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*Replantation and transplantation of teeth with incomplected root formation. Review of literature and presentation of clinical cases*

Avulsion is the most severe tooth injury. Replantation does not always give sufficient effect, especially in immature teeth with incomplete root formation. Many factors play a part in the replantation outcome. Three tissues are involved in the healing process after replantation of an avulsed tooth: the pulp, periodontal ligament (PDL), and alveolar bone of the tooth socket. Following dental trauma, the pulp can show three healing modalities: pulp survival, pulp obliteration, or pulp necrosis. With regard to periodontal healing, three different types of post-traumatic external root resorption have been distinguished in the literature: surface resorption, inflammatory resorption, and replacement resorption (1).

Pulp revascularization is favored when apical foramen is not completely formed (2). Furthermore, it has been found that revascularization takes place only in teeth with an apical diameter which exceeds 1 mm (3, 4). Ebeleseder et al. analyzed pulp survival of replanted avulsed teeth in varying age groups. They reported pulp survival in 41% of immature teeth in children (8 years), 9% of mature teeth in adolescents (12 years), and in 0% of teeth in adults (25 years). Pulp survival was never observed in the Chappuis et al. study (1).

The extraoral timing and storage medium also appear to affect potential pulp revascularization. Prognosis is favorable if the time of replantation is no longer than 45 min post-avulsion. Revascularization following dry storage usually occurs in about half of the cases when the storage period is less than 5 min. Further, the frequency of revascularization drops to about one third in the period from 6 to 20 min, and then continues to decrease consistent with the increase in drying periods. Thereafter, radiographic controls should be carried out after 2, 3 and 4 weeks in order to demonstrate signs of pulp necrosis, such as periapical radiolucency and/or inflammatory root resorption (2, 3).

Cvek et al. showed that pulp revascularization is highly dependent upon the presence or absence of bacteria in the pulpal lumen. It is possible that the movement of bacteria from the oral cavity or from contaminated root surfaces can occur during extraoral time. Bacterial penetration into the pulp canal space seems to be the cause of revascularization failure in the majority of the cases. This leads to pulp necrosis and inflammatory root resorption if endodontic treatment is delayed or pulp and dentin infection is severe (2). Therefore, the use of chemotherapeutic agents has been advocated in many studies to pharmacologically manipulate this process. In particular, during experimental animal studies, tetracycline has been shown to be effective in the prevention or attenuation of external root resorption when applied systemically and/or topically. Tetracycline has antiresorptive properties because of its inhibitory effect on collagenase activity and osteoclasts (1). Topical doxycycline

significantly increases the chances of successful pulp revascularization. Better results were observed with minocycline in experimental studies on animals (2).

The time needed for the initial healing of the periodontal ligament under normal conditions is approximately 10 days after replantation (2).

The process of revascularization is observed within 7 days and is completed after 4–5 weeks after the replantation of immature teeth. The nervous system needs more time for the regeneration process to occur (correct pulp reaction on stimulation can be observed no earlier than 1 month after replantation) (3, 4). Several studies have shown revascularization in replanted and autotransplanted immature teeth whose original pulp tissue was not removed. Inne et al. removed pulp tissue before replantation while conducting experimental studies on animals. Skogund et al. found that revascularization is not only connected with anastomosis but mainly with the in-growth of new vessels. They used immature teeth with open apices and mature teeth after apicoectomy and obtained a very high percentage of revascularization (5).

The ideal time for replantation or transplantation of immature teeth is during the fourth or fifth stage of root development according to Moorees' classification. Physiological process of root formation is significantly connected with pulp healing. Sometimes completed root development will not be achieved (total arrest or partial arrest), especially after use of a calcium hydroxide dressing to induce apexification (4).

A possible complication after replantation is inflammatory or replacement resorption. Inflammatory resorption is the result of the PDL injury. This process is more progressive in immature teeth that are connected with dentin structure (wide tubules and thin dentine layer).

Replacement resorption (ankylosis) deals with remodeling. Healing takes place from the adjacent bone. There are two forms of replacement resorption: transient and permanent. In the second, the entire root is resorbed. The rate of replacement resorption is proportional to the patients' rate of bone remodeling – occurring more quickly in adolescents, and more slowly in adults (bone remodeling in adolescents occurs at rate of 50% per year; in adults it is 2% per year) (3, 4, 6, 7, 8). Replacement resorption ranged from 9.5% in teeth with a short (<15 min) extraoral storage to 100% in teeth with dry storage exceeding 60 min (3).

