

Tricia Granger, Alasdair Gunn, Richard Welbury

Replantacija zuba: vježba vrijedna truda?

Tooth replantation: a worthwhile exercise?

Zavod za dječju stomatologiju Stomatološkog fakulteta Sveučilišta u Glasgou
Department of Paediatric Dentistry, University of Glasgow Dental School

Sažetak

Ako se izbije zub, to je ozbiljan napad na zubna tkiva i okolni parodont, pa tako postupak replantacije završava vrlo različito. Pritom je glavni zadatak održati vitalnost stanica parodontnog ligamenta i njegovo funkcijsko cijeljenje te povećati mogućnost revaskularizacije pulpe. Kako bi se ustanovilo je li replantacija zuba vrijedna truda, potrebna je analiza dokaza na dvama područjima – može li se replantirani zub zadržati trajno (uspješno parodontalno cijeljenje) ili može li, uz nadomjesnu resorpciju (ankilozu), razmjerno normalno rasti i održati alveolarni greben do uporabe nadomjestka kojim će se popuniti prostor ako je zub izgubljen u kasnim adolescentnim godinama.

Zaprimljen: 14. ožujka 2011.

Prihvaćen: 10. svibnja 2011.

Adresa za dopisivanje

Richard Welbury
University of Glasgow Dental School
Department of Paediatric Dentistry,
378 Sauchiehall Street
Glasgow G2 3JZ, Scotland
Richard.Welbury@glasgow.ac.uk

Ključne riječi

zub, izbijanje; zub, reimplantacija; poboljšanje tkiva (stomatološko); parodontalni ligament

Uvod

Ako se izbije zub, to je ozbiljan napad na zubna tkiva i okolni parodont, pa tako postupak replantacije završava vrlo različito. Pritom je glavni zadatak održati vitalnost stanica parodontnog ligamenta i njegovo funkcijsko cijeljenje te povećati mogućnost revaskularizacije pulpe. Kako bi se ustanovilo je li replantacija zuba vrijedna truda, potrebna je analiza dokaza na dvama područjima – može li se replantirani zub zadržati trajno (uspješno parodontalno cijeljenje) ili može li uz nadomjesnu resorpciju (ankilozu) razmjerno normalno rasti i održati alveolarni greben do uporabe nadomjestka kojim će se popuniti prostor ako je zub izgubljen u kasnim adolescentnim godinama (neuspješno cijeljenje, ali razmjerno uspješno jer je zub zadržan dok nije postigao približno puni rast).

Rani gubitak trajnoga prednjeg zuba znatno utječe na zubni razvoj zbog gubitka alveolarne kosti i spontanoga pomicanja susjednih zuba. To može rezultirati naginjanjem okolnih zuba, njihovom migracijom čime se gubi prostor, pomakom središnje linije i prekomjernim nicanjem. Sve to stvara estetske nedostatke i područja sa stagnacijom. Ako se u toj mladenačkoj dobi postave držači prostora ili protetička zamjena, oni također povećavaju rizične čimbenike.

Izbijanje zuba i replantacija imaju više posljedica ako je riječ o djetetu kojemu kosti lica još aktivno raste. Premda nadomjesna resorpcija (ankilozu) može pacijentu znatno smanjiti dugovječnost zuba, ako je privremeno ostao u ustima omogućena je kontinuirana alveolarna stabilnost dok služi

Introduction

Avulsion is a serious assault on both dental tissues and the surrounding periodontium and in consequence the process of replantation creates a wide range of outcomes. The main aim of replantation is to maintain periodontal cell viability and the possibility of functional healing of the periodontal ligament (PDL) and maximise the possibility of pulpal revascularisation. To identify whether replantation is worthwhile requires analysis of the evidence in two areas: whether the replanted tooth can be retained indefinitely (successful periodontal healing), or whether even in the presence of replacement resorption (ankylosis) relatively normal growth and maintenance of alveolar ridge contour can occur until utilisation of a prosthesis to fill the space when the tooth is lost in late teenage years (unsuccessful healing but relative success in that the tooth is retained until near full growth achieved).

Early loss of a permanent anterior tooth significantly affects dental development with alveolar bone loss and spontaneous movement of adjacent teeth. This can result in tilting of adjacent teeth, migration of teeth with resultant space loss, midline shift and over eruption. These all produce an aesthetic deficit and stagnation areas. If space maintenance or prosthetic replacement is provided at this young age then they too bring about increased risk factors.

Avulsion and replantation has more repercussions in the child patient with an actively growing facial skeleton. Although replacement resorption (ankylosis) can drastically reduce the long term retention of a tooth, its temporary reten-

kao držač prostora. Ipak, traumatizirani se zub često zadržava u infraokluziji dok se gornja čeljust nastavlja razvijati ovisno o dobi i skeletalnom razvoju. To rezultira lošom estetikom i funkcijskim gubitkom zuba te zahtijeva koštanu augmentaciju u budućnosti. Jasno da krajnji ishod izbijanja i replantacije, nazvan "uspješno cijeljenje" ili "neuspješno cijeljenje, ali relativan uspjeh", ovisi o izbjegavanju povezane patologije.

Znanstvenih dokaza nema za smjernice u slučaju da je zub izbijen i potrebna je replantacija. Naime, nisu obavljena klinički dokumentirana istraživanja na ljudima, nego se većina laboratorijskih dokaza temelji na pokusima na životinjama (mačku, psu, gvinejskoj svinji, hrčku, zecu, štakoru i majmunu). Dvije najnovije kliničke smjernice dali su International Association of Dental Traumatology (2007.), (1) i American Academy of Paediatric Dentistry (2010.), (2).

