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AVULZIJA STALNIH ZUBA KOD DECE I ODRASLIH - TERAPIJSKE MOGUĆNOSTI ZA DUŽI OPSTANAK PERMANENT TOOTH AVULSION IN CHILDREN AND ADULTS – THERAPEUTIC OPTIONS FOR LONGER SURVIVAL

*Simona M. Stojanović^{1,2}, Miloš R. Tijanić^{1,2}, Kristina N. Burić³, Nina N. Burić^{3,4}, Milan S. Spasić²,
Kosta M. Todorović^{1,2}, Branislava B. Stojković^{5,2}, Marija G. Jovanović⁶, Milica S. Petrović⁷, Dušan
M. Mitić⁸*

¹ UNIVERZITET U NIŠU, MEDICINSKI FAKULTET, PREDMET ORALNA HIRURGIJA, NIŠ, SRBIJA

² KLINIKA ZA DENTALNU MEDICINU, NIŠ, SRBIJA

³ UNIVERZITET U NIŠU, MEDICINSKI FAKULTET, STUDENT DOKTORSKIH STUDIJA, NIŠ, SRBIJA

⁴ KLINIKA ZA DENTALNU MEDICINU, LEKAR NA SPECIJALIZACJI, NIŠ, SRBIJA

⁵ UNIVERZITET U NIŠU, MEDICINSKI FAKULTET, PREDMET PREVENTIVNA I DEČJA STOMATOLOGIJA, NIŠ, SRBIJA

⁶ UNIVERZITET U NIŠU, MEDICINSKI FAKULTET, PREDMET PROTETIKA, NIŠ, SRBIJA

⁷ UNIVERZITET U NIŠU, MEDICINSKI FAKULTET, PREDMET ORALNA MEDICINA I PARODONTOLOGIJA, NIŠ, SRBIJA

⁸ UNIVERZITETSKI KLINIČKI CENTAR NIŠ, KLINIKA ZA ONKOLOGIJU, ODELJENJE RADIOTERAPIJE, NIŠ, SRBIJA

¹ UNIVERSITY OF NIŠ, FACULTY OF MEDICINE, DEPARTMENT OF ORAL SURGERY, NIŠ, SERBIA.

² CLINIC FOR DENTAL MEDICINE, NIŠ, SERBIA

³ UNIVERSITY OF NIŠ, FACULTY OF MEDICINE, PHD STUDENT, NIŠ, SERBIA

⁴ CLINIC FOR DENTAL MEDICINE, RESIDENT, NIŠ, SERBIA

⁵ UNIVERSITY OF NIŠ, FACULTY OF MEDICINE, DEPARTMENT OF PREVENTIVE AND PEDIATRIC DENTISTRY, NIŠ, SERBIA

⁶ UNIVERSITY OF NIŠ, DEPARTMENT OF PROSTHODONTICS, NIŠ, SERBIA

⁷ UNIVERSITY OF NIŠ, FACULTY OF MEDICINE, ORAL MEDICINE AND PERIODONTOLOGY, NIŠ, SERBIA

⁸ UNIVERSITY CLINICAL CENTER NIŠ, ONCOLOGY CLINIC, DEPARTMENT OF RADIOTHERAPY, NIŠ, SERBIA

Sažetak

Uvod: Avulzije stalnih zuba (traumatska ekstrakcija, izbijanje zuba) predstavljaju jedne od najtežih povreda stalnih zuba i mogu se javiti kao samostalne povrede ili udružene sa ostalim povredama zuba ili povredama regije lica i vilica. Avulzije zuba definišu se kao izbijanje zuba iz alveole, uz potpuno kidanje periodontalnih vlakana, pri čemu jedan deo njih ostaje vezan za cement korena zuba, a drugi za alveolarnu kost, kompromitujući zubnu pulpu, cement korena i alveolarnu kost. Visoka zastupljenost i brojne posledice na stogotogati sistem, koje za sobom ostavljaju, čine da se avulzije stalnih zuba mogu smatrati povredama od značaja za javno zdravlje.

Cilj rada: je da ukaže na terapijske mogućnosti avulzije stalnih zuba, koje mogu obezbediti njihov duži opstanak u usnoj duplji.

Zaključak: Strategija lečenja avulziranih stalnih zuba uvek je bazirana na ograničavanju infekcije korenskog kanala i periradikularne upale, prebacujući ravnotežu od nepovoljnog zarastanja (resorpcija zamene) prema povoljnom (periodontalnom) zarastanju. Uspeh terapije i periodontalno zarastanje zavise od trajanja i uslova ekstraoralnog čuvanja zuba, stepena oštećenja periodontalnog ligamenta i stanja pulpe.

