Healing Complications After Permanent Tooth Injuries

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Abstract

Crown fractures and luxations occur most frequently of all dental injuries. An appropriate treatment plan after an injury is important for a good prognosis. An appropriate treatment plan after an injury is important for a good prognosis. Guidelines are useful for dentists and other healthcare professionals in delivering the best care possible in an efficient manner Clinical and experimental studies have shown that these healing complications can, to a certain extent, be predicted.

Keywords : Avulsion, luxation, tooth fracture, revascularization, Replantation

Introduction

Traumatic dental injuries represent a multi-faceted problem with regard to diagnosis, acute and long-term treatment, and follow-up. Some injuries (e.g. enamel infraction, enamel fractures) rarely represent a risk to the health or survival of injured teeth, whereas others like intrusions and avulsions with replantation represent a high risk for a number of complications such as pulp necrosis, root resorption, and loss of marginal bone followed by subsequent tooth loss. Clinical and experimental studies have shown that these healing complications can, to a certain extent, be predicted.

Pulpal Healing and Pulpal Necrosis

Pathogenesis : Two main scenarios are involved in the development of pulp necrosis following traumatic dental injuries. The first one is coronal or apical invasion of bacteria through dentinal tubules, or directly via exposed pulp tissue in the case of complicated crown fractures. The second scenario follows rupture of the neurovascular supply to the pulp through the apical foramen with subsequent bacterial infection of the ischemic pulp so that revascularization of the pulp cannot occur. It should be understood that the two trauma situations can also occur simultaneously. In the situations described in the first scenario, in teeth with exposed pulps, a good prognosis for pulpal healing can be expected if pulp capping or pulpotomy is performed. In situations in which severance of the apical neurovascular supply occurs, revascularization of the pulp is possible, and the success rate is primarily linked to the size of the apical foramen. Successful revascularization results in pulp canal obliteration, as normal dentinogenesis is lost after the revascularization. The revascularization process may be arrested at any level in the root canal if bacteria gain access to the ischemic part of the pulp.

Predictors For Pulpal Healing/pulpal Necrosis

The strongest healing predictor appears to be the size of the pulp-periodontal interphase (apical foramen). This factor has been found to apply to luxated teeth, avulsed and replanted teeth as well as root fractures. In 1971, Nygaard-O¨ stby & Hjortdal performed studies that can be considered the forerunner of pulpal regeneration .[1] The larger the diameter of the apical foramen, the more likely the chance of pulp revascularization. Another important predictor appears to be the length of the pulp that must undergo revascularization, and applies to luxated, avulsed, and replanted teeth. Indirectly, it also applies to root fractures in that the level of the fracture determines the length of pulp tissue needing revascularization. The shorter the pulpal length, the more likely that revascularization will take place. Since then, human avulsion case series and controlled animal studies have shown radiographic and histological evidence of successful revascularization of immature permanent teeth after replantation. In this situation, the necrotic uninfected pulp acts as a scaffold for the in-growth of new tissue from the periapical area. The absence of bacteria is critical for successful revascularization because the new tissue will stop at the level it meets bacteria in the canal space.[1]Age as a factor is closely linked to both previously mentioned factors, and in addition, after complete root formation, increasing age seems to limit the chances for pulp revascularization.

A serious consequence of intrusion of teeth with immature root formation is that the trauma results in contusion of the apical part of the pulp, thereby reducing the otherwise good chance of revascularization. Bacterial contamination of the periodontal ligament (PDL) and the pulp, a frequent occurrence in tooth avulsions, appears to decrease the chance of successful revascularization. Bacterial invasion through the dentinal tubules in luxated teeth with associated nontreated enameldentin fractures also contributes to an increased risk of pulp necrosis. In the case of enameldentin fracture without concomitant luxation injury, abstaining from treatment only appears to

imply a risk in the case of deep cervical crown fractures. Untreated pulp exposures will eventually lead to either pulp polyp formation or result in pulpal necrosis. Finally, optimal repositioning in root fracture situations has been found to favor pulp healing with hard tissue formation between fragments.