Adequate time and flexibility of splinting material also plays a significant role in replantation outcome. Rigid splinting has a negative effect on pulp revascularization and periodontal healing. Small movements during the healing period prevent ankylosis and enhances the in-growth of new vessels into the pulp tissue (3).

#### MATERIAL AND METHODS

Radiological documentation of patients of Department and Clinic of Maxillofacial Surgery and Department of Pediatric Dentistry was evaluated. The procedure of teeth replantation and transplantation was conducted in Clinic of Maxillofacial Surgery, post-surgery follow-up treatment was conducted in the Department of Pediatric Dentistry, Medical University of Lublin.

#### RESULTS

**Patient 1.** An eight-year-old male patient was referred to the Department of Oral and Maxillofacial Surgery after avulsion of the left upper central incisor (the adjacent central incisor was severely luxated). The tooth was transported in milk and replanted 1.5 hours after injury. Before replantation, the tooth was soaked in Doxycycline solution (100 mg/10 ml) for 5 min. The patient obtained Amoxycycline systematically. Non-rigid splinting was employed for 10 days. The replanted

tooth was in the 4<sup>th</sup> stage of root development according to Moorees' classifications (Fig. 1). The patient was referred to the Department of Pediatric Dentistry (DPD), though the first admission to the DPD was three months post-trauma due to patient irresponsibility. After thorough examination, pulp necrosis was diagnosed in two central incisors. Delayed time after injury complicated the process of treatment. Endodontic management focused on the elimination of severe bacterial infection. After three weeks of treatment, the tooth condition improved and inflammation of the periapical tissues was reduced. Root canals in two central incisors were filled with a calcium hydroxide dressing to obtain apexification. Temporary root canal fillings were changed every two months. Four months post-injury, endodontic treatment was finished (root canals were filled using the method of lateral condensation) (Fig. 2).



Fig. 1. The left upper central incisor after replantation (right upper central incisor after reposition)



Fig. 2. The left upper central incisor after root canal filling

In this case, root formation after replantation was not ideal, but the more important aim was to obtain closure of the apex foramen. Twenty-five months after replantation, radiographic control revealed replacement resorption (Fig. 3). The growth of alveolar bone was correct.

**Patient 2.** A seven-year-old female patient was referred to the Department of Oral and Maxillofacial Surgery after avulsion of the right upper central incisor (the adjacent central incisor was severely luxated). The tooth was transported in a paper handkerchief and replanted 1 hour after injury. Before replantation, the tooth was soaked in Doxycyclin solution (100 mg/10 ml) for 5 min. The patient also obtained Amoxycyclin systematically. Due to transient dentition, the splinting of the avulsed tooth was obtained by composite fixation of both central incisors for 10 days. The replanted teeth were in the fourth stage of root development according to Moorees' classifications. Two weeks post-injury, inflammatory resorption was diagnosed on x-ray imaging (Fig. 4). Endodontic treatment was carried out. Firstly, the root canal was filled with Pulpomixin for 7 days, followed by a mixture of calcium hydroxide and Pulpomixine for two weeks. As a result of the treatment, rapid resorption process was observed 5 weeks after injury took place (Fig. 5).



Fig. 3. The left upper central incisor 25 months after replantation



Fig. 4. The right central incisor 10 days after replantation, external inflammatory resorption on a distal root site



Fig. 5. The right central incisor 24 days after replantation. rapid progression of inflammatory resorption

**Patient 3.** A sixteen-year old male patient was referred to the Department of Oral and Maxillofacial Surgery due to retention of the 2nd left lower molar (Fig. 6). Orthodontic treatment was not agreed upon by the parents due to the cost of treatment. The surgical treatment plan was to perform extraction of the 2nd lower left molar and transplantation of the lower left wisdom tooth germ into the socket of the 2nd molar. Treatment plan was accepted by the parents. The transplanted tooth was in the third stage of root development according to Moorees' classification.



