OKTOBAR / OCTOBER 2004 • VOLUMEN / VOLUME 10 • BROJ / NUMBER 1-2 www.mednal.com

MEDICINSKI ŽURNAL
MEDICAL JOURNAL

KLINIČKI CENTAR UNIVERZITETA SARAJEVO - INSTITUT ZA NAUČNO ISTRAŽIVAČKI RAD I RAZVOJ

KLINIČKI CENTAR UNIVERZITETA SARAJEVO

INSTITUT ZA NAUČNO ISTRAŽIVAČKI RAD I RAZVOJ

ISSN 1512-5866

TRAUMATSKE POVREDE ZUBA - FRAKTURE KORIJENA
TRAUMATIC INJURIES TO THE TEETH ROOT FRACTURES

Halid Sulejmanagić , Naida Sulejmanagić, Samir Prohić
Clinic for Oral Surgery and Oral Medicine, School of Dental Medicine, University of Sarajevo
Bolnička 4a, 71 000 Sarajevo, Bosnia and Herzegovina
Klinika za oralnu hirurgiju i oralnu medicinu, Stomatološki fakultet, Univerzitet u Sarajevu
Bolnička 4a, 71000 Sarajevo, Bosna i Hercegovina

SAŽETAK

U ovom radu predmet interesovanja autora su frakture korijena kao segment traumatskih povreda zuba.
Frakture korijena su takva vrsta dentalne traume kod koje su zahvaćeni dentin, cement i pulpa. Rijetko se javljaju o čemu govori i podatak da im pripada 0.5 do 0.7% svih trauma stalne denticije i 2-4 % svih trauma mliječne denticije. Najčešće nastaju kao posljedica djelovanja jake frontalne sile pri tučama i povredama stranim tijelima. Obično se javljaju kod populacije između 11 i 20 godina pri čemu je zahvaćena stalna denticija i to prevashodno maksilarni incizivi. Kod pacijenata sa nezavršenim rastom i razvojem korijena, frakture se rijeđe javljaju što se objašnjava elasticitetom alveolarne čašice. Frakture korijena se obično javljaju u kombinaciji sa drugim tipovima dentalnih povreda. Među njima se najčešće nađu prateće frakture alveolarnog grebena, posebno u regiji mandibularnih inciziva. U radu se ističe značaj dijagnoze i problemi sa kojima se susreću mnogi kliničari pri dolasku do prave dijagnoze.
Poseban dio rada odnosi se na ulogu pulpe i periodontalnog ligamenta u procesu zarastanja fraktura korijena. Shodno tome opisani su načini zarastanja i vrste resorptivnih procesa koji prethode zarastanju.
U dijelu o terapiji fraktura korijena dat je prikaz iz literature najnovijih pokušaja raznih autora kojima je svima cilj što duže zadržavanje zuba sa frakturom korijena u usnoj šupljini.
Ključne riječi: fraktura korijena, resorpcija, zarastanje

Root fractures belong to the dental traumas that affect dentine, cement and pulp. They rarely occur and this is proved by the fact that they account for only 0.5 to 0.7 % of all traumas of permanent dentition and 2-4 % of all traumas of deciduous dentition.

ABSTRACT

This article deals with root fractures as a segment of traumatic injuries to the teeth. Root fractures belong to dental traumas that affect dentine, cement and pulp. They occur rarely and this is proved by the fact that they account for only 0.5 to 0.7 % of all traumas of permanent dentition and 2- 4 % of all traumas of deciduous dentition.
Most commonly, they occur as a result of a strong thrust force in fights and foreign body- related injuries. They commonly occur in patients aged 11 to 20 years afflicting the permanent dentition, primarily the maxillary incisors.
In patients with growth and root development not yet completed, fractures occur even less frequently which is accounted for by the elasticity of alveolar caliculus. Root fractures commonly appear coupled with other types of dental fractures. The most common concomitant effects are alveolar ridge fractures, particularly in the region of mandibular incisors.
This article focuses on the paramount importance of proper diagnosis and the problems clinicians encounter in arriving at such a diagnosis.
A part of this article is related to the role of pulp in root fracture healing process. In accordance with that, different modes of healing and different kinds of resorption processes prior to healing have been described.
In the part of the article on root fracture treatment we have presented a survey of references concerned with the most recent efforts of various authors whose aim is to preserve the teeth with root fracture in the dental cavity as long as possible.
Key words: root fracture, resorption, healing

INTRODUCTION

Root fractures belong to the dental traumas that affect dentine, cement and pulp. They rarely occur and this is proved by the fact that they account for only 0.5 to 0.7 % of all traumas of permanent dentition and 2-4 % of all traumas of deciduous dentition.