PDL Healing And Root Resorption

Resorption is an important part of a multitude of physiological and pathological processes in the human body. Resorption can affect hard tissues such as bone and dental hard tissues, but it can also involve soft tissue and foreign material such as necrotic pulp tissue or materials used in pulp capping or root filling extruded through the apical foramen. A well-known example of physiological hard tissue resorption is resorption of bone by osteoclastic activity, known as bone turnover. Parathyroid hormone (PTH), secreted by the parathyroid glands, increases the amount of calcium in the blood by various methods, one of which involves release of calcium from bones. Pathological overproduction of PTH, hyperparathyroidism, will result in imbalance in the physiological bone resorption apposition cycle, and can cause radiolucent hyperparathyroidism lesions in the jaws . PTH and PTH-related protein (PTHrP) induce spontaneous osteoclast formation and are required for tooth eruption[2] Cells resorbing hard tissues Osteoclasts are multinuclear cells responsible for resorption of bone, while odontoclasts are corresponding cells resorbing dental hard tissues. The multinuclear cells are formed by fusion of mononuclear cells. Microscopic studies of odontoclasts using three-dimensional reconstruction have shown that several mononuclear odontoclast precursor cells may undergo fusion simultaneously with each other and with multinuclear cells. Mononuclear odontoclasts can also actively resorb dental hard tissue, although during progressive resorption most cells have several nuclei. Actively resorbing mononuclear osteoclasts have also been reported .Comparative studies on cell ultra structure have shown that odontoclasts resorbing dentin or cementum are similar to those resorbing enamel . Close similarity to bone osteoclasts was also documented. A study of key enzymes in the resorptive process, acid phosphatase, cathepsin K, and matrix metalloproteinase- 9 in osteoclasts and odontoclasts during physiological root resorption in human deciduous teeth found that there were no differences in the expression of these molecules between the two cells. Based on available knowledge about osteoclasts and odontoclasts, there does not seem to be any difference between these cells other than their site of action in the body; they share a common mechanism in cellular resorption of bone and teeth .[2]Minor injuries to the PDL, such as rupture of PDLfibers, is generally followed by complete regeneration of the tissue, including its normal architecture and function. In more severe injuries, however, such as compression or crushing of the PDL as seen in subluxations, the tissue damage will stimulate macrophage recruitment to remove the injured tissue. In even more severe dental trauma (e.g. lateral luxation and intrusive luxation), in which tissue damage includes adjacent bony tissue, the recruitment of osteoclasts often occurs, leading to resorption of the root surface. The result is surface resorption (repair-related resorption) or ankylosis-related resorption (replacement resorption) depending on the size of the compression injury. Large injury areas favor ankylosis-related resorption over surface resorption . Initial resorption cavities present in surface resorption situations allow initiation of infection-related resorption (inflammatory resorption) through increased osteoclastic activity in response to bacterial presence in the pulp canal and/or dentinal tubules.

Predictors For Root Resorption

The most significant predictors appear to be the type and severity of the luxation injury (measured by the extent of PDL damage, i.e. compression vs. rupture of the PDL). Accordingly, the hierarchy of dental traumas based on their resorption potential is as follows (from least to worst): concussion, subluxation, extrusion, lateral luxation, intrusion, and avulsion with subsequent replantation. Root resorption in avulsed/replanted teeth is very strongly related to extra oral time and choice of storage medium used before replantation.

Other factors related to the risk of root resorption appear to be the presence of bacteria in the PDL, in the dentinal tubules or in the pulp, and the quality of endodontic treatment provided . A relationship between the risk of root resorption complications and the tooth's stage of root development and the patient's age has been shown to exist as increasing age and root maturation adversely affect the risk of root resorption. Both factors possibly reflect the fact that with increasing age the bony alveolar socket becomes more rigid and thus a traumatic injury may result in more PDL tissue damage.

Marginal Bone Healing And Bone Loss

Pathogenesis : The loss of marginal bone support induced by dental trauma is a rather rare phenomenon affecting mainly teeth involved in intrusion, lateral luxation injuries, and alveolar and jaw fractures. However, the loss, when it does occur, can be very extensive and lead

to tooth loss. The etiology of marginal bone loss appears to be related to the crushing of bone found in intrusion and lateral luxation injuries as well as exposure of the alveolar bone to the oral cavity in severely displaced alveolar fractures and/or jaw fractures. Transient marginal breakdown is a specific type of bone loss where contused marginal bone is temporarily affected by osteoclastic activity and later replaced by newly formed alveolar bone.

Predictors For Marginal Bone Loss

Loss of marginal bone is a rather frequent event after intrusion injuries and this factor becomes very prominent in the case of multiple intrusions. The study also indicated that age is an important factor; thus older patients have a greater chance of marginal bone loss following this type of injury. Lateral luxation injuries have a slight risk of initiating bone loss, especially in lingual areas. Transient marginal breakdown may also occur in this type of injury. Teeth associated with alveolar fractures may suffer marginal breakdown, a finding that also applies to teeth in jaw fractures with marked displacement and late or unsuccessful repositioning .