Ključne reči: avulzija, stalni zubi, replantacija, terapija

Corresponding author:

Simona Stojanović, DDS,
Resident in Oral surgery, Faculty of Medicine, University of Niš,
Dr Zorana Djindjica Blvd 81, Niš, Serbia.
E-mail: tarana.simona@gmail.com.
Phone number: +381692245322

Abstract

Introduction: Permanent tooth avulsions (traumatic extraction; total luxation) are one of the most severe permanent tooth injuries and can occur as single injuries or associated with other dental injuries or injuries to the face and jaws region. They are defined as the luxation of teeth from the alveoli with complete rupture of periodontal fibres, or with one part attached to the root cementum and the other to the alveolar bone, thus compromising the dental pulp, root cementum, and alveolar bone. The high prevalence and numerous negative consequences on the stomatognathic systems they have suggest permanent tooth avulsions should be regarded as an important public health problem.

The aim: is to point out the therapeutic possibilities of permanent tooth avulsion that can ensure their longer survival in the oral cavity.

Conclusion: The treatment strategy for avulsed permanent teeth is always based on limiting root canal infection and periradicular inflammation, shifting the balance from unfavourable (replacement resorption) to favourable (periodontal) healing. The success of therapy and periodontal healing depend on the duration and conditions of extraoral tooth preservation, the degree of damage to the periodontal ligament, and the condition of the pulp.

Key words: avulsion; permanent teeth; replantation; therapy

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Uvod

Povrede stalnih zuba zauzimaju značajno mesto u oralnoj patologiji savremenog čoveka. Procena je da se učestalost povreda zuba u dečjem uzrastu kreće u rasponu od 2,4% do 34%, a da u odrasloj populaciji svaka četvrta odrasla osoba, tokom svog životnog veka, doživi neku vrstu povrede zuba¹. Istraživanja sprovedena širom sveta ukazuju na to da 0,5%-16% svih povreda stalnih zuba čine avulzije^{2,3}. U Srbiji avulzije zuba čine 5% svih povreda zuba⁴.

Avulzije stalnih zuba (traumatska ekstrakcija; izbijanje zuba) predstavljaju jedne od najtežih povreda stalnih zuba, i mogu se javiti kao samostalne povrede ili udružene sa ostalim povredama zuba ili povredama regije lica i vilica. Avulzije stalnih zuba definišu se kao izbijanje zuba iz alveole, uz potpuno kidanje periodontalnih vlakana, pri čemu jedan deo njih ostaje vezan za cement korena zuba, a drugi za alveolarnu kost, kompromitujući tako zubnu pulpu, cement korena i alveolarnu kost⁵. Epidemiološke studije ukazuju na to da su najčešće avulzirani zubi gornji centralni sekutići⁶, i da je uglavnom izbijen jedan zub, a ređe više stalnih zuba. Iako se mogu javiti u bilo kojoj životnoj dobi, avulzije stalnih zuba se, zbog visoke rezilijencije potpornog aparata mladih stalnih zuba i nezavršene mineralizacije okolne alveolarne kosti, u najvećem broju slučajeva javljaju u periodu između 7. i 14 godine života⁶. Visoka zastupljenost i brojne negativne posledice koje za sobom ostavljaju, čine da se avulzije stalnih zuba mogu smatrati povredama od značaja za javno zdravlje.

Zarastanje periodontalnog tkiva

Brz i adekvatan tretman, koji ima za cilj očuvanje avulziranog zuba i okolne alveolarne kosti od izuzetnog je značaja⁷. Terapija izbora u zbrinjavanju izbijenih zuba je replantacija, i sprovodi se sa ciljem obezbeđivanja zarastanja periodontalnog tkiva uz potpunu regeneraciju periodoncijuma. Revaskularizacija pulpnog tkiva počinje 4 dana od povrede⁸, i u koronarnom delu pulpnog tkiva dolazi do neoangiogeneze, proliferacijom mezenhimalnih ćelija. Nadalje, 7 dana posle replantacije avulziranog stalnog zuba dolazi do srastanja pokidanih gingivalnih vlakana periodoncijuma čime se smanjuje mogućnost prodora mikroorganizama kroz gingivalni džep. Utvrđeno je da revaskularizacija pulpnog tkiva napreduje brzinom od 0,5 mm dnevno i da je za kompletnu revaskularizaciju stalnih sekutića potrebno 30 do 40 dana⁹, pod uslovom da nije došlo do infekcije.

Introduction

Injury to permanent dentition occupies a significant place in the oral pathology of the modern man. It is estimated that the incidence of dental injuries in children ranges from 2.4 to 34% and that in the adult population, every fourth adult experiences some kind of dental injury during their lifetime¹. Researches conducted worldwide indicate that 0.5-16% of all permanent tooth injuries are avulsions^{2,3}. In Serbia, dental avulsions account for 5% of all dental injuries⁴.

Permanent tooth avulsions (traumatic extraction; total luxation) are one of the most severe permanent tooth injuries and can occur as single injuries or associated with other dental injuries or injuries to the face and jaws region (Figure 1). They are defined as the luxation of teeth from the alveoli with complete rupture of periodontal fibres, or with one part attached to the root cementum and the other to the alveolar bone, thus compromising the dental pulp, root cementum, and alveolar bone⁵. Epidemiological studies indicate that the most commonly avulsed teeth are upper central incisors⁶, usually one or, less often, several permanent teeth. Although they may occur at any age, permanent tooth avulsions mostly occur between the ages of 7 and 14 due to the high resilience of the supporting apparatus of immature permanent teeth and incomplete mineralization of the surrounding alveolar bone⁶. The high prevalence and numerous negative consequences they have suggest permanent tooth avulsions should be regarded as an important public health problem.

