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Treatment of root surface in delayed tooth replantation: a review of literature

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Abstract – The time elapsed between a trauma and tooth replantation usually ranges from 1 to 4 h. The chances of root surface damage are higher when tooth replantation is not performed immediately or if the avulsed tooth is not stored in an adequate medium. This invariably leads to necrosis of pulp tissue, periodontal ligament cells and cementum, thus increasing the possibility of root resorption, which is the main cause of loss of replanted teeth. This paper presents a comprehensive review of literature on root surface treatments performed in cases of delayed tooth replantation with necrotic cemental periodontal ligament. Journal articles retrieved from PubMed/MedLine, Bireme and Scielo databases were reviewed. It was observed that, when there are no periodontal ligament remnants and contamination is under control, replacement resorption and ankylosis are the best results and that, although these events will end up leading to tooth loss, this will happen slowly with no loss of the alveolar ridge height, which is important for future prosthesis planning.

Although dentoalveolar traumas are most commonly observed in children and adolescents, particularly boys, they may affect individuals of any age (1–3). Studies have demonstrated that replantation of avulsed teeth occurs most frequently between 1 and 4 h after avulsion (1–3).

One of the greatest concerns in tooth replantation has been the understanding of the mechanisms that rule healing process because if these mechanisms are better controlled, the organism might have better conditions to promote repair of the injured tissues (4). However, a great deal of difficulty is involved because tooth-supporting tissues are composed of a wide variety of cell types with different roles, characteristics and behaviors (5).

Teeth replanted under favorable conditions, which include preservation of periodontal ligament vitality, cementum integrity (6–8) and minimal bacterial contamination (9–11), usually have a good prognosis and survival rate. These conditions are directly related to the extra-alveolar time, storage medium and alterations of root surface (12, 13).

The likelihood of root surface damage increases if the avulsed tooth is not immediately replanted or is not stored in an appropriate medium; this invariably leads to necrosis of the pulp tissue and cemental periodontal ligament (5, 12, 14–16). The presence of necrotic periodontal ligament remnants stimulates the occurrence of external root resorption, which is the major cause of loss of replanted teeth (5, 11, 17–19).

It has been shown that chemical or mechanical removal or treatment of the necrotic cemental periodontal ligament leads to the occurrence of more areas of ankylosis rather than replacement resorption (20–22).

This paper presents a comprenhensive review of literature on the root surface treatments performed in cases of delayed tooth replantation with necrotic cemental periodontal ligament.

Review of literature

One of the steps of the root surface treatment is the removal of necrotic periodontal ligament. This can be performed either mechanically by scraping with curettes (20, 23–27), scalpel blade (17, 28, 29), rubber cup polishing with pumice/water slurry (30), diamond bur and sandpaper disk (31, 32) or chemically with sodium hypochlorite (21, 22, 33–35). Some authors do not perform this procedure and rather apply the substances directly on the necrotic ligament (36–46).

Several substances have been used for the treatment of the root surface of replanted teeth in an attempt to increase their retention rate, namely formol, acid solutions (such as citric acid, hydrochloric acid, acidulated fluoride and neutral fluoride), alkaline substances (such as calcium hydroxide and sodium hypochlorite), antibiotics (such as tetracycline and rifacin), antibiotic/corticosteroid combination, corticosteroid, alendronate, vitamin C, carbonic anhydrase inhibitor (acetazolamide) and tooth enamel protein (Emdogain®, Biora AB, Malmö, Sweden).

The findings of a previous study showed that the use of 40% formol to treat root surfaces of replanted and

transplanted dogs' teeth led to rapid and complete root destruction within 6 months, with no periodontal ligament regeneration (47).

Several authors have recommended the use of fluoride solutions in different forms and concentrations to treat the root surface in cases of delayed tooth replantation, assuming that the demineralized dentin surface would be more prone to fluoride incorporation and might become more resistant to resorption.

Among the fluoride solutions, the use of 2% acidulated sodium phosphate fluoride has shown a decrease in inflammatory root resorption and the predominance of areas of ankylosis and replacement resorption (23, 33, 36, 37, 48). Fluoride probably acts directly on the bone tissue, cementum and dentin, by converting hydroxyapatite into fluorapatite, or by a specific inhibitory action on the clastic cells, or even an association of both hypotheses (38). Another property of fluoride is its ability to inhibit microbial growth and metabolism, decreasing cell pH (49). Some authors used neutral sodium fluoride and did not find any difference in repair compared with acidulated sodium fluoride (37).