Disturbed Root Development

Pathogenesis : Luxation injuries involving teeth with incomplete root development may damage the Hertwig's epithelial root sheath (HERS). This structure is responsible for the morphology and shape of roots and any significant damage to this structure will result in partial or total arrest of further root formation. Experiments have shown that partial damage to HERS can lead to partial root development whereas total damage leads to total arrest of root development. Damage to the HERS structure in connection with dental trauma can lead to emergence of the teeth by different paths, either through direct physical damage (e.g. intrusion or lateral luxation), or indirect damage due to delayed revascularization caused by incomplete repositioning , or from damage caused by the toxic effects of acute inflammation from coronally infected pulp tissue .

Predictors For Disturbed Root Development

Among injuries leading to root development disturbances are luxations with displacement, i.e. extrusion, lateral luxation, and intrusion. Furthermore, avulsion with subsequent replantation and jaw fractures are noted for this complication. Intrusion of primary teeth may also disturb root formation in permanent successors. Finally, incomplete repositioning of displaced teeth leading to damage of the HERS has been found to be related to root development disturbances.

Tooth Survival And Tooth Loss

Pathogenesis : Tooth loss after trauma to permanent teeth can be immediate or can occur later due to complications caused by insufficient pulp or periodontal healing.

Predictors For Tooth Loss

A series of clinical investigations has shown that trauma-associated tooth loss in the permanent dentition is primarily related to avulsion/replantations, intrusions, root fractures, and crownroot fractures. In the following, each type of injury will be described with its relationship to tooth loss. It is important to recognize that trauma associated tooth loss especially affects children, and primarily in the anterior regions of the mouth; thus the esthetic impact is great and the psychological implications are significant.

Avulsion Injuries

The term “tooth avulsion” is used to describe a situation where, as a result of trauma, a tooth has been displaced out from its socket which is in fact the severing of periodontal alveolus and adjacent teeth. When the tooth is outside the socket, the cells of pulp and periodontal ligament begin to deteriorate due to the effects of lack of blood supply to the cells and other environmental factors like drying and/ or bacterial contamination. It is important to note that favorable periodontal ligament healing is the crucial factor for the success of replanted teeth.[3]These injuries have a poor prognosis due to the detrimental effect of extra oral time and storage upon the PDL and the pulp . The damage from drying and insufficient storage medium protection frequently leads to progressive root resorption. This has promoted the concept that, as a rule, replantation should not be performed in children except for exceptional cases in which the extra oral time is 5 min. It can, however, be argued that even a resorbing root, if decoronated, may lead to preservation of the alveolar process. Such preservation is necessary in order to provide an esthetic and well functioning prosthodontic or implant solution. The decoronation procedure, which was introduced in the early 1980s, uniquely allows the maintenance of both the vertical and labio-lingual growth of the alveolus supporting the decoronated root. The procedure has dramatically changed and broadened the indication for replantation of avulsed teeth even in young children. In adults, it has been found that replanted teeth undergoing progressive resorption can serve for long periods of time.

Intrusive Luxation

Monitoring of pulpal vitality in luxated teeth is

important because pulpal necrosis is common sequelae to these types of injuries. Andreasen has found that necrosis occurred in 96% of laterally luxated teeth, 64% of extruded teeth and 26% of subluxated teeth. However, traumatized teeth are inconsistent in their response to normal sensitivity tests, and thus the diagnosis of necrosis in these teeth is extremely difficult. Traumatized vital teeth have been reported to give negative responses to vitality tests initially and to have transient color changes. Return of vitality has been reported as late as two years after trauma. Andreasen has described a phenomenon of transient apical breakdown (TAB) after luxation injuries in which periapical pathosis is noted radiographically after trauma and appears to resolve without intervening treatment. In that retrospective study of 637 luxated teeth, TAB was found to occur in 2.2% of subluxated teeth, 11.3% of extruded teeth and 12.3% of laterally luxated teeth.[4]An intrusive luxation injury is characterized by crushing of the PDL and severance of the apical neurovascular interface. Owing to the very nature of this injury, numerous healing complications are to be expected. These include a high frequency of root resorption, pulp necrosis, and loss of marginal bone. In spite of this, a significant number of teeth will still survive for long periods of time, indicating that treatment efforts to retain intruded teeth are appropriate.