Periodontal Tissue Healing

Prompt and adequate treatment, which aims to preserve the avulsed tooth and the surrounding alveolar bone, is crucial⁷. Replantation is the therapy of choice in the management of avulsed teeth, and it is carried out to ensure the healing of periodontal tissue with complete regeneration of the periodontium. The revascularization of the pulp tissue begins 4 days after the injury⁸, and the proliferation of mesenchymal cells results in neoangiogenesis, which occurs in the coronal part of the pulp tissue. Furthermore, 7 days after the replantation of the avulsed permanent tooth, the ruptured gingival fibres of the periodontium coalesce, thereby reducing the possibility of microorganisms penetrating through the gingival pocket. It was found that

Međutim, u kliničkim uslovima ovo uglavnom nije moguće očekivati, te se pozitivnim ishodom može smatrati i zarastanje periodontalnog ligamenta uz reparatorne procese koji dovode do površinske resorpcije korena. Eksterna inflamatorna resorpcija korena i zarastanje periodontalnog tkiva uz zamensku resorpciju korena predstavljaju nepovoljan ishod replantacije izbijenog stalnog zuba.

Prilikom avulzije zuba dolazi do prekida neurovaskularnog snopa u predelu vrha korena zuba i rupture pulpe, što za posledicu može imati nekrozu pulpnog tkiva. Nekrotična pulpa podložna je bakterijskoj kontaminaciji. Ako ne dodje do revaskularizacije ili se ne sprovede adekvatna endodontska terapija, kanal korena postaje inficiran. Kombinovana mikrobiološka flora u korenskom kanalu oštetiće cement na spoljnoj površini korena, dovodeći do pojave eksterne inflamatorne resorpcije koja može biti vrlo agresivna. Eksterna inflamatorna resorpcija posledica je prodora bakterijskih metabolita iz inficiranog pulpnog tkiva, kroz dentinske kanaliće, do eksponirane površine korena. Kiseli bakterijski metabiliti dovode do porasta kiselosti što predstavlja stimulans za početak osteoklastne aktivnosti. Resorptivni procesi, u početku dešavaju se na okolnom koštanom tkivu, jer je cement korena otporniji na inflamatorne agense. Cement i predentin smatraju se prvom linijom odbrane od resorpcije. Utvrđeno je to da osteoklasti ne resorbuju nemineralizovani koštani matriks. Spoljašnji sloj cementa prekriven je slojem cementoblasta formirajući zonu nemineralizovanog cementoida, dok je dentin prekriven predentinom, sa sličnom organskom strukturom. Eksterna resorpcija korena dogodiće se u slučaju oštećenja predentina i precementa kada inflamatorni agensi deluju na nezaštićenu površinu korena¹⁰. Eksterna resorpcija nastaviće se sve dok se mikrobnii agensi ne uklone iz korenskog kanala i okoline korena, i može imati superakutni tok uslovljavajući brzi gubitak zuba¹¹. Andreasen i sar.¹² utvrdili su to da progresija resorpcije korena zuba zavisi od uzrasta pacijenta. Ovi autori su utvrdili da je stopa resorpcije korena zuba značajno veća kod pacijenata koji su u trenutku povrede imali između 8 i 16 godina u odnosu na pacijente koji su u trenutku povrede imali između 17 i 39 godina.

Ako se periodontalna vlakna, koja su ostala vezana za površinu korena ne isuše, posledice avulzije zuba obično su minimalne^{13,14}.

the revascularization of the pulp tissue progresses at a rate of 0.5 mm per day and that complete revascularization of permanent incisors takes about 30 to 40 days⁹, provided that no infection has occurred.

However, this is generally impossible to expect in clinical conditions. Therefore, the healing of the periodontal ligament with reparative processes that lead to superficial root resorption may be considered a positive outcome. External inflammatory resorption of the root and healing of the periodontal tissue with replacement root resorption represent an unfavourable outcome of the replantation of the avulsed permanent tooth.

At the time of tooth avulsion, the neurovascular bundle is interrupted at the level of the tooth root tip, and the pulp ruptures, which can result in pulp tissue necrosis. Necrotic pulp is susceptible to bacterial contamination. Unless revascularization occurs or adequate endodontic therapy is performed, the root canal becomes infected. The combined microbiological flora in the root canal will damage the cementum on the outer surface of the root, leading to external inflammatory resorption, which can be rather aggressive. External inflammatory resorption is a consequence of the penetration of bacterial metabolites from the infected pulp tissue, through dentinal tubules, to the exposed root surface. Acidic bacterial metabolites lead to an increase in acidity which is a stimulus for the onset of osteoclast activity. Resorptive processes initially occur on the surrounding bone tissue, given that the root cementum is more resistant to inflammatory agents. The cementum and predentin are considered the first line of defence against resorption. Osteoclasts were found not to resorb unmineralized bone matrix. The outer layer of the cementum is covered with the cementoblast layer forming a zone of unmineralized cementoid, while the dentin is covered with predentin, with a similar organic structure. External root resorption will occur in cases of predentin and precementum damage when inflammatory agents act on the unprotected surface of the root¹⁰. External resorption will continue until microbial agents are removed from the root canal and the root environment, and may have a superacute course causing rapid tooth loss¹¹. Andreasen et al.¹² concluded that the progression of tooth root resorption depended on the age of the patient. These authors found that the rate of tooth root resorption was significantly higher in patients aged 8 to 16 compared to patients aged 17 to 39 at the time of injury.