Fig. 6. Patient qualified for extraction of the left second mandible molar and transplantation of the third lower molar in the socket after second molar

Extraction and transplantation of the teeth was conducted under local anesthesia, and the extraoral period of the wisdom tooth germ was about 5 min. The storage medium was a solution of Doxycycline (100 mg/10 ml). The transplanted tooth was fixed in the socket with surgical sutures, without any splinting (Fig. 7) The patient obtained Amoxycycline systematically. Thirteen months follow-up examination revealed periodontal fissure of normal width, however slight signs of replacement resorption (transient) was diagnosed on the medial site of the medial root. Radiological

examination thirteen months after transplantation showed slight progression in the apexogenesis of the transplanted third molar germ, however pulp vitality during this period was negative (Fig. 8). The transplanted tooth needed periodical follow-up due to pulp vitality and periodontium status.



Fig. 7. The third molar in the socket of second molar, after transplantation



Fig. 8. The transplanted tooth thirteen months after procedure.  
Slight signs of replacement resorption

#### DISCUSSION

Replantation and transplantation are not always successful. The duration of extraoral time and dry storage affect the result of this procedure. Although the prognosis for re-/transplanted teeth in this longitudinal study is not definite, in many cases this procedure allows the patient to avoid pediatric dentures. This kind of denture should be often controlled and changed in adolescent patients. After tooth injury or tooth loss, older patients can be supplied with prosthodontic dental bridges or implants. Dental implants seem to be the best method of treatment if tooth re-/transplantation was impossible or due to its failure. In fact, dental implant treatment is still limited by patient age and by cost.

Unfortunately the procedure of replantation is strictly dictated by tooth injury. The pattern of dental injury, i.e. the force, direction, and oral hygiene conditions, tend to be variable and affects prognosis and the outcome of replantation. Teeth with incomplete root formation due to its

morphological structure are more exposed to complication from infection. The patient in the second case demonstrates the most frequent example of complications resulting from extraoral timing, tooth transport conditions and cooperation with the child-patient. These factors are unpredictable and influence greatly the treatment outcome.

The procedure of tooth autotransplantation, although similar to replantation, differs significantly mainly due to exclusion of traumatic background. Although tooth extractions also involve some PDL trauma, it can be balanced by the oral surgeon. Oral cavity conditions may be also modified with antibacterial rinsing, while the extraoral timing of the transplanted tooth can be limited and storage medium may be arbitrary.

In conclusion, although autotransplantation treatment can be affected by different factors which are modified by the oral surgeon, the outcome of this procedure is not always predictable as in replantation. There are many advantages of re- and transplantation. This treatment prevents bone and gingival papilla atrophy, and bone augmentation is not required to obtain a satisfactory outcome. Eruption and orthodontically stimulated movement is possible in replanted or autotransplanted teeth (4). Procedures of replantation and transplantation are weighed against the risk of complication, such as inflammatory or replacement resorption, however, the outcome's value of successful treatment exceeds possible complications.

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#### SUMMARY

The aim of this study is to expose the differences in treatment and final outcome in replantation and transplantation of the opened-apex teeth. The present study is based on medical documentation of the patients treated in the Department and Clinic of Maxillofacial Surgery and Department of Pediatric Dentistry, Medical University of Lublin. Results: treatment outcomes differed in replantation and transplantation of the immature teeth. Conclusion: treatment of the teeth with opened apices after

replantation is difficult due to traumatic background and risk of complications. In transplantation traumatic factor and risk of infection can be partially limited by surgeon.

Replantacje i transplantacje zębów z niezakończonym rozwojem wierzchołka korzenia  
Przegląd literatury i prezentacja przypadków klinicznych

Celem pracy było wykazanie różnic w leczeniu i rezultatach końcowych w przypadku zębów replantowanych i transplantowanych z niezakończonym rozwojem wierzchołka korzenia. W pracy wykorzystano dokumentację medyczną pacjentów leczonych w Zakładach Chirurgii Szczękowo-Twarzowej i Stomatologii Wieku Rozwojowego AM w Lublinie. Uzyskano odmienne wyniki leczenia w przypadku zębów replantowanych oraz w przypadku zębów transplantowanych z niezakończonym rozwojem wierzchołka korzenia. Zęby z niezakończonym rozwojem wierzchołka korzenia po replantacji są trudne w leczeniu ze względu na tło urazowe i tym samym możliwość powikłań. W przypadku transplantacji sytuacja wygląda inaczej ze względu na atraumatyczność zabiegu i sterylne warunki pracy.