Most commonly, they occur as a result of a strong thrust force in fights and foreign body-related injuries. They commonly occur in patients aged 11 to 20 years afflicting the permanent dentition, primarily the maxillary incisors. The statistical data indicate that 75% of injuries pertain to maxillary incisors (1).

In patients with growth and root development not yet completed, fractures are less common which is accounted for by the elasticity of alveolar caliculus. Therefore, these teeth tend to be more sensitive to luxations rather than to root fractures. Nevertheless, the careful analysis of x-ray shots in luxations can reveal partial root fractures.

In deciduous dentition root fractures do not commonly occur prior to completion of growth and root development, and as a result, they occur most commonly in children aged 3-4 years with the onset of physiological resorption which has enfeebled the root itself in this way.

Most commonly, root fractures appear coupled with other kinds of dental injuries. The most frequent concomitant effects are alveolar bridge fractures, particularly in the region of mandibular incisors. Forty percents of root fractures are coupled with alveolar ridge fractures (1). Besides that, soft tissue and adjacent teeth injuries are quite common in this case. All this indicates to the importance of proper diagnosis after a dental trauma. At this, we must not neglect agonist and antagonist teeth. The treatment should be multidisciplinary and it must involve a harmonized surgical, orthodontic and prothetic therapy. Periodical control check-ups are indispensable (1).

DIAGNOSIS

Clinical examination data indicate to how the injury has occurred. Clinical examination of the tooth with root fracture enables us to see that such a tooth is slightly extruded and it often tilts lingually (Figure1).

As a result of fracture, the tooth shows a certain degree of mobility but, most commonly, it is impossible to ascertain clinically whether it is a consequence of luxation or root fracture. Diagnosis depends entirely on x-ray. If we have doubts about the possibility of root fracture and yet, it is not shown in x-ray shot, we may take two control x-ray shots, one at the angle which is 15 "higher and another at the 15" lower angle in relation to the first x-ray shot. It often occurs that we fail to diagnose root fracture immediately after the injury has been sustained, but it is clearly detected in subsequent x-ray shots. This may be caused either by bleeding or granulated tissue between the fragments which, in turn, move the coronary fragment towards incisors or by resorption process along the fracture line which constitutes an integral part of the healing process. Root fractures may occur in cervical, middle and apical part of the root. Most commonly, we come across individual transversal fractures but also slant or multiple fractures.

The most recent studies have found evidence that middle root fractures are most common although apical and cervical root fractures are equally present.

In general, middle root fractures are overlooked in x-ray shots unless the additional ones are made at different angles. The treatment of such teeth consists of instantaneous reposition and firm immobilization in the duration of 3 months. Due to a good healing prognosis the endodontic therapy of root canal can be postponed until the confirmation of pulp necrosis. Hard and fibrous tissue and bone or the combination of the two is responsible for the healing process while root canal obliteration is a concomitant process (3).

In order to detect better root fractures in x-ray shots, in vitro studies have been conducted wherein the extracted one-root teeth with or without root fracture have been immersed into wax blocks prior to taking x-ray shots. Three x-ray shots have been made in the sizes of 1:1, 2:1 and 1:2.An expert radiologist has randomly analyzed x-ray shots without any awareness as to what teeth have sustained root fracture. The results obtained in this way have been analyzed by applying statistical tests which have proved that the three types of x-ray shots did not vary as to the correct diagnosis of fracture (4).