Hidrirane ćelije periodontalnog ligamenta delimično će održati svoju vitalnost i omogućiti će zarastanje ligamenta bez razvoja veće inflamacije. Inflamacija se može razviti na ograničenim delovima korena ali će zarastanje korena biti moguće deponicijom novog cementa. U slučaju prekomernog sušenja periodontalnih vlakana pre replantacije, oštećene ćelije će izazivati difuzni inflamatorni odgovor na površini korena. Tada, za razliku od delimično oštećenog korena, koji biva pokriven cementoblastima, nema ovakvog zarastanja. Postoji velika površina korena koju cementoblasti ne mogu prekriti u kratkom periodu, tako da se kost direktno vezuje za površinu korena. Koren se postepeno zamenjuje košću, što je poznato kao zamenska resorpcija korena ili ankiloza^{15,16}. Ankiloza može imati uticaj na rast alveolarnog grebena i može oslabiti položaj neoštećenog susednog zuba¹⁷. Ankilotični zub ima karakterističan perkutorni zvuk, izmenjenu boju krunice i vremenom se nalazi u infraokluziji (Slika 1). S obzirom na to da se povrede dešavaju najčešće u prednjem, estetskom segmentu gornje vilice, potrebno je naći dobro rešenje za ublažavanje ovakvih posledica.

If the periodontal fibres that remain attached to the root surface do not dry out, the consequences of tooth avulsion are usually minimal^{13,14}. Hydrated cells of the periodontal ligament will partially maintain their vitality and allow the ligament to heal without the development of greater inflammation. Inflammation can develop on limited parts of the root, but root healing will be possible with the deposition of new cementum. In the case of excessive drying of periodontal fibres before replantation, the damaged cells will provoke a diffuse inflammatory response on the root surface. Then, unlike the partially damaged root that will be covered with cementoblasts, there is no such healing. There is a large root area that cementoblasts cannot cover in a short time, thus the bone binds directly to the root surface. The root is gradually replaced by bone, which is known as replacement root resorption or ankylosis^{15,16}. Ankylosis can affect the alveolar ridge growth and can weaken the position of an intact adjacent tooth¹⁷. The ankylosed tooth has a characteristic percussion sound, a changed colour of the crown, and eventually becomes infraoccluded (Figure 2). Given that injuries most often occur in the anterior, aesthetic segment of the maxilla, it is necessary to find a good solution to mitigate such consequences.



Slika 1. Ankilotičan avulzirani zub 11 u infraokluziji kod devojčice stare 12 godina. Replantacija avulziranog zuba izvršena 17 sati nakon povrede. Avulzirani zub endodontski tretiran

Figure 1. Ankylotic avulsive tooth 11 in infracclusion in a 12-year-old girl. Replantation of the avulsed tooth was performed 17 hours after the injury. Avulsated tooth endodontically treated



Slika 2. (A) Avulzija zuba 12,11,21 udružena sa frakturom alveolarnog nastavka i nosnih struktura; (B) Izgled posle repozicije koštanih struktura i avulzije stalnih zuba, imobilizacija zuba izvršena rigidnom vezom; (C) Izgled pacijenta godinu dana posle povrede.

Figure 2. (A) Tooth avulsion 12, 11, 21 associated with fracture of alveolar process and nasal structures; (B) Appearance of the patient one year after the therapy (replantation and immobilization of avulsed teeth)

Strategija lečenja avulziranih zuba

Strategija lečenja avulziranih stalnih zuba uvek je bazirana na ograničavanju infekcije korenskog kanala i periradikularne upale, prebacujući ravnotežu od nepovoljnog zarastanja (resorpcija zamene) prema povoljnom (periodontalnom) zarastanju.

Redosled zbrinjavanja avulzija stalnih zuba preporučen je od Međunarodnog udruženja za dentalnu traumatologiju 2007. godine¹⁸, a dopunjen je 2012. godine¹⁹, pa zatim i 2020 godine²⁰.

Opšte je prihvaćeno to da uspeh terapije i periodontalno zarastanje zavise od trajanja i uslova ekstraoralnog čuvanja zuba, stepena oštećenja periodontalnog ligamenta i stanja pulpe^{21,22}. Starost pacijenta, kao i način i dužina splintiranja imaju uticaja na stepen i način preživljavanja avulziranih zuba u vilicama.

Najbolja terapija avulziranih zuba je neposredna replantacija na mestu povrede, koja ima za cilj da spreči sušenje periodontalnih vlakana na površini korena zuba, čme se povećava šansa za preživljavanje replantiranog zuba i smanjuje rizik od nastanka komplikacija u vidu eksterne resorpcije i zamenske resorpcije.

