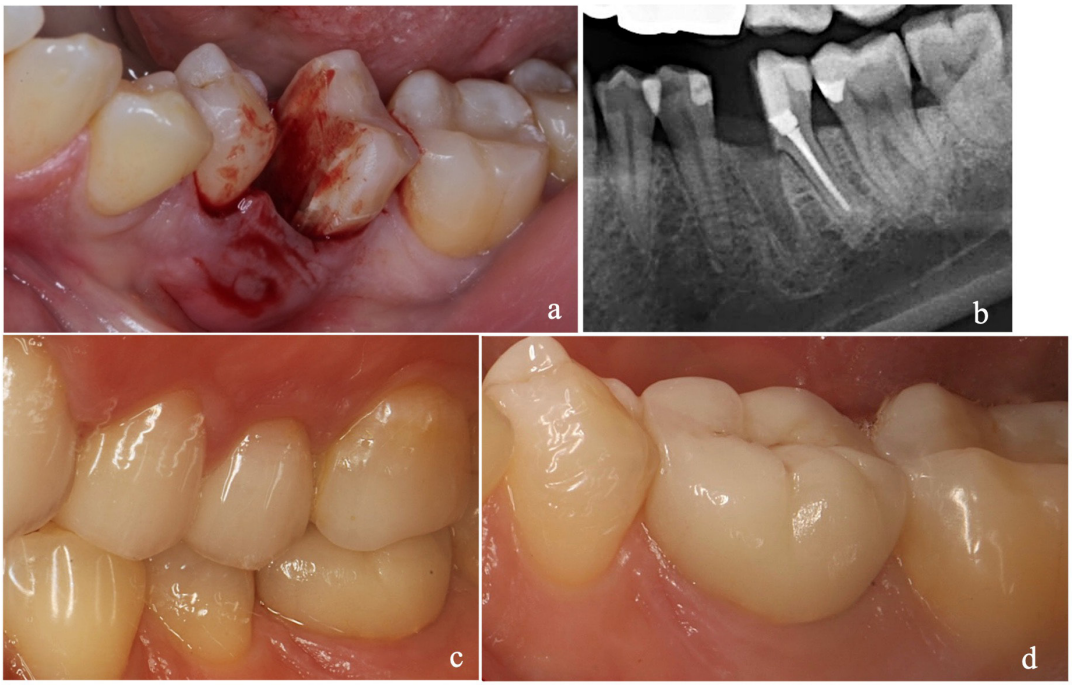

Figure 2. Surgical and prosthetic treatment phases respectively.
(a) Intraoral image after the extraction of the mesial root and its' associated crown
(b) Radiographic image taken after the extraction of the mesial root and its' associated crown
(c) Intraoral image of hemisected mandibular molar in centric occlusion after restored with a single zirconia crown
(d) Intraoral image of interproximal contacts and marginal adaptation of hemisected mandibular molar after restored with a single zirconia crown

Follow-up radiography was obtained on a routine control appointment at the end of the first year (Figure 3). The patient had no complaints related to the hemisection treatment within this one-year period. On intraoral examination, gingival tissues surrounding the hemisected molar were clinically healthy with a pink and firmly attached appearance. On radiographic examination, there was no sign of bone loss. Initial and follow-up findings of case 1 are given in Table 1.

Figure 3. Follow-up orthopantomogram taken on a control appointment 1 year post treatment.

Table 1. Initial and follow-up findings of case 1.

Case 1	Initial Findings	Follow-up Period (12 months)
Pain	Pain upon mastication	-
Swelling	Observed between teeth 35 and 36	Clinically healthy pink and firmly attached appearance
Probing Depth	11 mm probing depth on the mesio-buccal side	No more than 4 mm
Bleeding on Probing	+	-
Radiographic Evaluation	Orthopantomogram: Bone loss at the furcation area and around the coronal one third (1/3) of the mesial root CBCT: Circumferential bone loss	No sign of bone loss
Furcation Involvement	Early-stage furcation involvement (Grade I)	-