Moule and Kahler (5) have also done research on the problem of diagnosis of root fractures. Their conclusion is that vertical fractures are difficult to diagnose. Nevertheless, there are many specific clinical or radiological indicators which may issue a warning to a clinician that there is indeed a case of root fracture. The above authors have also considered the therapeutic procedures for anterior and lateral teeth.

Root fractures with growth not yet completed can be seen as partial-incomplete fractures which correspond to "green bough" fractures in long bones. These fractures are commonly seen as a unilateral rupture of continuity of a thin rim of the root canal. Thanks to hard tissue formation these fractures can heal (Figure 2).

Root fractures in deciduous dentition represent a special problem in respect of x-ray shots because of their superposition with permanent teeth which, in turn, aggravates or hinders the fracture diagnosis in the apical part of the root.

ROLE OF PULP AND PERIODONTAL LIGAMENT IN ROOT FRACTURE HEALING PROCESS

Pulp and periodontal ligament take part in the healing process after the root fracture, and as a result, there are two kinds of healing processes. If pulp remains intact along the fracture lines (with vascular provision preserved and devoid of any infection), the precedents of odontoblast will activate by creating a bridge of hard tissue which will bond apical and coronary fragments after 2-3 months. Cement originating in the tissue which grows in periodontal ligament will deposit in this callus. It is only in the third month after the injury that hard tissue formation between fragments can be clinically diagnosed.

In cases when pulp is significantly stretched between fracture fragments the revascularization process of the coronary part of pulp occurs. Without any bacteriological infection this process will

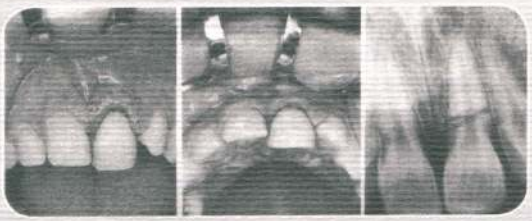

Figure 1. Clinical examination of the tooth with root fracture (2).

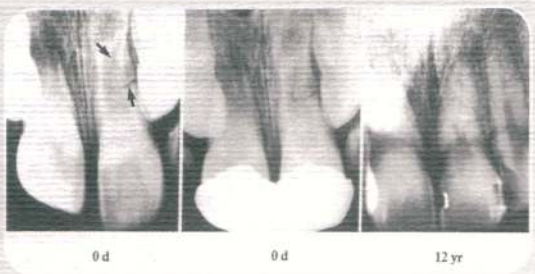

Figure 2. Root fracture with growth not yet completed – partial incomplete fractures (2).

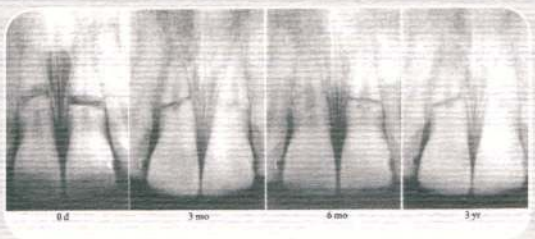

Figure 3. External and internal superficial resorption (2).

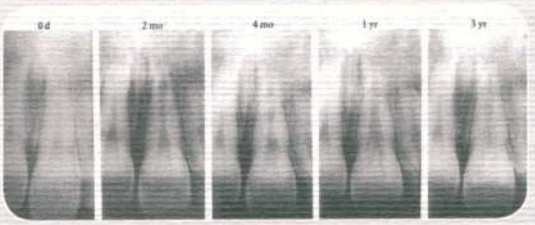

Figure 4. Internal tunnel resorption (2).