Treatment Strategy for Avulsed Teeth

The treatment strategy for avulsed teeth is always based on limiting the root canal infection and periradicular inflammation, shifting the balance from unfavourable (replacement resorption) to favourable (periodontal) healing.

The order of the management procedures for permanent tooth avulsions was recommended by the International Association of Dental Traumatology in 2007, amended first in 2012¹⁹, and then again in 2020²⁰.

It is generally accepted that the success of therapy and periodontal healing depend on the duration and conditions of extraoral preservation of teeth, the degree of damage to the periodontal ligament, and the condition of the pulp^{21,22}. The age of the patient, as well as the manner and duration of splinting, affect the degree and manner of the survival of avulsed teeth in the jaws.

The best therapy for avulsed teeth is immediate replantation at the injury site, which aims to prevent drying of periodontal fibres on the surface of the tooth root, thereby increasing the chances for survival of the reimplanted tooth and decreasing the risk of complications such as external resorption and replacement resorption.

Neposrednom replantacijom smatra se tretman izveden u prvih dvadeset minuta od trenutka povrede. Visok procenat preživljavanja imaju i zubi koji su replantirani u prvih 30 minuta od povrede¹⁵. Međutim, vrlo često ovakav tretman nije moguće izvesti, pa se u tom slučaju primenjuje odložena replantacija tj. replantacija zuba u periodu dužem od sat vremena od momenta povrede. Prema nekim autorima, vreme koje prođe od trenutka povrede do momenta javljanja lekaru, u proseku iznosi između jednog sata i 4 sata²³. Za to vreme, za ishod terapije od najvećeg je značaja prezervacija ćelija periodontalnog ligamenta, jer vitalne ćelije omogućavaju restituciju, dok nekrotične ćelije uzrokuju inflamaciju sa sledstvenom resorpcijom okolnih tkiva.

Izbor odgovarajućeg medijuma za transport avulziranog zuba, od mesta povrede do ustanove gde će biti ukazana pomoć i način čuvanja zuba jednako su značajni kao i vreme proteklo od povrede do zbrinjavanja. Idealan medijum za transport i čuvanje avulziranog zuba je onaj koji ima sposobnost održavanja vitalnosti ćelija periodontalnog ligamenta (PDL) i pulpe, koji poseduje klonogenske sposobnosti, deluje antioksidativno, ne sadrži mikroorganizme, ima kompatibilnu fiziološku pH i osmolalnost, visoku dostupnost i nisku cenu. Postoje mnogi pripremljeni rastvori za očuvanje vitalnosti ćelija pulpe i PDL, a jedan do njih je i Henkov rastvor u kome ćelije mogu održati vitalnost i preko 96 sati²⁴. Ovaj rastvor preporučilo je Međunarodno udruženje za dentalnu traumatologiju 2007 godine¹⁸. Od tada, pojavljuje se veći broj predloga za čuvanje avulziranih zuba, kao što su pljuvačka, voda, led, fiziološki rastvor, Viaspan[®], minimalni esencijalni medijum (MEM), propolis, ekstrakt zelenog čaja, crnog dudu, kokosova voda, sportski napitci i sredstva za oralnu rehidraciju^{25,26}. Kako bi održali normalne uslove za očuvanje vitalnosti zuba, ovi medijumi moraju imati isti osmolaritet, pH i ćelijske nutrijente. Testirane su i druge vrste rastvora, kao što su sojino mleko, mleko u prahu, enfamil i tečnost za kontaktna sočiva, ali bez zadovoljavajućih rezultata.

Kada postoji prekid kontinuiteta neurovaskularnog snopa, sve metabolite (kalcijum-fosfat, kalijum) i glukozu treba dopremiti ćelijama. U slučaju odložene replantacije, u cilju povećanja stope preživljavanja avulziranih zuba preporučuju se određeni pre-replantacijski postupci.

The term immediate replantation refers to the treatment performed within the first 20 minutes after the injury. Teeth replanted within the first 30 minutes after the injury also have a high survival rate¹⁵. However, such a treatment is very often impossible. Therefore, in that case, delayed replantation is used instead, i.e. tooth replantation within more than an hour after the injury. According to some authors, the time that elapses between the moment of injury and the moment of receiving medical help is on average between 1 and 4 hours²³. During this time, the preservation of the cells of the periodontal ligament is of the utmost importance for the outcome of therapy, given that vital cells enable restitution, whereas necrotic cells cause inflammation with consequent resorption of surrounding tissues.