Case Report 2

A 29-year-old female patient attended our clinic with the chief complaint of blunt pain upon mastication on the lower left side. The patient was systemically healthy, currently smoking 10 cigarettes a day, and didn't indicate regular medication use during medical anamnesis. The tooth was root canal treated in our clinic one and a half years ago and restored with a single metal-porcelain crown. During previous treatment, our patient was told that she has bruxism and was recommended to use a stabilization splint, but the patient didn't agree to this treatment. A diagnostic orthopantomogram was taken, and an enlargement of the lamina dura was observed in the furcation area of tooth 36, where the patient was describing the pain. After 15 days, bleeding on probing and 8 mm of pocket depth were observed when a periodontal probe was inserted into the mesial side of the distal root from the furcation area. Early-stage furcation involvement (Grade I) was noticed for tooth 36. The diagnosis of a vertical root fracture was made, and the treatment options were explained to the patient. The patient stated that she experienced intermittent gingival inflammations in the gingival tissues surrounding the implant in the area of 46. Bone loss around the most coronal part of the implant and the presence of initial periimplantitis were explained to the patient through radiographic images. The patient was informed that the probability of developing periimplantitis is higher in currently smoking patients who do not regularly participate in periodontal maintenance therapy. The patient was willing to retain the tooth, so root resection and a single crown as a more conservative and economic option compared to extraction, implant treatment or fixed partial denture was suggested. An informed consent was obtained before any interventions (Figure 4).

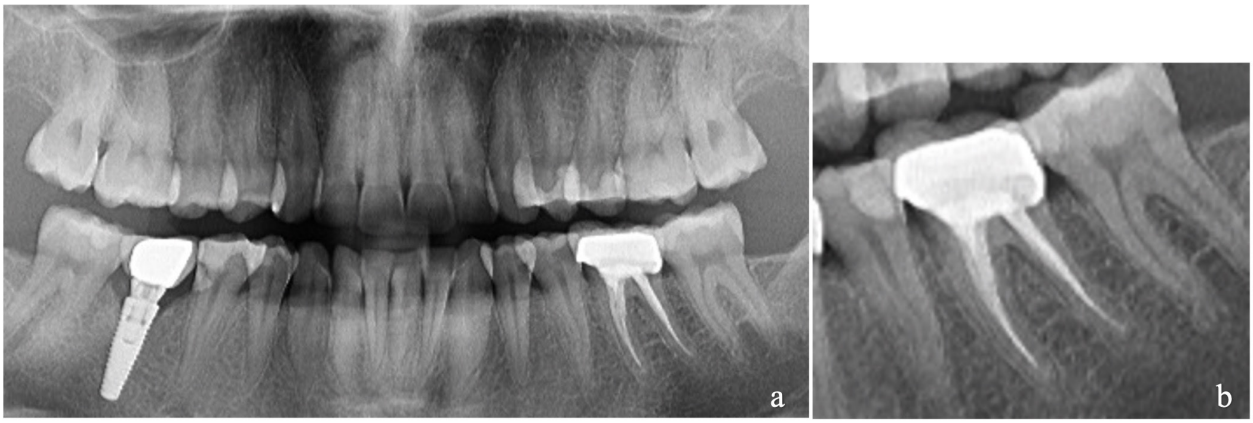

Figure 4. Pre-operative diagnostic radiographic images.
(a) Pre-operative diagnostic orthopantomogram
(b) Magnified orthopantomogram showing slight enlargement of the lamina dura at the furcation area where patient was localizing the pain upon mastication

The procedure of the preferred treatment was explained in detail, the metal-porcelain crown was removed, and scaling of the whole mouth was performed on the first appointment. As there were no acute infection indicators, no antibiotic prophylaxis was prescribed. A temporary crown was prepared with GC Tempsmart A2. At the second appointment, three weeks after the initial periodontal therapy, a temporary crown was removed, an inferior alveolar nerve block, and a buccal infiltration anesthesia were administered. Since the root canal treatment was performed in our clinic one and a half years ago, no reason was found for a retreatment. Without raising a flap, the distal root was separated from the mesial root and the crown at the level of furcation and extracted. Granulation tissues were curetted, and root planning of teeth 35 and 37 was performed as surgical access was provided. The extraction socket of the distal root was left for secondary healing. The patient was advised to continue brushing her teeth while paying attention to the intervention area and quit smoking for a minimum of seven days. The patient was informed to contact us in case of swelling or pain after three days of extraction. A NSAI analgesic (Brufen 400 mg 3x1) was prescribed for post-operative pain. Three months were waited before the prosthetic phase. The patient was satisfied with the previous metal-porcelain crown and had no esthetic concerns, so a new metal-porcelain single crown was decided as the material of choice and was also more affordable compared to zirconia. Feather edge preparation was used, and the impression was taken with GC Flexceed type A silicon at the third appointment. During the try-in of the metal framework, adaptation with the resected root and the marginal finish line was controlled at the fourth appointment. For the porcelain try-in, the selected shade was 3M2, and prepared with VITA VMK Master. Care was taken that the pontic extending towards the extracted distal root did not press on the gingiva and was cleanable for the patient. Occlusal contacts were carefully arranged and adjusted to prevent excessive loads on the resected root. On centric occlusion, contacts on the nonfunctional cusps were removed. Also, to prevent the detrimental effects of the oblique forces, lateral movements of the mandible were checked, and contacts were eliminated. Only the centric contact on the mesio-buccal cusp, which coincides with the resected root was kept (Figure 5).