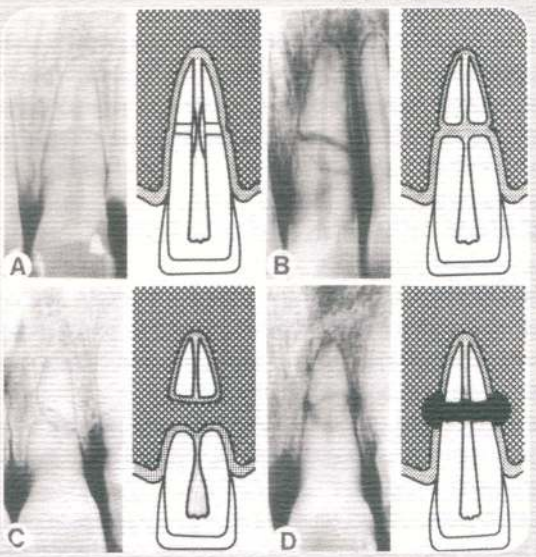

Figure 5. The modes of root fracture healing (2)

result in obliteration of the pulp canal crown part. If revascularization fails to attain the satisfactory level, the cells originating in periodontal ligament will take over bringing about the bonding of coronary and apical fragments through fibrous tissue.

And finally, if bacteria penetrate into coronary pulp we have the case of the infected pulp necrosis which results in accumulation of inflammatory granulation tissue between the fractured fragments of the root. At this, we should mention that by and large root resorption processes precede the healing processes (Figure 3 and 4). In general, these phenomena can be detected in the first year after injury. Resorption can be divided into three kinds:

1) external superficial resorption (it rounds the proximal borders of fracture on its periodontal side).

2) internal superficial resorption (it rounds fracture borders centrally on the pulp side of fracture).

3) internal tunnel resorption (it creates the tunnel beside the predentine layer and along the root canal rim in coronary fragment).

MODES OF HEALING OF ROOT FRACTURES

So far, on the basis of radiographic and histological examinations the following modes of root fracture healing have been discovered: (Figure 5)

A. Healing through calcified tissue
B. Healing by interposing of fibrous tissue
C. Healing by interposing of bone and fibrous tissue
D. Healing by interposing of granulation tissue

HEALING THROUGH CALCIFIED TISSUE

This mode of healing depends on pulp remaining intact and it is largely seen in cases without or with minor dislocation (in concussions or subluxations) of coronary fragment, mainly in the teeth with incomplete root development.

Accordingly, in this case it is the firm callus which bonds fragments. In most cases the deepest layer of the healed tissue comprises dentine while cement has helped incomplete healing of the fracture periphery part. The first layer of dentine is commonly cellular and atubular and it is followed by the normal tubular dentine layer. Cement depositing along fracture lines is commonly preceded by resorption process which runs both peripherally and centrally. In most cases there is no likelihood that cement will entirely bridge the gap between fracture surfaces but it will mix with fibrous tissue from periodontal ligament. Thanks to this coupling wherein cement manifests a greater radio-density compared to dentine, we can explain why fracture line is detected in x-ray shot in spite of the fact that fragments are closely related and the fracture itself has entirely healed.

By clinical examination of the traumatized teeth whose fragments have healed through calcified tissue we can notice that they show normal mobility in comparison with the uninjured adjacent teeth and a normal reaction to percussion. Their response to pulp sensibility tests is also normal or insignificantly enfeebled.

HEALING THROUGH FIBROUS TISSUE

This kind of healing is apparently related to a moderately injured pulp (extrusion or lateral luxation of coronary fragment) wherein pulp revascularization and/or re-enervation must be established prior to the inclusion of pulp in the healing process. In the meantime, periodontal ligament cells prevail in the healing process. This is seen histologically on the basis of fibrous tissue presence between the fragments.

In most cases, external superficial resorption precedes this mode of healing. In this mode of healing we can see rounding of fracture periphery borders in x-ray shot and x-ray brightness which separates the fragments in question.

Clinically, in this case the teeth are normally firm or slightly mobile with minor pain sensitivity when exposed to percussion. The response to sensitivity tests is commonly within the accepted boundaries.

HEALING THROUGH BONE AND FIBROUS TISSUE

Histologically, in this mode of healing we can detect a bridge which comprises bone and fibrous tissue between apical and coronary fragments while the normal periodontal ligament surrounds both fragments. In some cases the bone may penetrate into the root canals. This mode of healing is obviously a consequence of trauma prior to the completion of alveolar ridge growth; in spite of this, the coronary fragment continues its eruption while apical fragment remains fixed in the jaw.