U nastavku ćemo detaljno razraditi važne kliničke čimbenike koji utječu na rezultat replantacije.

Imedijatna replantacija i revaskularizacija pulpe

Najčešća dob u kojoj se događaju ozljede glave i lica jest između druge i četvrte godine, (3) ali mlađa djeca obično si ne izbiju zub, nego su to uobičajene luksacijske i ekstruzijske ozljede. Kod dječaka između osam i deset godina statistički je veća vjerojatnost da će si izbiti zub. U toj je dobi parodontni ligament širok i okružuje kratke, nepotpuno razvijene korijene. Revaskularizacija pulpe nakon što je zub izbijen vrlo je poželjna jer daljnji razvoj korijena može osigurati samo debeli dentinski zid otporniji na lomove i zatvoreni vršak korijena koji omogućuje naknadno endodontsko liječenje. Prema rezultatima istraživanja, potpuna revaskularizacija pulpe postiže se kod 18 posto zuba s nezavršenim rastom, ali samo ako je vršak korijena otvoren više od jednog milimetra i ako je zub vrlo brzo replantiran (4). Koliko je dugo zub bio izvan alveole na suhom, važan je čimbenik za uspjeh kod izbijenih zuba. Naime, imedijatna replantacija tijekom pet minuta omogućuje uspjeh, a ako je zub dulje na suhom, to smanjuje vjerojatnost periodontnog cijeljenja za 50 posto (5,6). I ostali čimbenici mogu utjecati na prognozu, primjerice koliko je kontaminirana površina korijena, a vrlo je malo stručnjaka istraživalo na ljudima taj rizični čimbenik za uspješno cijeljenje (6). Tako su Cvek i suradnici (1990.) pokazali da je revaskularizacija pulpe na sjekutićima majmuna bila itekako ovisna o tome ima li ili nema bakterija u pulpnom prostoru (7). Postoje različite teorije kako se kontaminira pulpa, uključujući zaključke da se to događa "kroz napukline u caklini i dentinu krune izbijenog zuba" i kontaminiranim ugruškom u alveoli, zatim da to čine normalne oralne komenzalne bakterije ili da je riječ o kontaminaciji površine korijena dok je zub bio izvan usne šupljine. Kao dopuna parodontnim kirurškim postupcima rabio se tetraciklin zato što može potaknuti dekontaminaciju i regeneraciju parodonta. Kada je u obliku minociklina, polagano otpušta antimikrobne tvari i dovoljno dugo sprječava bakterije da iz ugruška uđu u pulpni prostor te na taj način omogućuje revaskularizacija pulpe. Ritter

in the mouth does allow for continued alveolar stability while the tooth serves as a space maintainer. However the affected tooth is often retained in infraocclusion whilst the maxilla continues to develop at a rate dependant on age and skeletal development. This eventually leads to poor aesthetics and functional tooth loss with a need for future osseous augmentation. Plainly both the eventual outcomes of avulsion and replantation, namely 'successful healing' or 'unsuccessful healing but relative success', rely on the avoidance of associated pathology.

Creation of evidence based guidelines for avulsion and replantation is difficult due to the paucity of clinically documented human studies and much of the laboratory evidence has come from a variety of animal studies (cat, dog, guinea pig, hamster, rabbit, rat, and monkey). The two most recent clinical guidelines come from the International Association of Dental Traumatology (2007), (1), and the American Academy of Paediatric Dentistry (2010), (2).

Important clinical factors affecting outcomes in replantation will now be discussed in more detail.

Immediate Replantation and Pulp Revascularisation

The most common age for a craniofacial injury is between 2 and 4 years (3) but younger children tend not to suffer avulsion injuries and instead luxation or extrusion injuries are more common. Boys, age 8-12, are statistically more likely to suffer an avulsion. At this age the periodontium is loosely structured and surrounds short incompletely formed roots. Pulp revascularisation is highly desirable after tooth avulsion, since continued root development can ensure a thick dentinal wall more resistant to fracture and a closed apex to make subsequent endodontic therapy possible at a later date. Complete pulpal revascularisation has been shown to occur at a rate of 18% among immature teeth but only when the open apex is more than 1mm and the tooth is reimplanted within a very short time (4). The extra-alveolar dry time is an important factor in the success of an avulsion case. Immediate replantation within 5 minutes offers the best chance of success and a dry time greater than this reduces the possibility of periodontal healing to 50 % (5,6). Other factors can affect the prognosis such as level of contamination of root surface and few human studies have investigated this risk factor to successful healing⁶. Cvek et al (1990) showed that pulp revascularisation in monkey incisors was highly dependent on the presence or absence of bacteria in the pulp lumen (7). Various theories as to how the pulp becomes contaminated exist including 'through enamel and dentin cracks in the crown of the avulsed tooth' and from bacterial contamination of the blood clot within the socket from normal oral commensal bacteria or finally from contamination of the root surface whilst the tooth is extra-oral. Tetracycline has been utilised as an adjunct to periodontal surgical procedures because of the drug's ability to assist in decontamination and periodontal regeneration. When utilised as minocycline the slow release antimicrobial inhibits the clot derived bacteria from entering the pulp space long enough to allow pulp revascularisation to occur. Ritter et al

i njegovi kolege (2004.) uspješno su testirali tu hipotezu na psima i istaknuli da je "preživjela" pulpa 91 posto replantiranih zuba liječenih minociklinom u odnosu prema onima tretiranim doksiciklinom (73 %) i fiziološkom otopinom (33 %) koji su poslužili kao kontrola (8).