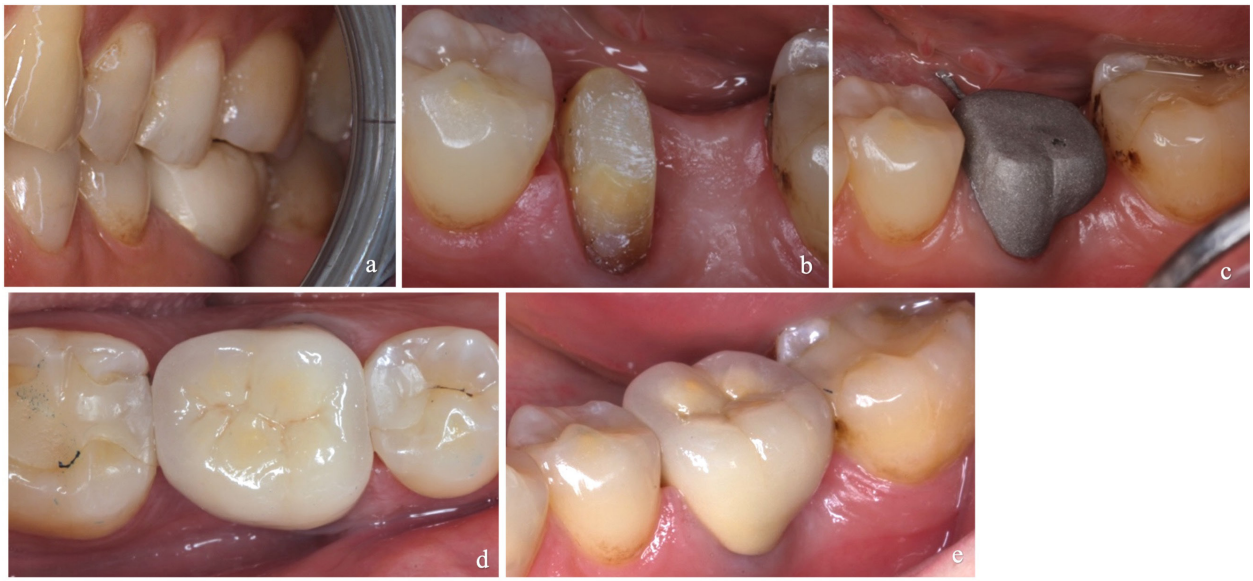

Figure 5. Prosthetic treatment phases respectively
(a) Intraoral image of the temporary crown prepared with GC Tempsmart A2
(b) Intraoral image of the feather edge preparation on hemisected mandibular molar
(c) Intraoral image of the metal framework try-in
(d) Intraoral image of porcelain try-in (occlusal view)
(e) Intraoral image of porcelain try-in (buccal view)

No radiolucency indicating bone loss around the resected root was observed on the control orthopantomograms taken at the patient's one year and 18-month appointments (Figure 6). No pathological findings related to the applied treatment were found in the intraoral examination. The gingival appearance surrounding the resected molar was clinically healthy, there was no bleeding on probing or pocket depths greater than 3 mm. The patient did not have any complaints about the hemisection treatment. Initial and follow-up findings of case 2 are given in Table 2.