In radiographic terms the bone bridge which separates fragments can be seen with the periodontal enclosure of both fragments. It is common to come across complete obliteration of root canals of both fragments. In clinical respect, such teeth are firm and their reaction to pulp tests is normal.

HEALING THROUGH GRANULATION TISSUE

A grave pulp injury and the subsequent pulp necrosis lead to this mode of healing. Histological examination of the teeth which heal in this manner can lead to the discovery of the inflamed granulation tissue between the fragments. In its coronary fragment the pulp is usually necrotic while its apical fragment tends to remain vital. Necrotic and infected pulp tissue is responsible for inflammatory changes along the fracture line. In some cases the communication between the fracture line and the gingival sulcus is a source of inflammation. A typical x-ray picture in this mode of healing is expansion of fracture line and rarefication of the alveolar bone which corresponds to the fracture line. If splinting immobilization is not undertaken, coronary fragment becomes mobile; it is slightly extruded and sensitive to percussion. If splinting immobilization is done, the apical fragment shifts in apical direction. Fistulas in labial mucus are common and they correspond to the fracture line itself. From the above we can notice that there are different modes of root fracture healing related to different factors. In their retrospective study on the sample of 208 teeth the authors Cvek and co-workers (6) have came to the conclusion that the roots with incomplete growth and development but the preserved pulp vitality are significantly related to pulp revitalization and healing with the hard tissue after trauma has been sustained. The same authors assert that if reposition is correctly done, there is a higher likelihood for pulp revitalization and healing with the hard tissue. In the end, they conclude that the results of this retrospective study cast a doubt on the efficacy of long-term immobilization and different kinds of splints on the root fracture healing process. Their suggestion is that the focus of further examination (investigation) should be on the means of immobilization and its duration (6).

Welbury and co-workers (7) have also dealt with different healing modes of root fractures. The aim of their study was to assess the treatment outcome of permanent incisors with root fracture with regard to pulp vitality, unity of root structures, and also to examine the influence of clinical and radiographic parameters and firm immobilization (splinting) on the outcome of therapy. The research was done on 84 teeth. They have reached a conclusion that the loss of vitality is related to crown fracture which affects porcelain and dentine. Pulp necrosis and coronary fragment luxation significantly affect the unity of the hard root tissue. The poorest survival record was noticed with root fractures in the gingival part. The firm rigid immobilization did not exert any significant influence on pulp vitality and a kind of tissue that bonded the fractured fragments (7). The incomplete growth and development of root as well as the preserved pulp vitality in a trauma are related to healing and hard tissue reparation. This assertion is also true for optimal reposition of a coronary fragment unlike the insufficient reposition. Fractures in the cervical part of root have a healing potential. Factors affecting the healing process of fractures in other parts of root are valid for this kind of fracture as well. Considered in long-term, transversal fractures have a poorer prognosis in comparison with slant fractures and this is due to tooth mobility after the treatment which invariably leads to new luxations caused by minor force (8).

THERAPEUTIC APPROACH TO TEETH WITH ROOT FRACTURE

The underlying principles of root fracture therapy in permanent teeth are the reduction of shifting of coronary fragment and firm immobilization (reposition, firm immobilization, preferably with a splint applied passively until the firm callus is formed which commonly occurs three months later). If therapy is given immediately after the trauma, digital reposition is easily achieved. The fracture of alveolar labial rim is the most likely factor which provokes resistance during the reposition procedure. In this case it is indispensable to repose the fractured bone first prior to attempting the root reposition. After the reposition of fragments it is necessary to make a control x-ray shot.

Consequently, there are counter-indications for the application of orthodontic rings in the immobilization of coronary fragment because of the traumatic effect on the pulp which has already been traumatized. This may result in pulp necrosis.

The recommendation is to use a composite splint applied passively acid - etch technique. The period of immobilization is 2-3 months so as to ensure the consolidation of hard tissue. Nevertheless, not a single research undertaken so far, has ascertained the influence of immobilization duration on the process of fracture healing. The authors Quin and co workers (9), have assessed the prognosis of the subluxated and luxated teeth as well as those with root fracture in children who were treated with a removable splint designed to stabilize the mobile anterior teeth and to eliminate the occlusal trauma due to malocclusion. The examination conducted on a large sample (270 of traumatized teeth) has shown that removable splints have a positive effect on the healing process after the sustained traumatic injuries, and this has been confirmed by a small number of complications which appeared in the monitoring period from the age of 3 to 9 years.