The choice of the appropriate medium for the transport of avulsed tooth, from the site of injury to the facility where medical assistance will be provided, and the manner in which the tooth is stored are just as important as the time elapsed from the injury to received medical care. The ideal medium for transporting and storing the avulsed tooth is the one that is capable of maintaining the vitality of periodontal ligament (PDL) and pulp cells, has clonogenic abilities, acts as an antioxidant, does not contain microorganisms, has compatible physiological pH and osmolality, high availability and low price. There are various ready-made solutions for preserving the vitality of pulp and PDL cells, one of them being Hanks' solution in which cells can maintain vitality for over 96 hours²⁴. This solution was recommended by the International Association of Dental Traumatology in 2007¹⁸. Since then, numerous suggestions for the preservation of avulsed teeth have emerged - saliva, water, ice, saline, Viaspan[®], Minimal Essential Medium (MEM), propolis, green tea extract, black mulberry extract, coconut water, energy drinks, and oral rehydration agents^{25,26}. To maintain normal conditions for tooth vitality, these media must have the same osmolarity, pH, and cellular nutrients. Other types of solutions, such as soy milk, milk powder, Enfamil, and contact lens fluid, have also been tested but without satisfactory results.

When there is a break in the continuity of the neurovascular bundle, all metabolites (calcium phosphate, potassium) and glucose should be delivered to the cells. In the case of delayed replantation, certain pre-replantation procedures are recommended to increase the survival rate of avulsed teeth.

U pogledu sistemske primene antibiotika, prvi izbor trebalo bi da bude odgovarajuća doza tetraciklina, koji su osim antimikrobnih osobina, pokazali i anti-resorptivni učinak, kao i inhibitorni efekat na osteoklaste i kolagenazu. Međutim, kako je sistemska upotreba tetraciklina kod dece do 12. godine života u mnogim zemljama zabranjena, sistemski treba ordinirati penicilinske preparate ili makrolide. Lokalna primena kortiko preparata takođe smanjuje koštanu resorpciju. Imidijetna primena paste za tretman kanala korena zuba koje sadrže kombinaciju kortikosteroida i tetraciklina ima povoljan efekat na periradikularno tkivo, zbog kontrolisanog oslobađanja medikamenata kroz dentinske kanaliće prema periodoncijumu.

U pogledu splintiranja avulziranih zuba, preporuka je da se splintiranje vrši fleksibilnim splintom, a da trajanje splintiranja ne prelazi 2 nedelje¹⁹.

Tretman zuba sa nezavršenim rastom korena

Kod zuba sa nezavršenim rastom korena, kada se na rendgen snimku uočava da je apikalni otvor veći od 1.1 mm i kada je zub van alveole bio manje od 60 minuta, postoji mogućnost restitucije ćelija pulpe i periodontalnog ligamenta. Pre-replantacijske procedure nisu potrebne, jer bi produžile vreme boravka zuba van alveole i dovele do oštećenja periodontalnog ligamenta čiji se ostaci nalaze na korenu avulziranog zuba. Neki autori, pre replantacije predlažu potapanje zuba u rastvor sa tetraciklinom trajanju od 5 minuta, radi dezinfekcije pulpe, stimulisanja procesa revaskularizacije pulpnog tkiva i oporavka periodoncijuma^{27,28}.

Splint se postavlja u periodu od 7 do 10 dana, i poželjno je da bude jednostavan za fiziološko i mehaničko čišćenje. Pod ovim okolnostima potrebno je oko mesec dana za revaskularizaciju koja se dešava u oko 50% slučajeva²⁹. Kontrolne preglede zuba treba uraditi jednom mesečno. U slučaju nekroze pulpe, odmah treba endodontski lečiti zub. Punjenje kalcijum-hidroksidom ili u kombinaciji sa mineral-trioksid agregatom trebalo bi da stvori apikalnu barijeru i spreči resorpciju korena. Ako dođe do nekontrolisane inflamacije, usled sušenja periodontalnih vlakana ili zbog infekcije pulpe, eksterna resorpcija i gubitak zuba, obično se odigravaju brže i agresivnije nego kod zuba sa završenim rastom korena.

Regarding the systemic administration of antibiotics, the first choice should be an appropriate dose of tetracyclines, which, in addition to antimicrobial properties, have also shown an antiresorptive effect, and an inhibitory effect on osteoclasts and collagenase. However, since the systemic use of tetracycline in children under the age of 12 is prohibited in many countries, penicillin preparations or macrolides should be administered systemically. Topical application of corticosteroids also reduces bone resorption. The immediate application of the tooth root canal treatment paste containing a combination of corticosteroids and tetracycline has a beneficial effect on the periradicular tissue due to the controlled release of drugs through the dentinal tubules towards the periodontium.

Regarding splinting of avulsed teeth, it should be done with a flexible splint, and the duration of splinting should not exceed 2 weeks¹⁹.

Treatment of Teeth with Incomplete Root Development

In teeth with incomplete root development, when the X-ray shows that the apical opening is greater than 1.1 mm, and when the tooth was outside the alveolus for less than 60 minutes, there is a possibility of restitution of pulp and periodontal ligament cells. Pre-replantation procedures are not necessary as they would prolong the time the tooth spends outside the alveolus and lead to damage to the periodontal ligament, whose residuals are found on the root of the avulsed tooth. Some authors suggest immersing the tooth in a tetracycline solution for 5 minutes prior to replantation to disinfect the pulp, stimulate the process of the revascularization of the pulp tissue, and recover the periodontium^{27,28}.