Root fractures

Root fractures (horizontal, intra-alveolar) represent a very complex injury where almost all components of the tooth are injured (cementum, dentin, pulp, PDL, and sometimes also the bone). In spite of this, a significant number of these teeth will heal, and about 2030% of these will heal with a hard tissue barrier at the fracture level providing an excellent healing outcome. In approximately 25% of root fractures, pulp necrosis occurs, but this usually only affects the coronal fragment. These teeth have been found to respond very well to endodontic treatment extending only to the fracture line. In approximately 50% of teeth with root fractures, a connective tissue (PDL tissue) union is found between the fragments. This union is stationary and leads to some increased mobility. This is generally an acceptable situation, as the mobility in most cases does not seem to increase with advancing age. However, a new trauma may lead to extrusion or avulsion of the coronal fragment, an event that appears to occur in 2224% of the cases over the long term .

Crown Root Fractures

Teeth with crown root fractures have traditionally been considered hopeless to preserve and are often extracted after the injury. However, a number of procedures can be considered before removing the damaged tooth, such as coronal fragment removal with preservation of the remaining root for later restoration following gingivectomy and/or osteoectomy . Furthermore, orthodontic extrusion is a treatment possibility with a good long-term prognosis. Even intra-alveolar transplantation of the remaining tooth fragment has been found to have a good long-term prognosis.

Favorable and unfavorable outcomes include some, but not necessarily all of the following.

Favorable outcome	Unfavorable outcome
1. Asymptomatic; positive response to pulp testing; continuing root development in immature teeth. Continue to next evaluation	Symptomatic; negative response to pulp testing; signs of apical periodontitis; no continuing root development in immature teeth. Root canal treatment is indicated
2. Positive response to pulp testing (false negative possible up to 3 months). Signs of repair between fractured segments. Continue to next evaluation	Negative response to pulp testing (false negative possible up to 3 months). Clinical signs of periodontitis. Radiolucency adjacent to fracture line. Root canal treatment is indicated only to the line of fracture
3. Positive response to pulp testing (false negative possible up to 3 months). No signs of apical periodontitis. Continue to next evaluation	Negative response to pulp testing (false negative possible up to 3 months). Signs of apical periodontitis or external inflammatory resorption. Root canal treatment is indicated

References

1. K. Reynolds et al. Pulp revascularization of necrotic bilateral bicuspids using a modified novel technique to eliminate potential coronal discolouration: a case report. International Endodontic Journal 42, 8492, 2009.
2. Markus Haapasalo et al. Internal inflammatory root resorption: the unknown resorption of the tooth Endodontic Topics 14, 6079, 2006.
3. Adil N. F. et al. Delayed replantation of avulsed teeth. J Indian Soc Pedod Prevent Dent - Supplement 2007.
4. Boyd KS .Transient apical breakdown following subluxation injury: a case report. Endod Dent Traumatot 11: 37-40;1995.
5. Mesaros SV et al. Revascularization of traumatized teeth assessed by laser Dopplerflowmetry: case report Endod Dcnl Traumatot 13: 24-30;1997.
6. Cohenca Net al. Transient apical breakdown following tooth luxation. Dent Traumatol 19:289-291;2003.
7. Oikarinen K. Tooth splinting: a review of the literature and consideration of the versatility of a wirecomposite splint Dent Traumatol 6: 237-250; 1990.
8. West NM et al.Biologic root-end closure on a traumatized and surgically resected maxillary central incisor: An alternative method of treatment. Endod Dent Traumatol 1: 146- 149; 1985
9. Uji T et al. Occurrence of traumatic injuries in the oromaxillary region of children in a Japanese prefecture. Dent Traumatol 4: 63-69; 1988.
10. Maria Jose´ de Carvalho Rocha.Reimplantation of primary tooth case reportDental Traumatology 24: e4e10; 2008.
11. Onetto JE et al. Dental trauma in children and adolescents in Valparaiso, ChileTraumatol 10: 223-227; 1994.
12. Zadik Y. Oral trauma and dental emergency management recommendations of first-aid textbooks and manualsDental Traumatology 23: 304306; 2007.
13. Flores MT et al .Guidelines for the management of traumatic dental injuries. I. Fractures and luxations of permanent teeth .Endodontic Topics 14, 102118; 2006.
14. Mitsuhiro Tsukiboshi et al. Optimal use of photography, radiography and micro computed tomography scanning in the management of traumatized teeth Endodontic Topics 14; 419,2006

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