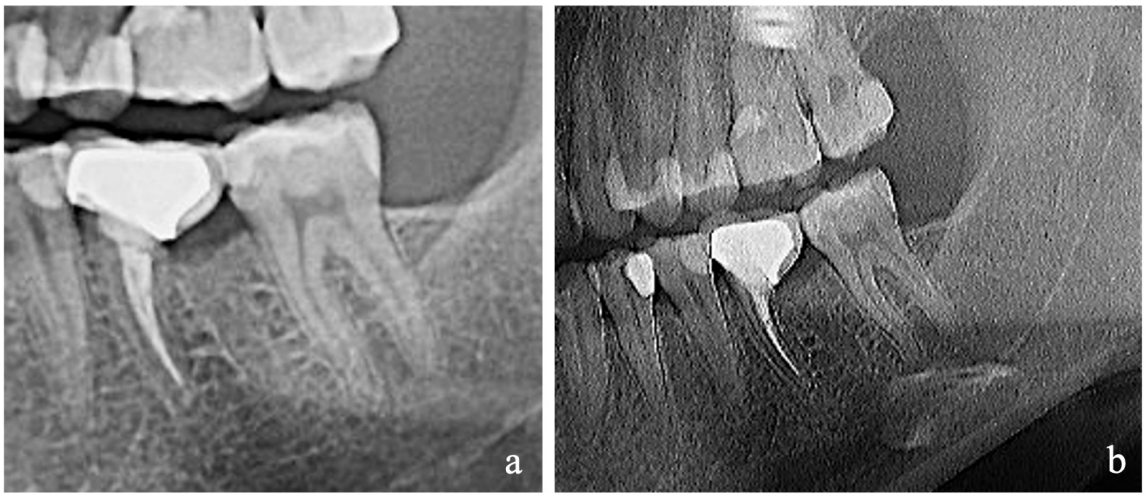

Figure 6. Follow up radiographs
(a) Control orthopantomogram taken at the patient's 1 year post treatment
(b) Control orthopantomogram taken at the patient's 18-month post treatment

Table 2. Initial and follow-up findings of case 2.

Case 1	Initial Findings	Follow-up Period (12 months)
Pain	Blunt pain upon mastication	-
Swelling	-	Clinically healthy pink and firmly attached appearance
Probing Depth	8 mm probing depth at mesial side of the distal root	No more than 3 mm
Bleeding on Probing	+	-
Radiographic Evaluation	Enlargement of the lamina dura at the furcation area of tooth 36	No sign of bone loss
Furcation Involvement	Early-stage furcation involvement (Grade I)	-

Discussion

Endodontic failures, strip perforations, advanced coronal destructions, vertical root fractures, severe furcation involvements, or endo-perio lesions, if confined to one root only, mandibular molars can be considered good candidates for root resection and hemisection.[7,9-11]

In this present case report, two cases were treated with root resection and hemisection methods; both cases were mandibular molars with vertical root fractures. Intraoral and radiographic findings such as swelling, increased probing depth, bleeding on probing, bone loss, pain upon mastication, and radiolucency around the fracture line were taken into consideration during diagnosis. In both cases, related roots with vertical root fractures were separated from the furcation area and extracted. In order to keep the treatment process as minimally invasive as possible, a flapless surgical protocol was performed by the same surgeon in both cases. Prosthetic rehabilitation of remaining roots and associated crowns as single crowns was performed 3 months after extractions. Within 1-year follow-up periods, root resected and hemisected molars were healthy clinically and radiographically. Extended periods of follow-up may be needed for long-terms results.

There are several case reports focusing on root resection and hemisection methods in the literature.[7,8,12-24] Hemisection of a mandibular right second molar with vertical root fracture on the mesial root was presented in a case report by Uysal et al. in 2015 and after 3 years of follow up case was healthy clinically and radiographically.[7] In a case report Jun-Beom Park hemisected two mandibular molars

with periodontal pathosis, no noticeable bone loss or mobility was detected after 7 years.[13] Hemisection of a mandibular molar due to decay was performed in another case report by Saad et al. and used for 1 year without any complications as the terminal abutment of a fixed prosthesis.[14] Also a case report with over 36 months follow up by Hanafi, aimed to retain a mandibular primary second molar treated by hemisection in order to avoid orthodontic disorders that might result from extracting primary molars and leaving the area without any space maintainers.[15]

Given the available treatments for replacing severely damaged and unrestorasble teeth like fixed partial denture, removable partial denture, and dental implants, the use of root resection and hemisection may offer better prognosis.