At this, we should bear in mind that the teeth with incomplete growth of root and with incomplete root fracture do not require immobilization; the fracture will heal with hard tissue. However, these teeth may be included in splint in cases of multiple injuries of teeth. During this period the tooth in question should undergo radiographic and sensibility tests so that we can detect pulp necrosis in due time.

The proximity of fracture line to gingival sulcus may determine a kind of treatment because there is a slimmer chance for its healing with the calcified tissue if the cervical fracture line is very near the gingival sulcus. The therapeutic choice in this case is removal of the coronary fragment and orthodontic or surgical extrusion of the remaining apical fragment.

In the case study report of Roeters and Bressser (10) the fracture of incisors has been described wherein one fracture pertained to crown and root while the other case was related only to the crown fracture. The therapy comprised surgical extrusion and restoration with adhesive materials. Eleven months later the tooth showed normal healing and restored function (10).

One of the reasons why doctors decide for root extrusion is related to finance. It is true that implants and mobile prothetic aids can successfully replace the missing teeth. However, their high price can often present a great problem for many patients. Besides, fixed and mobile prothetic aids can affect the carrier teeth in a destructive manner resulting in the damage of teeth and soft tissue. In the study (11) the treatment of incisors with a complicated crown and root fracture has been described. The fracture ran beneath the gingival border and the alveolar bridge. The treatment consisted of root extrusion followed by sprue-pin superstructure and the porcelain crown on top of it (11).

Different studies have shown that if fracture is located in the cervical part of root and beneath the alveolar ridge there is a possibility of healing and the conservative approach is justified. In cases with the satisfactory oral hygiene the therapy can comprise the permanent fixation of the coronary fragment on the adjacent teeth, which have not been traumatized, by applying composite material over contact surfaces.

In case of a dental trauma with root fracture in the middle part and pulp necrosis, the therapy included multiple application of calcium hydroxide until a calcified tissue was formed along the fracture line (12).

The similar procedure was applied by Gomes and co-workers (13). Their case study deals with the treatment of permanent incisors with crown and root fractures. The coronary fragment was treated by applying calcium hydroxide for 18 months. In clinical respect the tooth became firm and two years later the x-ray shots showed the hard tissue presence along the fracture line (13).

There have been attempts to apply adhesive cement (adhesive resin cement) in the treatment of root fracture (14). In fact, vertical fractures lead to peridontium loss which results in the creation of deep pockets and vertical bone defects. The aim of this study was to assess peridontium healing in the teeth with root fracture which has been treated by applying the adhesive resin cement. In 22 patients 23 teeth with the vertical root fracture were treated by applying 4- META/MMA-TBB cement. At this, eleven roots were treated by applying cement through the canal (Group A) while twelve roots were treated by applying adhesive cement extra orally followed by replanting (Group B). The following parameters were monitored: depth of the pocket, bleeding index from gingiva and radiographic level of bone. In all the three cases improvement was recorded. Accordingly, on the basis of the obtained results the authors recommend the adhesive resin cement in root fracture therapy because it has a good prognostic potential.

In cases where conservative treatment is not feasible and where the tooth must be extracted, we have to bear in mind that negligent extraction can result in the extensive damage of the alveolar bridge and the subsequent atrophy, particularly in labio-lingual direction. This, in turn, brings into focus the problem of aesthetic restoration treatment. This problem can be partially prevented by careful removal of apical fragment without or with minor sacrificing of the labial bone. Accordingly, if apical fragment cannot be removed through alveolar, we should consider the surgical procedure by raising mucoperiostal flap with osteothomy above apex and, in this way, push apex from the alveolar. We must not remove the marginal alveolar rim; otherwise, it will bring about the labio-lingual collapse of the alveolar ridge.