Utjecaj medija za pohranu

Ako imedijatna replantacija nije moguća, uvjeti za pohranu trebaju omogućiti barem to da se što bolje sačuvaju periodontne stanice dok pacijent putuje prema oralnom kirurgu ili u bolnicu. Cvek i suradnici (1974.) izvijestili su da je resorpcija u fazi cijeljenja zahvatila samo 13 posto zuba držanih na suhom 15 minuta, ali 100 posto zuba koji su bili na suhom dulje od 60 minuta (9). U dodatnim istraživanjima postignuto je još bolje vrijeme preživljenja izbijenih zuba s umjerenom ozljedom parodonta i pohranom u idealnoj izotoničnoj fiziološkoj otopini (5,10). Analizirano je mnogo otopina koje bi mogle poslužiti kao medij za pohranu izbijenog zuba, a najboljom se pokazala Hanks Balanced Salt Solution (HBSS). Sigalas i suradnici (2004.) dokazali su da stanice pohranjene u otopini HBSS-a mogu preživjeti i umnažati se bolje od bilo koje stanice ostavljene u nekom drugom mediju. Rezultati su bili još bolji ako se otopina čuvala u ledu (11). Nažalost, otopine HBSS-a nema u svim ordinacijama i sportskim centrima. Sigalas i suradnici (2004.) ističu da u mlijeku, osobito ako sadržava malo masnoće (2 %), stanice mogu preživjeti izvan alveole zajamčeno do šest sati. Testirana je i otopina za kontaktne leće, no Gatorade (12) ističe da nije idealan medij za pohranu jer periodontne stanice nemaju veću vijabilnost negoli kad su pohranjene u običnoj vodi iz slavine, a kako je takva voda i hipotonična i kontaminirana, nije ništa bolja za pohranu periodontnih stanica od čuvanja na suhome. Otopinom za kontaktne leće ne bi se smjelo koristiti, osim za prvu pomoć. U slučaju kratkog držanja zuba izvan usne šupljine predlaže se čuvati ga u slini (pacijentovoj ili njegovih roditelja), (13). Zanimarimo li dostupnost, slina ima mnogih nedostataka. Primjerice, zub se može slučajno progutati, a nepoželjna je i aktivnost mikroorganizama te salivarnih enzima. Najbolje je ipak koristiti se mlijekom. U jednoj studiji ističe se da bjelanjak kokošjeg jajeta statistički omogućuje sličan rezultat čuvanja kao i mlijeko, no vrijeme izvan usne šupljine i vrijeme pohrane bilo je samo jedan sat. Zato su potrebna daljnja istraživanja (14).

Uporaba kutije za "spašavanje" zuba (proizvođači Dentosafe: Iserlohn, Njemačka ili Tooth saver: Phoenix, Arizona, SAD), u kojoj je kao medij specijalna kultura stanica, pokazala se uspješnom za čuvanje zuba do 53 sata (15). To je neprocjenjivo u slučaju kompleksnijih ozljeda kada se najprije zbrinjavaju medicinski prioriteti, osobito životno ugroženih ljudi. No, spašeni se zub nakon 24 sata mora premjestiti u novu kutiju ako ga je potrebno još dulje čuvati. Kutijama za spašavanje zuba rok trajanja je oko tri godine, ako su spremene na sobnoj temperaturi. Idealno bi bilo kad bi bile dostupne na svim mjestima visokoga rizika za traumatske ozljede, npr. u školama, sportskim dvoranama i odjelima za hitnu pomoć.

(2004) tested this hypothesis successfully in dogs and found a 91% pulp survival rate in the minocycline treated replanted teeth compared to both doxycycline (73%) and saline (33%) acting as a control (8).

Effect of storage media

If immediate replantation is not possible then the storage conditions should at least provide maximum preservation of the periodontal cells whilst the patient heads to the dental surgery or hospital department. Cvek et al (1974) demonstrated that only 13% of teeth kept dry for 15 mins but 100% of teeth kept dry for >60 mins showed resorption in the healing phase (9). Additional studies suggest even better survival times for avulsed teeth with moderate periodontal damage and storage in ideal physiological isotonic solutions (5,10). Many solutions have been examined as possible storage media for avulsed teeth but by far the best is (HBSS) or Hanks Balanced Salt Solution. Sigalas et al (2004) demonstrated that cells stored in HBSS solution were able to survive and proliferate better than any other cell stored in a different storage medium and the results were even better if the solution was also stored in ice (11). Unfortunately, HBSS solution is not widely available in all surgeries and sports arenas. Sigalas et al (2004) also suggested that milk, especially a low fat variety (2%), was an excellent system in which survival of the cells could be guaranteed for extra alveolar times of up to 6 hours. Other solutions tested included contact lens solution and Gatorade (12) and suggested that these are not ideal storage media. Gatorade provided the periodontal cells with no more increased viability than when the teeth were stored in ordinary tap water and since tap water is both hypotonic and contaminated it affords cells of the periodontium no better storage medium than dry storage alone. Contact lens solution should not be used except in anything other than a complete emergency. For short extra-alveolar times, storage in saliva (the patients own or parent's) has been advocated (13). Despite its' availability, however it has many disadvantages; namely that the tooth can be accidentally swallowed as well as the unwelcome activity of microorganisms and salivary enzymes, however for short extra-alveolar times it is a useful adjunct to milk. One study also found that chicken egg white gave a statistically similar outcome for storage as milk but the total storage and extra-alveolar time was only an hour and further studies are required (14).