The splint is placed for a period of 7-10 days, and physiological and mechanical cleaning should be simple. Under these circumstances, revascularization takes about a month to occur, and it is reported in about 50% of cases²⁹. Dental check-ups should be done once a month. In case of pulp necrosis, the tooth should be treated endodontically. Filling with calcium hydroxide or in combination with mineral trioxide aggregate should create an apical barrier and prevent root resorption. If there is uncontrolled inflammation as a result of drying of periodontal fibres or due to pulp infection

Razlog tome je to što kod mladih pacijenata, prilikom oštećenja cementa, široki dentinski kanalići dopuštaju slobodno kretanje iritansa ka spoljnoj površini korena i dovode do brže eksterne resorpcije.

Treba izbegavati rigidno šiniranje. Duži period nošenja splinta preporučuje se jedino kada je avulzija zuba sa nezavršenim rastom korena udružena sa frakturom alveolarnog nastavka.

U slučaju kada je kod zuba sa nezavršenim rastom korena od trenutka povrede prošlo više od jednog sata, postoje različiti stavovi po pitanju replantacije. Pojedini stomatolozi, zbog mogućih komplikacija, ne predlažu replantaciju avulziranog zuba, već ortodontski tretman³⁰. Drugi, kao prelazno rešenje koje bi sprečilo resorpciju alveolarnog grebena, nastalog usled vađenja zuba, predlažu dekoronaciju³¹. Na ovaj način preventira se deformitet dentoalveolarnog segmenta do perioda povoljnog za implantaciju³². Međutim, prema aktuelnom vodiču za tretman avulziranih zuba sa nezavršenim rastom korena¹⁹, čak iako je od trenutka povrede prošlo jedan sat ili više sati, replantaciju treba razmotriti kao terapiju izbora, koja se sprovodi sa ciljem privremenog očuvanja konture i visine alveolarnog grebena radi kasnije protetske terapije^{1,4,30-32}. Međutim, ishod odložene replantacije u ovom slučaju najčešće je loš.

Endodontski tretman zuba sa nezavršenim rastom korena treba izbegavati, osim u slučaju kada se klinički i radiografski dijagnostikuje nekroza pulpe¹⁹.

Tretman zuba sa završenim rastom korena

Kompletno zarastanje periodontalnog ligamenta, kod zuba sa završenim rastom korena, sigurno je samo u slučaju ako je zub replantiran u prvih pet minuta od trenutka povrede³³. U svakom slučaju, treba insistirati na replantaciji u prvih 15 do 20 minuta.

Kod zuba sa završenim rastom korena, revaskularizacija pulpe nije moguća, tako da je endodontski tretman neizbežan. U zavisnosti od načina čuvanja, načina nastanka povrede i vremena proteklog od nastanka povrede, predloženo je više terapijskih mogućnosti, kako bi se održala vitalnost okolnog tkiva, odložila ankiloza i resorpcija. Ako je replantacija urađena u prvih 20 minuta, poželjno je koren zuba obraditi u istoj poseti lekaru i napuniti pastom koja sadrži kortikosteroide i tetracikline. Punjenje se kasnije menja, a zub puni kalcijum-hidroksidom.

external resorption and tooth loss usually occur faster and more aggressively than in teeth with completed root growth. The reason is that in young patients, when the cementum is damaged, wide dentinal tubules allow free movement of irritants towards the outer surface of the root and lead to faster external resorption.

Rigid splinting should be avoided. A longer period of wearing a splint is recommended only when the avulsion of the tooth with incomplete root growth is associated with a fracture of the alveolar process.

Regarding teeth with incomplete root development, in case that more than one hour has passed since the moment of injury, attitudes concerning replantation are different. Due to possible complications, some dentists do not suggest replantation of the avulsed tooth, but orthodontic treatment³⁰. Others suggest decoronation as a temporary solution that would prevent the resorption of the alveolar ridge, caused by tooth extraction³¹. In this way, the deformity of the dentoalveolar segment is prevented until a period favourable for implantation³². However, according to current guidelines for the treatment of avulsed teeth with incomplete root development¹⁹, even if one or more hours have passed since the injury, replantation should be taken into consideration as the therapy of choice to temporarily preserve the contour and height of the alveolar ridge for later prosthetic therapy^{1,4,30-32}. Nevertheless, the outcome of delayed replantation in such cases is usually poor.

Endodontic treatment of teeth with incomplete root development should be avoided, except when pulp necrosis is clinically and radiographically diagnosed¹⁹.

Treatment of Teeth with Completed Root Development

Complete healing of the periodontal ligament in teeth with completed root development is safe only if the tooth is replanted in the first five minutes from the moment of injury³³. Anyway, it should be insisted on the replantation in the first 15-20 minutes.