The recommended alternative to the above mentioned procedure

is to keep the apical fragment which normally comprises the vital pulp tissue. The experimental evidence have shown that deliberately imprinted root fragments in the alveolar ridge with the vital pulp, either prevent or slow down the resorption of alveolar ridge. Commonly, the roots in question are covered by a new layer of cement and also by a thin layer of the new bone over the fracture line. Apart from that, the pulp remains vital. Preliminary clinical studies indicate that apical fragments following the root fracture behave likewise, and this can be seen after healing by interposing bone and fibrous tissue has taken place. The answer to the question whether this kind of treatment is reliable or not will be provided after long-lasting clinical investigations.

We can leave the deciduous teeth which have sustained the root fracture without dislocation. It is not usually possible to immobilize these teeth nor is it relevant in any significant way. The coronary fragments with a big dislocation should be removed; otherwise, we may risk the formation of pulp necrosis. In order to prevent damage of the permanent tooth-germ we should not insist on removing the apical fragment, but instead of that, we should leave it to the processes of physiological resorption.

We should also mention that root fractures can heal spontaneously. The authors Artvinli and co-workers (15) have described this process in their case study. Nevertheless, the prognosis for the fracture healed in this manner is never as good as it is in fractures which have been treated properly.

CONCLUSION

Root fractures are still important topic in dentistry, mainly because of unsolved problems of resorption process.
Different results after treating root fractures depend of trauma greatness and proper therapy.

LITERATURE

(1) Majorana A., Pasini S., Bardellini E., Keller E. Clinical and epidemiological study of traumatic root. Dent. Traumatol 2002; 18(2):77-80

(2) J.O.Andreasen., F.M. Andreasen. Textbook and color atlas of traumatic injuries to the teeth, Munskgard, Copenhagen, 1997

(3) Camp J.H. Management of sports – related root fractures. Dent. Clin. North. Am. 2000;44(1):95-109

(4) Kositbowornchai S., Sikram S., Nuansakul R., Thinkhamrop B. Root fracture detection on digital images: effect of the zoom function. Dent. Traumatol. 2003;19(3):154-159.

(5) Moule A.J., Kahler B. Diagnosis and management of teeth with vertical root fractures Aust. Dent. J. 1999; 44(2):75-87

(6) Cvek M., Andreasen J.O., Borum M.K. Healing of 208 intraalveolar root fractures in patients aged 7-17 years. Dent. Traumatol. 2001;17(2):53-62

(7) Welbury R., Kinirons M.J., Day P., Humphreys K., Gregg T.A. Outcomes for root-fractured permanent incisors: a retrospective study. Pediatr. Dent. 2002;24(2): 98-102.

(8) Cvek M., Mejare I., Andreasen J.O. Healing and prognosis of teeth with intra-alveolar fractures involving the cervical part of the root. Dent. Traumatol. 2002;18(2):57-65

(9) Qin M., Ge L., Bai R. Use of removable splint in the tretment of subluxated, luxated and root fractured anterior permanent teeth in children. Dent. Traumatol. 2002; 18(2):81-85

(10) Roeters J., Bressers J.P. The combination of a surgical and adhesive restorative approach to treat a deep crown-root fracture: a case report. Quintessence Int. 2002; 33(3):174-179

(11) Brown G.J., Welbury R.R. Root extrusion, a practical solution in complicated crown-root incisor fractures. Br. Dent. J. 2000;189(9):477-478

(12) Sousa-Neto M.D., Santos E.S. Estrela C., Saquy P.C., Pecora J.D. Treatment of middle apical root fracture in necrotic teeth. Aust. Endod. J. 2000;26(1):15-18

(13) Gomes A.P., de Araujo E.A., Gonclaves S.E., Kraft R. Treatment of traumatized permanent incisors with crown and root fractures: a case report. Dent. Traumatol. 2001; 17(5):236-239

(14) Sugaya T., Kawanami M., Noguchi H., Kato H., Masaka N. Periodontal healing after bonding treatment of vertical root fracture. Dent. Traumatol. 2001; 17(4):174-179

(15) Artvinli L.B., Dural S. Spontaneously healed root fracture: report of a case. Dent. Traumatol. 2003;19(1):64-66.