Studies have also investigated the use of 1% and 10% stannous fluoride and reported that the concentration of 10% was more deleterious to the periodontal ligament, pulp and alveolar bone, whereas the use of 1% stannous fluoride yielded better results, with fewer areas of external root resorption. Among the disadvantages of these solutions are the possibility of tooth crown staining, environmental instability and connective tissue irritation (31, 38, 39).

Hydrochloric acid has also been used in association with an enzyme, hyaluronidase, with the aim of decalcifying the cementum without denaturing the collagen matrix and has been shown to decrease root resorption significantly (28). Nordenram et al. (50) evaluated the use of hydrochloric acid alone but did not have favorable results. Phosphoric acid at 50% has been used for the same purpose, and the results revealed that its use alone increased the occurrence of root resorption (40).

In an attempt to expose collagen fibers on root cementum and promote a contact surface for reattachment of periodontal ligament collagen fibers, some authors (24, 25, 51, 52) have proposed the treatment of root surface with citric acid and observed a large number of areas of ankylosis and replacement resorption. Ripamonti & Petit (32), after demineralizing the root surface with citric acid, used a concentrate of allogenic fibronectin–fibrin with the aim of preventing ankylosis but did not succeed.

Andreasen & Kristerson (53) investigated the autotransplantation of connective tissue, such as that found in the fascial sheath or subcutaneous, mucosal and periosteal tissues, for potential replacement of the periodontal ligament. The results showed that this procedure was unable of both completely preventing ankylosis and forming new cementum. Only tissues of odontogenic origin, such as periodontal ligament, tooth follicle and gingival connective tissue, have such an ability.

In cases of delayed tooth replantation, the presence of devitalized periodontal ligament may lead to partial or total resorption of the root of the replanted tooth. Therefore, the removal of necrotic periodontal ligament remnants has been recommended in an attempt to increase the survival rate of replanted teeth. Among the chemical agents used for periodontal ligament removal, sodium hypochlorite at various concentrations has been advised because of its capacity of dissolving connective tissue and bactericidal effect. The best results have been achieved with lower concentrations and consisted predominantly of long-term replacement resorption and ankylosis and short-term absence of resorption (21, 22, 33, 34).

The use of a calcium hydroxide saturated solution for the treatment of root surface produced replacement resorption and ankylosis (17, 40, 41). Isolan & Carvalho (42) tested the buffered alkaline solution and had similar results.

The findings of previous studies (43, 54) showed that the treatment of root surface with the antibiotic rifacin M (75 mg) prevented inflammatory resorption from the 10th to 60th postreplantation day, but was not able to prevent the occurrence of replacement resorption and dentoalveolar ankylosis. The action of tetracycline on microorganisms that contaminate the root surface during the extra-alveolar period has also been investigated. Although it had no effect on the microorganisms present in the necrotic pulp tissue, tetracycline reduced the occurrence of ankylosis and inflammatory resorption (39, 44, 45). Minocycline, a tetracycline-derived antibiotic, has also been investigated, but its use for root surface treatment is not recommended because of its inability to prevent or attenuate external root resorption (55).

The use of a commercially prepared antibiotic–corticosteroid product (Otosporin, Farmoquímica S/A, Rio de Janeiro, Brazil) has been evaluated for root surface treatment (43). It was shown to reduce inflammation when applied topically for a short time, but induced an intense inflammatory reaction when maintained in contact for a longer period, thus compromising the periapical healing.

Sae-Lim et al. (56) assessed the topical effect of dexamethasone and its systemic association in cases of tooth replantation and concluded that topical use improves the repair, but it does not avoid the occurrence of replacement resorption.

Alendronate, a substance capable of inhibiting osteoclastic activity, has also been employed for root surface treatment before replantation of avulsed teeth in order to prevent the occurrence of inflammatory resorption. The results revealed a decrease in the resorption process but not in the occurrence of ankylosis (35, 57).

Taking into account the characteristics of vitamin C, mainly its role in collagen synthesis and its acid pH, Panzarini et al. (33) evaluated the use of vitamin C for the treatment of root surface in cases of delayed replantation, aiming at providing a longer survival for replanted teeth. The results were similar to those obtained with 2% acidulate sodium phosphate fluoride, with areas of replacement resorption and ankylosis.