Several other studies as systematic reviews and analysis have been made about the survival and failure rates of root resected and hemisected teeth.[9,25-30] According to a review article by Saraf et al. outcomes of several studies reveal success rates ranging from 62% to 100% with follow up periods of 1 to 23 years and they came to the conclusion that when hemisection is performed, an overall success rate of approximately 88% can be predicted.[9] In a systematic review by Nadim et al. survival and failure rate of root resection/hemisection ranging from 40.3% to 100% and follow up from 6 months to 23 years were reported.[25] The long terms results of root resection and hemisection of 195 patients with up to 40 years follow up were evaluated in a retrospective analysis by Megarbane et al. and showed that the overall survival rate was 94.8%.[26] On the other hand, Buhler reported a 32% failure rate at 10 years follow-up on 34 resected molars with the main reason of failure as root fracture and endodontic pathology, while only one tooth was extracted due to periodontal breakdown. A similar failure rate was found by Blomlof et al., in a follow-up 3 to 10 years later.[27,28] Long-term results of success or failure is depended on case selection and careful operation of the root resection and hemisection methods as well as the restoration of the resected/hemisected teeth.[1,7-9]

There are studies in the literature which focus on restorations of resected/hemisected teeth.[31-33] In 2014, V. Ronay et al. evaluated survival and patient satisfaction of CAD/CAM reconstructions to restore root resected molars by using ceramic single-unit crowns and demonstrated that this may be regarded as a cost-effective and conservative treatment modality with high patient satisfaction.[31] Also, Schmitz et al. studied the clinical success and survival of single crowns on root resected molars in a retrospective multicentric study and stated that the overall survival rate was 93%.[32] However, finite element and photo elastic methods were employed to investigate the stress distribution in a stress analysis study of different fixed prosthesis designs after hemisection of molar teeth in 2007 and resulted that the stress around the reserved root in the single crown was over 3 times as much.[33]

In both of the presented cases, single crown restorations were performed as a more conservative and respectful approach to remaining sound tooth structure compared to a fixed partial denture. However, the stress-bearing capacity and distribution of this stress are the main concerns in this method. Centric and eccentric forces directing to single crowns should be arranged for long-term survival. Contacts on the nonfunctional cups during centric occlusion and contacts during lateral movements of the mandible were eliminated. Also, centric contact on the cusp that coincides with the resected/hemisected root was preserved to distribute the occlusal force along the long axis of the root.

Studies not only evaluating the survival of resected/hemisected molars but also comparing their survival with that of molar implants have been made.[34,35] Root resected or hemisected mandibular molars and dental implants for replacing mandibular molar teeth were evaluated and compared for their complication and survival rates during a maintenance care period of at least 4 years by Zafiropoulos et al. in a retrospective nonrandomized study and indicated that a complication-free survival of 6 years could be expected.[34] Also, molar position implants and root resected molars were compared in function by Fugazzotto. The study resulted that the highest degree of failure when molar implants and hemisected molars were lone-standing terminal abutments, and overall success rates of 97.0% for molar implants and 96.8% for root resected molars were found.[35]

By referring to these studies with extended sample sizes and follow-up periods, the root resection and hemisection method can considered as valid option for furcated molars. In this present case report, two mandibular first molars were treated with root resection and hemisection due to the vertical root fracture of one of the roots. In both cases, the fractured roots were extracted without allowing further bone loss around the healthy section of the tooth. Patient age, oral hygiene habits, periodontal status, and preference to retain a tooth also affected the treatment of choice. When a mandibular molar is

root resected/hemisected, the lone standing root will have to withstand the functional occlusal forces by itself. Therefore, careful selection of the restoration type and correction of the occlusion are necessary.

Conclusion

Mandibular molar teeth with a vertical root fracture, if the fracture is limited to one root only, can be successfully treated with root resection/hemisection methods, and restored with a single crown prosthesis. These methods are valid options and should be considered before extraction or implant treatment of any furcated molar. Patient selection, execution of the root resection/hemisection procedure, and restoration of the resected/hemisected tooth require a multidisciplinary approach and have a great influence on the survival rate. Further follow-up on the cases is required.

Conflict of interest

None of the authors of this article has any relationship, connection or financial interest in the subject matter or material discussed in the article.

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Authorship Contributions

Idea/Concept: D.K, B.K, D.Ş Design: B.K Control/ Supervision: D.Ş Literature Review: D.K, B.K Data Collection and/or Processing: D.K, B.K Analysis and/or Interpretation: B.K, D.Ş Writing the Article: B.K Critical Review: D.Ş

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