The use of a tooth rescue box (manufactured by Dentosafe: Iserlohn, Germany or Tooth saver: Phoenix, Arizona), contains a special cell culture medium and has proved successful in storing teeth for up to 53 hours (15). This would be invaluable in cases of more serious injuries where medical priorities take precedence especially where life is endangered. However a rescued tooth should be rehoused in a new tooth rescue box after 24 hours if even longer storage times are necessary. Tooth rescue boxes have a shelf life of approximately 3 years if kept at room temperature, and ideally should be distributed to all locations with a high risk of traumatic injuries, e.g. schools, sporting facilities and emergency units.

Odgođena replantacija i resorpcija

Ako replantacija nije imedijatna, ili ako se izbijeni zub ne čuva u povoljnim uvjetima, počinje odumiranje i pulpnog kompleksa i stanica parodontnog ligamenta. Tada su moguća dva patološka procesa – upalna resorpcija ili nadomjesna resorpcija.

Upalna resorpcija

Zbog ozljeda parodontnog ligamenta i/ili cementa zbog traume ili kontaminacije bakterijama stvaraju se male resorpcijske šupljine na površini korijena. Naime, tada ogoljela površina zuba ostaje bez precementa pa je mineralizirani dio korijena izložen staničnim čimbenicima koji sudjeluju u preoblikovanju kosti te će, ako je u korijenskom kanalu inficirano nekrotično tkivo, toksini iz tog područja prodrijeti kroz dentinske kanaliće do postraničnih tkiva parodontnog ligamenta gdje će prouzročiti upalni odgovor i potencirati nakupljanje medijatora osteoklasta. Na taj način počinje i održava se resorpcijski proces. Kad se ukloni uzročnik, može početi cijeljenje, a to je najlakše postići ako nema upale pulpe. Zato se upalna resorpcija onemogućuje pravodobnom endodontijom (16,17).

Nadomjesna resorpcija

Obilježava je nedostatak vitalnog parodontnog ligamenta i spajanje alveolarne kosti na korijensku površinu. Kako proces ankiloze napreduje, tako nestaju osnovne strukture koje štite korijensku površinu od koštane pregradnje – nema cementoblasta, precementa ni Malassezovih epitelnih ostataka. Progresivna nadomjesna resorpcija nastaje kad se veliki dijelovi parodontnog ligamenta uklone prije replantacije ili su uništeni zbog prekomjernog isušivanja (18,19). Ipak, moguća je i prolazna nadomjesna resorpcija uz malu štetu. Pretpostavlja se da oštećeno područje ponovno naseljavaju stanice iz susjedne koštane srži (20).

Liječenje korijenskog kanala

U literaturi kao da postoji konsenzus u vezi s tim da se svi replantirani zubi trebaju endodontski liječiti ako ne uspije revaskularizacija. To je od vitalnog značenja jer se mora spriječiti da toksini iz nekrotične pulpe kroz dentinske kanaliće potaknu upalne promjene u parodontnom ligamentu (21). Korijenski kanal treba početi liječiti sedam do deset dana nakon replantacije ako se ne očekuje revaskularizacija (1,2). Takvu pravodobnu i ranu intervenciju zagovaraju Stewart i suradnici (2009.) nakon što su istražili niz slučajeva kod kojih je nađeno manje rane korijenske resorpcije uz ekstirpaciju pulpe tijekom deset dana (22). U svojem sustavnom preglednom radu Hinckfuss i Messer (2009.) istaknuli su znatnu povezanost u razvoju upalne resorpcije i ekstirpacije odgođene više od 14 dana, a kod one poduzete unutar 10 dana nije bilo značajne povezanosti (23). Kalcijev hidroksid smatra se najučinkovitijim sredstvom za privremeni uložak sustava korijenskih kanala jer usporava upalnu resorpciju. Ipak, postoje dokazi da bi imedijatno postavljanje ledermiksa moglo po-

Delayed replantation and resorption

If replantation is not immediate or the avulsed tooth is not stored under favourable conditions then the likelihood of death of both the pulp complex and the periodontal ligament cells occurs. Two possible 'pathological outcomes' are then likely, inflammatory resorption or replacement resorption.

Inflammatory Resorption

Damage to the periodontal ligament and / or cementum due to trauma or contamination with bacteria induces small resorption cavities on the root surface. The damage leaves the tooth surface denuded and without precementum thus exposing the mineralised portion of the root to bone's remodelling cellular agents and if the root canal contains infected necrotic tissue, toxins from these areas will penetrate along the dentinal tubules to the lateral periodontal tissues and provoke an inflammatory response and potentiates accumulation of osteoclastic mediators. In this way the resorptive process is initiated and maintained. Once the causative agent is eliminated, healing can commence and this is most easily obtained in absence of pulpal inflammation. Inflammatory resorption is therefore often alleviated by timely endodontics (16,17).

Replacement Resorption

This is characterised by the absence of a vital periodontal ligament and fusion of alveolar bone to the root surface. As the process of ankylosis continues the essential protective structures for protection of the root surface against bony remodelling agents disappear: there are no cementoblasts, precementum or epithelial rests of Malassez. Progressive replacement resorption will occur when significant proportions of the ligament have been removed before replantation or destroyed by extensive drying (18,19). However transient replacement resorption is possible with minor damage. It is assumed the damaged area is repopulated from adjacent bone marrow cells (20).