In teeth with completed root development, pulp revascularization is not possible. Therefore, endodontic treatment is inevitable. Depending on the method of preservation, type of injury, and the time elapsed since the injury, several therapeutic

U slučaju odložene replantacije, kada je ekstraalveolarno vreme duže od 60 minuta, ćelije periodontalnog ligamenta definitivno su izgubile vitalnost. Uklanjanjem ovih ostataka, smanjuje se mogućnost inflamacije. Može se primeniti kiretaža oštrom kiretom, skalrom ili potapanje u limunsku kiselinu i natrijum-hipohlorit. Posle ispiranja zuba sterilnim fiziološkim rastvorom, poželino je zub staviti u dvoprocentni rastvor natrijum-fluorida na 5 minuta. Fluoridi dovode do konverzije hidroksiapatita sa oštećene površine korena u fluorapatit, koji se taloži na površinu korena i ima zaštitnu ulogu.

Za stimulaciju zarastanja cementa i periodontalnog ligamenta lokalna aplikacija proteina gleđnog matriksa (Emdogain, Biora, Malme, Švedska) na koren avulziranog zuba i unutar alveole, može biti od koristi u slučaju replantacije zuba u periodu do 60 minuta od nastanka povrede, dok je kasnija upotreba sa ograničenim uspehom³⁴.

Lokalna upotreba baznog fibroblastnog faktora rasta bFGF dovodi do stvaranja novih ćelija periodontalnog ligamenta i kolagenih vlakana koja se direktno vezuju za cement i kost, smanjujući tako ankilozu i resorpciju korena zuba kod kojih je urađena odložena replantacija³⁵⁻³⁷.

Kako bi se izbeglo širenje infekcije iz korenskog kanala kod odložene replantacije, poželino je endodontski tretman odraditi neposredno i van alveole: koren prvo napuniti antibiotskom pastom sa dodatim kortikosteroidima, a kasnije kalcijum-hidroksidom, definitivnim punjenjem. Glavni efekat kalcijum-hidroksida je antibakterijsko svojstvo, a osim toga kalcijum-hidroksid pokazuje i povoljni uticaj na mestu resorpcije ier čini sredinu više alkalnom i promovira stvaranje čvrstog tkiva³⁸. Međutim, ne treba ga ostavljati u kanalu korena na period duži od 3 meseca, ier može dovesti do nekroze ćelijske populacije koja teži da zaceli mesto povrede na površini korena.

Zaključak

Strategija lečenja avulziranih stalnih zuba uvek je bazirana na ograničavanju infekcije korenskog kanala i periradikularne upale, prebacujući ravnotežu od nepovoljnog zarastanja (resorpcija zamene) prema povoljnom (periodontalnom) zarastanju. Uspeh terapije i periodontalno zarastanje zavise od trajanja i uslova ekstraoralnog čuvanja zuba, stepena oštećenja periodontalnog ligamenta i stanja pulpe.

options have been proposed to maintain the vitality of the surrounding tissue, delay ankylosis and resorption. If the replantation is done within the first 20 minutes, the tooth root should be processed at the same time and filled with corticosteroid and tetracycline paste. The filling is changed later, and the tooth is filled with calcium hydroxide.

Regarding delayed replantation, i.e. when the extra-alveolar time is longer than 60 minutes, the periodontal ligament cells have unquestionably lost their vitality. By removing these residues, the possibility of inflammation is reduced. Curettage with a sharp curette or scaler or immersion in citric acid and sodium hypochlorite can be used. After rinsing the tooth with a sterile physiological solution, it is necessary to put the tooth in 2% sodium fluoride solution for 5 minutes. Fluorides lead to the conversion of hydroxyapatite from the damaged root surface to fluorapatite, which is deposited on the root surface and has a protective role.

To stimulate the healing of the cementum and periodontal ligament, the local application of enamel matrix protein (Emdogain, Biora, Malmo, Sweden) to the root of the avulsed tooth and inside the alveolus may be useful in the cases of tooth replantation within 60 minutes from injury, whereas later use has limited success³⁴.

Topical use of the basic fibroblast growth factor (bFGF) leads to the formation of new periodontal ligament cells and collagen fibres that bind directly to the cementum and bone, thus reducing ankylosis and the resorption of tooth roots in which delayed replantation has been performed³⁵⁻³⁷.

To avoid the spread of infection from the root canal during delayed replantation, it is desirable to perform endodontic treatment immediately and outside the alveoli. The root is first filled with antibiotic paste with added corticosteroids, and then with calcium hydroxide, as a final filling. The main effect of calcium hydroxide is its antibacterial feature. Furthermore, calcium hydroxide has a favourable effect at the resorption site given that it makes the environment more alkaline and promotes the formation of solid tissue³⁸. However, it should not be left in the root canal for longer than 3 months since it can lead to necrosis of the cells that tend to heal the site of injury on the root surface.

Conclusion

The treatment strategy for avulsed permanent teeth is always based on limiting root canal infection and periradicular inflammation, shifting the balance from unfavourable

Starost pacijenta, udruženost povreda i način i dužina splintiranja od esencijalnog su značaja za stepen i način preživljavanja avulziranih zuba u vilicama.

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(replacement resorption) to favourable (periodontal) healing.

The success of therapy and periodontal healing depend on the duration and conditions of extraoral tooth preservation, the degree of damage to the periodontal ligament, and the condition of the pulp. The age of the patient, concomitant injuries and the manner and duration of splinting are essential to the degree and manner of survival of avulsed teeth in the jaws.

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