Pulp and periodontal tissue repair - regeneration or tissue metaplasia after dental trauma. A review

Abstract – Healing subsequent to dental trauma is known to be very complex, a result explained by the variability of the types of dental trauma (six luxations, nine fracture types, and their combinations). On top of that, at least 16 different cellular systems get involved in more severe trauma types each of them with a different potential for healing with repair, i.e. re-establishment of tissue continuity without functional restitution and regeneration (where the injured or lost tissue is replaced with new tissue with identical tissue anatomy and function) and finally metaplasia (where a new type of tissue replaces the injured). In this study, a review is given of the impact of trauma to various dental tissues such as alveolar bone, periodontal ligament, cementum, Hertvig’s epithelial root sheath, and the pulp.
Alveolar bone ischemia and crushing

This event has been examined in intrusion cases, and the general feature is that the bone regeneration is good especially in children with immature root formation, whereas in cases with mature root formation, transient or permanent loss of bone may occur (12, 13).

Periodontal ligament

Periodontal ligament loss facing the alveolar bone

One study has examined the role of this structure and it appears that the loss does not prevent regeneration of the PDL (9) (Fig. 3).

Periodontal ligament ischemia or contusion

In several experiments, it has been found that this may lead to repair-related resorption or resorption ankylosis (10, 14, 15) (Fig. 4).

Periodontal ligament loss facing the cementum

In several experimental and clinical studies, it has been shown that this leads to ankylosis (3, 6, 10, 14, 16). However, a size factor exists; in animal experiments, defects less than 4mm²; showed either complete healing or a transient ankylosis site which was later resorbed and repair-related root resorption developed in these sites (14) (Fig. 5). In larger sites (i.e. exceeding 4 m²), a permanent ankylosis site was formed (14) (Fig. 6).

Cementum

Cementum loss

This event is created in case of an osteotomy affecting the root surface (20–24) (Fig. 7) or apicoectomy (17, 18) (Fig. 8) and in relation to a root fracture (19). In these cases, new cementum will be found on the exposed dentin (9, 17, 18) (Fig. 8). This process apparently starts from existing cementoblasts next to the tissue loss (17, 18, 20, 24).

Hertvig’s epithelial root sheath

Loss of Hertvig’s epithelial root sheath (HERS)

This event may occur during avulsion and extrusion where a separation zone may occur at the level of the pulpal papilla (1). If the tooth is not replanted the isolated apical papilla plus, the HERS may continue its activity and form a root tip (25–27). Under experimental conditions, it has been found that partly removal of the HERS may lead to a compromised root development and invasion of PDL and bone into the pulp canal (28) (Fig. 9).

HERS and ischemia damage

This event may occur because of marked inaccurate reposition where the revascular process becomes delayed whereby the HERS becomes avital. This leads to invasion of bone, PDL and cementum in the pulp canal and lack of further root formation (28, 29) (Fig. 9).

HERS and contusion damage

This event may occur after lateral luxation, intrusion, and avulsion with subsequent replantation (1, 12, 13). The healing event appears to be similar to HERS ischemia.

Pulp

Pulp loss

This may occur as a therapeutic measure. Experiments in monkeys have shown that in mature teeth a pulp...
The revascularization process becomes arrested (8, 30, 31). In teeth with immature root formation, pulp revitalization will occur, although at a slower rate compared with a situation where the ischemic pulp is preserved (32–34).

Pulp ischemia

Such events lead to severe changes in the pulp chamber, ranging from pulp regeneration, pulp repair with accelerated dentin formation (PCO) (1), or pulp metaplasia where PDL ± bone invade the pulp and finally a sterile or infected pulp necrosis may occur (1) (Fig. 10). The revitalization process appears to be very dependent upon the size of the apical foramen, being very frequent with apical diameters above 1.0 mm and infrequent with diameters below 0.3 mm (35).

Fig. 3. (a) Isolated removal of the alveolar part of the periodontal ligament (PDL). (b) Healing of the entire PDL.

Fig. 4. (a) Contusion or ischemia of the entire periodontal ligament. (b) This may lead to ankylosis.

Fig. 5. (a) Isolated removal of the cemental part of the periodontal ligament. (b) This may lead to transient ankylosis (c and d).
Pulp contusion damage

This injury may occur subsequent to intrusion into the bone of teeth with immature roots (12, 13). Statistics have shown that this event represents a high risk of infected pulp necrosis as well as a risk of PCO or PDL plus bone invasion. This addiction arrested root development is a frequent finding (12, 13). All of these events possibly relate to the damage or loss of HERS whereby invasion of periodontal structures (cementum periodontal ligament and bone) obtain a preference to invade the pulp chamber (1).

Conclusion

This survey of the healing responses in the pulp and periodontium after trauma strongly indicates that the survival of the cell layer next to cementum appears to be crucial for PDL healing including alveolar bone. The survival of HERS appears to be decisive for further root development. Finally, the presence of ischemic but intact pulp tissue appears to be strongly related to survival or regeneration of tertiary dentin. However, the latter will only occur if the ischemic pulp tissue do not become infected, and the apical foramen has a certain critical width allowing the revitalization of the ischemic pulp tissue.
Reference


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Fig. 9. (a) Hertwigs epithelial root sheath is damaged. (b) Bone and periodontal ligament invasion may take place in the root canal.

Fig. 10. Infected pulp necrosis.