Root canal treatment

There is consensus in the literature, that all replanted teeth should be endodontically treated should revascularisation fail. This is vital to prevent the necrotic pulp toxins initiating inflammatory change in the periodontium via the dentinal tubules (21). Root canal therapy should be initiated some seven to ten days after replantation in cases where revascularisation cannot be expected (1,2). This early intervention is supported by Stewart et al (2009) (22) in a case series study where less early root resorption was found with pulp extirpation within 10 days. A well structured systematic review by Hinckfuss & Messer (2009), (23) found a significant association between increased development of inflammatory resorption and extirpation delayed beyond 14 days but no significant association when undertaken in less than 10 days. Calcium hydroxide is regarded as the most effective material for interim dressing of root canal systems because it controls the progression of inflammatory resorption. However there is some evidence that immediate placement of led-

voljno djelovati jer može difundirati kroz korijen i spriječiti širenje dentinoklasta (24). Kod replantiranih zuba komplikirana je i zahtjevna tehnička izvedba liječenja korijenskog kanala jer materijal za punjenje kanala (i materijal za medikamentni uložak) mora osigurati hermetično brtvljenje na vršku korijena i cijelom duljinom korijena (25). Postupak je lakši ako su zubi zreli i imaju zatvoren vršak, što omogućuje dobro brtvljenje trajnog punjenja korijenskog kanala, no proces uspješne apeksifikacije nezrelih zuba može trajati mjesecima. Kalcijev hidroksid dobar je u slučaju apeksifikacije – stopa uspješnosti iznosi od 74 do 100 posto (26). Prosječno vrijeme potrebno da se stvori barijera koje se navodi u literaturi, jest između pet i dvadeset mjeseci (27). Andreasen (2002.) ističe da je, osim korijenskih kanala, u slučaju kasne apeksifikacije povećan i rizik od prijeloma korijena – rezultati su pokazali da je tijekom jedne godine pola uzorka nezrelih zuba punjenih kalcijevim hidroksidom za 50-posto smanjilo otpornost na lomove (28). Moguća hipoteza bila bi da denaturirani i hidrolizirani utjecaj kalcijeva hidroksida na dentinski matriks povećava rizik od lomova. U naknadnom istraživanju potvrđeno je gotovo 50-postotno smanjenje mikrotenzilne otpornosti na lomove zuba ako su im korijenski kanali bili ispunjeni kalcijevim hidroksidom najmanje sedam, pa do osamdeset i četiri dana (29). Zbog toga su predložene različite zamjene za kalcijev hidroksid, a jedna je i agregat mineralnog trioksida (MTA). Klinička mu je primjena mnogostruka – služi za prekrivanje pulpe, popravak perforacija i fraktura korijena te poticanje apikalne barijere kod zuba s nezavršenim apeksom. Za tu posljednju namjenu upotrebljava ga u Velikoj Britaniji dvije trećine trenutačnih savjetnika iz pedodoncije (30). Kad se MTA usporedi s kalcijevim hidroksidom kao lijek za punjenje kanala / medikamentni uložak in vitro na modelu ovce, vidi se da smanjuje podložnost lomovima zuba čak i samo mjesec dana ispunjenih kalcijevim hidroksidom (31). Predložen je postupak kliničkog liječenja s jednomjesečnom uporabom kalcijeva hidroksida kako bi se dezinficiralo i isušilo apikalno područje prije uporabe MTA za zatvaranje apeksa, no potrebne su usporedbe in vivo (31).

Preparation of the alveole

Taj postupak uglavnom uključuje uklanjanje krvnih ugrušaka i djelića kosti kako bi se olakšala replantacija. Obično se obavlja što rjeđom uporabom kireta i ispiranjem fiziološkom otopinom (32). Posebice je loša prognoza za izbijene zube koji su bili izvan alveole na suhom dulje od 60 minuta. Mnogi su znanstvenici željeli pronaći uspješnu metodu za proturesorpcijsko i regenerativno liječenje (istraživali su uglavnom na životinjama). Pokazalo se da punjenje alveolne čašice emdogainom, proteinom caklinskog matriksa, potiče proliferaciju parodontnog ligamenta. Molekule caklinskoga matriksa induciraju stvaranje acelularnog cementa na traumom pogođenim korijenskim površinama. Smatra se da su pričuva za ponovno naseljavanje površine korijena preostale vitalne stanice nediferencirane stanice iz koštane srži i progenitorske stanice iz alveole (5). Trope i suradnici (1997.), (33) istaknuli su da uvjeti u alveoli imaju važnu

ermix may be beneficial as it can diffuse through root roots and inhibits spread dentinoclasts (24). In replanted teeth the technical procedure of root canal treatment is difficult and highly demanding because the root filling material (and its initial dressing) must provide a tight seal at the apex as well as all along the root length (25). The process is easier in a mature tooth where a closed apex will affect a good seal with definitive root canal obturation but the process of successful apexification in immature teeth can take many months. Calcium hydroxide as a successful promoter of apexification is well documented, with success rates of 74-100% (26). The average time for barrier formation reported in the literature, is between five and twenty months (27). However Andreasen (2002) would suggest that for those canals where apexification is delayed, then there is an increased risk of root fracture: the results demonstrated that within a year, half the sample of calcium-hydroxide filled immature teeth exhibited 50% reductions in fracture resistance (28). A possible hypothesis could be the effect of calcium hydroxide denaturing and hydrolysing the dentin matrix which in turn increases fracture risk. A subsequent supporting study, depicted an almost 50% reduction in micro-tensile fracture strength of calcium hydroxide canal root canal filled teeth in as little as seven to eighty four days (29). Various alternatives to Calcium hydroxide have been suggested, and one such material is mineral trioxide aggregate (MTA). It has many clinical applications including its use as a pulp capping agent, root perforation/fracture repair agent and for inducing apical barrier formation in teeth with immature apices. This latter function is currently being utilised by two thirds of the current consultants in paediatric dentistry in the United Kingdom (30). When MTA is compared with calcium hydroxide as a root filling / medicament in vitro with a sheep model, it is seen to reduce fracture susceptibility even in teeth which have been dressed with Calcium hydroxide for only one month's duration (31). A proposed clinical treatment regime is for the use of one month calcium hydroxide to disinfect and dry up apical zones prior to utilising MTA for apical closure, but this will require in vivo comparisons (31).