For teeth with completely formed roots that are replanted after extra-alveolar periods longer than 60 min, the International Dental Traumatology Association

has recommended that the avulsed teeth should be immersed in an acidulated sodium phosphate fluoride solution and that the sockets should be filled with Emdogain® (58).

Mori & Garcia (59) used acetazolamide for root surface treatment in an attempt to minimize the occurrence of root resorption in the replanted teeth. This substance inhibits the carbonic anhydrase enzyme that is responsible for maintaining the pH acid within the resorption area, which is essential for the action of most enzymes involved in the resorption process. Because of the presence of hydrogen ions, the pH in the resorption zone drops to around 4.7. The formation of hydrogen ions, in turn, depends on carbon dioxide gas hydration. As this reaction is catalyzed by the carbonic anhydrase enzyme, the absence or inhibition of this enzyme alters the resorption cycle and ends up limiting resorption. However, in the aforementioned study (59), acetazolamide was not capable of preventing the occurrence of ankylosis and inflammatory and replacement resorptions.

The use of Emdogain®, which is an enamel matrix derivative, has been studied, based on the hypothesis that the development of acellular cementum would be preceded by a period of protein secretion related to the enamel and that the key for re-establishing a functional periodontal ligament is the formation of acellular cementum (9). Gestrelius et al. (60) investigated the influence of Emdogain® on the properties of periodontal ligament cells, such as migration, adhesiveness, proliferation, biosynthetic activity and nodule formation. They found that although this substance increased the proliferation of periodontal ligament cells and protein synthesis, as well as the formation of nodules, it had no significant effect on the migration and adhesiveness of these cells. Other studies using Emdogain® in delayed tooth replantation found that it was unable to prevent or heal ankylosis after tooth replantation (61–64).

Discussion

Although there are studies reporting excellent results in the absence of periodontal ligament (21, 23), most authors agree that the maintenance of vital periodontal ligament on root surface is of paramount importance for fiber reattachment and emphasize the major role of its cells in the repair process after replantation of the avulsed tooth (5, 9).

As far as tooth replantation is concerned, the occurrence of areas of necrosis, inflammatory exudate and blood clot formation in the periodontal ligament space is generally observed. Although the maintenance of the periodontal ligament fibers and space depends on several factors, cementoblasts, precementum and the epithelial rests of Malassez are fundamental for preserving root integrity (7, 65, 66). When these structures cannot be kept viable, it is likely that a resorption process initiates (8, 9, 20, 66–68).

Tooth resorption may be classified as an inflammatory or replacement resorption, according to the induction mechanism and the mechanism of maintenance of the resorption process. The triggering phenomenon for most tooth resorption processes is the occurrence of a great cementoblastic damage, which leaves the tooth surface denuded and without precementum, thus exposing its mineralized portion to the onset of bone remodeling units. The aggression responsible for the cementoblastic damage also induces an inflammatory process in the same area, providing an increased accumulation of mediators of local osteoclastic activity. Tooth resorption induced and maintained in this way is classified as an inflammatory tooth resorption (66, 69).

Inflammation has two basic goals: destruction of the aggressive agent and repair of the affected area. Once the causative factor is eliminated, the process tends to heal. In this type of resorption, the main aggressive agent derives from pulp necrosis associated with periodontal ligament damage and contamination. It may therefore be prevented and/or managed by endodontic treatment and systemic antibiotic therapy (6, 10, 15, 69, 70).

Replacement resorption, on the other hand, consists of the substitution of dental tissue by bone tissue. Loss of periodontal ligament and bone tissue incorporation onto root surface ends up including the mineralized dental tissue into the resorbed area as part of the bone remodeling process. Dentoalveolar ankylosis may occur after periodontal ligament loss and its replacement by bone tissue, thus leaving the root surface in direct contact with the alveolar bone (6, 71). As the dentoalveolar ankylosis is established, the essential structures for the protection of the root surface against the installation of the bone remodeling units disappear; there are no longer cementoblasts, precementum or epithelial rests of Malassez (7).

The direct contact between the tooth surface and the alveolar bone as well as dental tissue incorporation into the alveolar bone structure, even if only in part of the root surface, promotes its inclusion in the bone remodeling process. Because of these developing characteristics, root resorption associated with ankylosis is known as replacement resorption (6).

The prevention or delaying of this resorption also relies on a set of procedures, such as root canal therapy, treatment of root surface and alveolus, contention and systemic antibiotic regimen. Although the purpose of this paper is to present a review of literature on one of these procedures – root surface treatment – it is important to perform an overview of the other procedures.