Preparation of the alveolus

This generally involves the removal of obstructive blood clots and bone fragments to facilitate replantation. It is usually achieved with the minimal use of curettes and saline irrigation (32). Avulsed teeth with especially poor prognosis are those with an extra-alveolar dry time of greater than 60 mins. Much research (albeit largely in animals) has searched for an effective ART (anti-resorptive and regenerative treatment). Filling the alveolar socket with Emdogain which is an enamel matrix protein has been shown to promote periodontal ligament proliferation. Enamel matrix molecules are inductive for acellular cementum formation on traumatised root surfaces. The progenitor cell pool for repopulating the root surface is thought to be the remaining vital cells on the root surface, undifferentiated cells from the marrow, and progenitor cells from the socket (5). Trope et al (1997) (33) have shown that the socket environment plays an important role in the

ulogu u zarastanju replantiranog zuba te pretpostavljaju da bi stanice parodontnog ligamenta na stijenama alveole mogle biti progenitorske stanice važne za emdogain. Ipak, potrebna su detaljna istraživanja jer se emdogain i druge tehnike za regeneraciju tkiva moraju tek potvrditi kao pouzdane za ponovno naseljavanje stanica parodontnog ligamenta.

Sistemska uporaba antibiotika

Svrha je liječenja antibioticima izbjeći umnažanje bakterija u području procesa zarastanja i spriječiti upalne resorpcije. Tako se danas predlaže sedmodnevno liječenje antibioticima širokoga spektra (1,2). U sustavnom preglednom radu Hinckfussa i Messera (2009.) predstavljena je metaanaliza na ograničenoj bazi podataka, no nisu pronašli ništa značajnoga što bi govorilo u prilog te prakse ili protiv nje (34).

Tretiranje površine korijena

Noviji pregledni rad o toj temi objavili su Panzarini i suradnici 2008. godine (35).

Antibiotici

Cvek i suradnici (1990.) istaknuli su da je kod zuba majmuna, koji su bili uronjeni u 1-postotnu otopinu doksiciklina pet minuta prije replantacije, postignut veći postotak revaskularizacije pulpe (36), a to su u svojem istraživanju 2000. godine potvrdili Yansipeta i Trope (37). Osim što povoljno utječe na revaskularizaciju pulpe, smatra se da uranjanje izbijenog zuba u otopini antibiotika smanjuje učestalost ankilozе i upalne nadomjesne resorpcije, premda rezultati još nisu potvrđeni. Bryson i suradnici (2003.) zabilježili su da endodontsko liječenje prije replantacije sprječava da upaljena pulpa djeluje na cijeljenje parodontnog ligamenta (38). No, nisu mogli dokazati korist od držanja u minociklinu prije replantacije na modelu traume psa, premda taj antibiotik ima antibakterijski i antiresorpcijski učinak. Ipak, u jednom drugom istraživanju minociklinom tretiranih replantiranih endodontski liječenih zuba majmuna, ističe se nešto češće potpuno zarastanje nego kod kontrola ostavljenih u fiziološkoj otopini (39).

Uklanjanje nekrotičnog parodontnog tkiva

U literaturi se nalazi nekoliko metoda za uklanjanje nekrotičnog parodontnog tkiva – od mehaničkog debridmana sa skalpelom, do uporabe Robinsonove četke s plovućcem. Objema metodama dodatna je prednost u tome što sloj vitalnog cementa ostaje intaktan (40). Zagovara se trominutno namakanje zuba u 3-postotnoj limunskoj kiselini (41). Hipoklorit također uklanja nekrotična parodontna vlakna a ostavlja cementni sloj, no toksično djeluje na potporna parodontna tkiva (42), a to može potaknuti stvaranje vezivnoga tkiva koje ne prianja uz zubnu površinu (43).

Tretiranje nekrotične površine korijena

Mnogo je literature u kojoj se predlaže tretirati zubne površine izravno bez uklanjanja nekrotičnog sloja, kako bi se potaknula antiresorpcija i regeneracija. Tretiranje korijenske površine fluorom opisali su Shulman, Bjorvatn i Barbakow

healing of replanted teeth suggesting that the periodontal ligament cells on the socket wall may be important progenitor cells for Emdogain. However more research need to be done as Emdogain and other guided tissue regeneration techniques have yet to prove to be reliable in repopulating periodontal ligament cells.

The use of systemic Antibiotics

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. Current guidelines suggest a broad spectrum antibiotic should be prescribed for 7 days (1,2). A systematic review by Hinckfuss & Messer (2009) (34) undertook a meta-analysis on a limited data base and could not find any significance for or against this practice.

Root surface treatments

A recent review of the topic was published by Panzarini et al in 2008 (35).

Antibiotics

Cvek et al (1990) (36) demonstrated that monkey teeth which were soaked in doxycycline 1% solution for 5 minutes prior to reimplantation had a greater rate of pulpal revascularisation and this is supported by a study by Yansipet and Trope in 2000 (37). In addition to the benefits of pulp revascularisation, soaking an avulsed tooth in an antibiotic solution has been thought to decrease the frequencies of both ankylosis and inflammatory replacement resorption although the results are still inconclusive. Bryson et al (2003) (38) recorded that the effects of an inflamed pulp on periodontal healing were negated by endodontically treating the teeth prior to reimplantation. However they could find no benefit from pre-soaking in minocycline antibiotic prior to re-implanting in the dog trauma model despite minocycline having a known antibacterial and ant-resorptive effect. However in another study minocycline treatment of reimplanted endodontically treated monkey teeth demonstrated a slightly higher occurrence of complete healing than saline soaked controls (39).

Removing necrotic periodontal material

Several methods for removing necrotic periodontal material have been published in the literature. From mechanical debridement with scalpel to the use of a Robinson's bristle brush with pumice. Both have the added advantage that the vital cementum layer remains intact (40). Soaking the tooth in 3% citric acid for 3 minutes has also been advocated (41). Hypochlorite also removes the necrotic periodontal fibres whilst still retaining the cemental layer but its disadvantages are its toxicity to the supporting periodontal tissues (42) and this may lead to the formation of a connective tissue that does not reattach to the tooth surface (43).

Treatment of the necrotic root surface

There is a body of literature which suggesting treating the root surface directly without any removal of the necrotic layer, in an effort to promote anti-resorption and regeneration. Treatment of the root surface by fluoride has been de-

(44-46). Smatra se da fluor djeluje izravno na koštano tkivo, cement i dentin stvarajući fluorapatit ili sprječavanjem osteoklastične aktivnosti. Osim toga onemogućuje rast i metabolizam mikroorganizama tako što snižava stanični pH. Osnovni razlog za takav postupak jest u dokazima da će on odgoditi, ali ne i onemogućiti ankilozu; fluorapatit je otporniji na ankilozu od hidroksilapatita (47). Nakon petogodišnjeg praćenja pokazalo se da znatno smanjuje rizik od resorpcije (48). Još je jedan lijek opisan u literaturi – kombinirano liječenje antibiotikom i kortikosteroidom. Procijenjeni su rezultati uporabe komercijalno pripremljenih kombiniranih lijekova – premda je bilo očito da su smanjili upalu nakon što su bili topikalno aplicirani kraće vrijeme – izazvali su jaku upalnu reakciju kad su bili dulje u kontaktu i nisu spriječili rekurentnu nadomjesnu resorpciju (49). Nalazi i u jednom prijašnjem istraživanju na psima, pokazali su da je uporaba 40-postotnog formalina za tretiranje površine replantiranih i transplantiranih zuba potaknula brzu i potpunu destrukciju korijena tijekom šest mjeseci bez znaka ikakve parodontne regeneracije (50).

Ostali medikamenti za površinu korijena

Emdogain je derivat caklinskoga matriksa i pretpostavlja se da pomaže migraciji, pričvršćivanju, proliferaciji i aktivnosti stanica parodontnog ligamenta (51). Tretiranjem ankiloziranih zuba koji su bili zahvaćeni zamjenskom resorpcijom u prosjeku 10 mjeseci, postignuti su dobri rezultati. Naime, ankilozirani zubi izvađeni su i naknadno prilagođeni nadogradnjama od titanija prije nego što su površina korijena i alveole bili tretirani emdogainom. Premda je broj uzoraka u studiji bio mali, postignuti su dobri rezultati: počelo je cijeliti 15 zuba, a samo su četiri bila ponovno zahvaćena ankilozom tijekom desetomjesečnoga razdoblja praćenja (52). No, kako je već istaknuto, potrebna su daljnja istraživanja u vezi s pripremanjem alveole kako bi se razjasnilo djelovanje emdogaina.

Postoje pokazatelji koji upućuju na to da ART (antiresorpcijska regenerativna terapija) s lokalnom primjenom glukokortikoida i derivata caklinskoga matriksa (emdogaina), uz sistemsku primjenu doksiciklina, može omogućiti funkcijsko cijeljenje zuba čije se parodontno stanje nije održavalo adekvatnim fiziološkim čuvanjem. Pohl i suradnici (2005.) pokazali su cijeljenje uz pomoć ART-a na tri od osam zuba čije je parodontno stanje bilo ocijenjeno kao “beznadno” (53). Supstancijom alendronata također se tretirala korijenska površina, a rezultat je bila rjeđa pojava resorpcijskog procesa, ali ne i ankilozе (54). U prvoj “dvostruko slijepoj” eksperimentalnoj studiji s randomiziranom kontrolom istraživao se učinak Timozina alfa 1 (Talfa 1) na replantaciju izbijenog zuba, a rezultati su objavljeni 2008. godine (55). Talfa 1 je stimulator imuniteta i, kao što se pretpostavljalo, povoljno je utjecao na smanjenje boli i razinu medijatora upale te znatno smanjio broj bijelih krvnih stanica lokalno tijekom prva četiri dana pokazujući velika imunološka svojstva. U istraživanju se ipak propustilo zaključiti ili barem zabilježiti bilo što o tome kakav se dugoročni rezultat očekuje u vezi s izbijenim zu-

scribed by Shulman (44), Bjorvatn (45) and Barbakow (46). It is thought that fluoride acts directly on the bone tissue, cementum and dentin, likely converting them into fluoroapatite or by inhibiting osteoclastic activity. In addition fluoride inhibits microbial growth and metabolism by reducing cell pH. The rationale for the treatment is based upon evidence that the procedure will delay, but not prevent, ankylosis; fluoroapatite is more resistant to ankylosis than hydroxyapatite (47). It has been shown to significantly reduce risk of resorption after a follow-up of 5 years (48). Another medicament described in the literature is a combined antibiotic / corticosteroid therapy. The results of utilising commercially prepared combined treatments has been evaluated and although it was evident that they reduced inflammation when applied topically for a short time, they also induced an intense inflammatory reaction when maintained in contact for a longer time period and did not prevent the recurrence of replacement resorption (49). Findings of an older animal study in dogs (50) 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 six months with no evidence of any periodontal regeneration.