Irrespective of the type of root surface treatment, there is consensus in the literature that replanted teeth should be endodontically treated because the necrotic pulp and its toxins affect the periodontal ligament through the dentinal tubules and play a decisive role to the resorption process (5, 72, 73). In this case, calcium hydroxide is the most recommended material for root canal filling of teeth to be replanted, because of its well-known capacity of controlling the progression of inflammatory resorption (10, 58).

Another aspect of dental replantation is the preparation of the socket, which consists of removal of obstructions such as blood clots and bone fragments in order to facilitate the replantation (58, 74–76). Preparation of the socket may be performed with the use of curettes and irrigation with saline, in addition to filling with

Emdogain® (58). Contention of replanted teeth is another variable that might affect the prognosis of tooth replantation. Basically, it should not interfere with oral hygiene, allow physiological tooth mobility and remain for a short time in order to reduce the incidence of ankylosis (3, 77).

The goal of antibiotic therapy is to avoid bacterial proliferation in the area of the ongoing repair process and contribute to the prevention of inflammatory resorption. Ideally, a broad-spectrum antibiotic should be administered for 7 days (70).

As regards the removal of necrotic root periodontal ligament, the authors who employed the chemical removal with sodium hypochlorite justify its use because this technique preserves the cementum layer (21, 22, 33, 34), which is an important barrier against the external root resorption (20, 65). In spite of being an excellent organic material solvent and efficient agent for the removal of periodontal ligament remnants (78), sodium hypochlorite is considered to be toxic for the supporting periodontal tissues (22, 34).

Mechanical removal of periodontal ligament remnants by scalpel blade scraping or Robinson bristle brush with pumice has been assessed under scanning electron microscopy (79). The quantitative and qualitative analyses of the results showed that both techniques were effective and preserved the cementum layer. The mechanical method has the additional advantages of not damaging the tissues, being rapid and easy to perform.

Other studies evaluated several substances for root surface treatment without removing the necrotic periodontal ligament and found similar results, i.e. ankylosis and replacement resorption (36–46).

It has been demonstrated that the application of acid alone for root surface treatment does not yield good results (25, 51). Likewise, the use of alkaline solutions alone, such as sodium hypochlorite, particularly at high concentrations, may possibly lead to the formation of a connective tissue that does not reattach to the tooth surface (22, 34).

Treatments employing alkaline substances (e.g. sodium hypochlorite) followed by the use of acidic solutions (e.g. 2% acidulated sodium phosphate fluoride) seem to provide more favorable results (21, 33, 46). Some substances tested more recently, such as vitamin C and Emdogain®, have shown similar results to those obtained with acidulated sodium phosphate fluoride (33, 63). The International Dental Traumatology Association (58), in its guidelines for avulsed teeth with completely formed roots that are replanted after an extra-alveolar period longer than 60 min half-dry, suggests that, after mechanical removal of periodontal ligament remnants, the teeth should be immersed in an acidulated sodium phosphate fluoride solution at 2.4%, pH 5.5, for 5 min.

When the periodontal ligament is absent and contamination is under control, the best results that may be expected are ankylosis and replacement resorption (66). Although these processes will eventually lead to failure of the replantation procedure, tooth loss will happen more slowly without loss of the alveolar edge height, which is important for future prosthetic planning (29).

The management of dental avulsions should be addressed by educational campaigns for the prevention and improvement of case prognosis, and demands the qualification of health professionals for an adequate, comprehensive and timely first attendance and follow up of the trauma patients. The aim is to reduce the extra-oral time of avulsed teeth and instruct the population on how to store avulsed teeth properly. These factors cannot be controlled by the dentist and interfere directly with the viability of the periodontal ligament cells of the teeth to be replanted, which is fundamental for their repair (80, 81).

Although in cases of delayed replantation the presence of necrotic periodontal ligament might compromise the survival rate of the replanted tooth, replantation of avulsed teeth should always be encouraged, regardless of the viability of the periodontal ligament remnants. The replanted teeth might remain in function in the oral cavity for years before a prosthetic treatment is required. This, among other advantages, enables the patient to become psychologically adapted to the loss.

Root surface treatment is of paramount importance to the success of tooth replantation, especially because replantation usually occurs under unfavorable conditions regarding the vitality of the periodontal ligament cells and may influence the retention of the replanted teeth in the oral cavity for a longer period.

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