Other root surface medicaments

Emdogain is an enamel matrix derivative and it is thought to aid migration, attachment, proliferation and activity of the periodontal cells (51). Promising results were achieved treating previously ankylosed teeth which had been affected by replacement resorption over a mean 10 month period. The ankylosed teeth were extracted and retrograde titanium posts fitted prior to treating the root surface and socket with emdogain. Although the numbers in the study were small, favourable results occurred: showing the healing of 15 teeth whilst only 4 reverted to ankylosis over a 10 month follow up period (52). However as mentioned under ‘preparation of the alveolus’ further work is needed to clarify the role of Emdogain.

There is some evidence to suggest that ART (anti-resorption –regeneration therapy) with local application of glucocorticoids and an enamel matrix derivative (Emdogain) along with the systemic use of doxycycline might afford functional healing to those teeth whose periodontal condition had not been supported by adequate physiological storage. Pohl et al (2005) (53) demonstrated healing with the adjunct of ART in three out of eight teeth deemed to have a periodontal condition described as “hopeless”. The substance Alendronate has also been employed for root surface treatment and its use resulted in a decrease in the occurrence of the resorption process but not of ankylosis (54). The first double blind randomised control pilot study tested the effects of Thymosin alpha 1 (Talpha 1) on the reimplantation of avulsed teeth and the results were published in 2008 (55). Talpha 1 is an immune stimulant and as predicted gave favourable outcomes of reduced pain, inflammatory mediator levels and significantly reduced white blood cell counts locally within the first 4 days reflecting its substantial immune properties. However the study failed to conclude or even record any favourable long term survival outcomes for the

bima. Premda neki od tih medikamenata obećavaju, njihov relativni uspjeh treba odvagati i usporediti s jeftinijim i lakše dostupnim alternativama koje bi mogle dati slične rezultate, poput onih s tetraciklinom, doksiciklinom i ledermixom kao intrakanalnim lijekovima.

U novim smjernicama International Association for Dental Traumatology (IADT-a) preporučuju se sistemski antibiotici u slučaju avulzije i mikrosfere minociklina za tretiranje površine korijena zuba s otvorenim apeksom koji su bili na suhom kraće od 60 minuta, te uranjanje u 2-postotnoj otopini natrijeva fluorida 20 minuta svih zuba koji su bili izvan usne šupljine na suhom dulje od 60 minuta (nakon uklanjanja parodontnog ligamenta) (1).

Šiniranje (imobilizacija)

U novim smjernicama savjetuje se da izbijeni zubi trebaju funkcijsku šinu do dva tjedna kako bi se omogućili funkcijski ili fiziološki pokreti korijena (1,2). U novom sustavnom preglednom radu Hinckfassa i Messera (2009.) autori su postavili stroge uvjete izbora te su pronašli vrlo malo odgovarajućih istraživanja, pa metaanaliza nije bila moguća (56). Njihov je zaključak da su argumenti za kratkoročno šiniranje neuvjerljivi, ali da treba poduprijeti nove smjernice. Uporaba kratkoročnog šiniranja trebala bi smanjiti ankilozu. Funkcijska šina zadržava zub u alveoli, ali dovoljno je fleksibilna i dopušta funkcijsku stimulaciju parodontnog ligamenta. U svojoj prospektivnoj analizi 400 izbijenih i replantiranih zuba Andreasen je istaknuo da varijable poput vrste šine i vremena šiniranja nisu značajne (57,58). Zapravo, argumenti koji podupiru protokol funkcijskog šiniranja temelje se na pretpostavkama iz istraživanja na životinjama kojima su zubi bili vrlo kruto šinirani, čak su bolje cijelili životinjama koje su izgubile šinu (59). U drugim istraživanjima osporavale su se trenutne smjernice – Berude i suradnici (1988.) nisu pronašli veće razlike u načinu cijeljenja parodontnog ligamenta (ankilozu, aktivna i zaustavljena resorpcija te zarastanje parodontnog ligamenta) između fiziološki šiniranih, kruto šiniranih ili nešiniranih replantiranih zuba (60). Premda nije dobro stvarati zaključke na temelju animalnih studija, ovo je istraživanje važno jer “baca svjetlo” na nedostatak pravih argumenata u vezi s trajanjem i vrsti šiniranja. Suvremeni trend, kad je riječ o funkcijskoj šini, podupire se u preglednim radovima u kojima se uspoređuju klinički pokazatelji u posljednjih 40 godina (24,61–63). Pokušaji da se podaci o šiniranju analiziraju postupcima “evidence based” u sustavnim preglednim studijama, nisu dali SIGN-razinu dokaza veću od četiri, zato što su retrospektivne analize podložne biasu tj. sustavnim pogreškama, te s obzirom na to da nema kontrolne skupine. Ipak, one predstavljaju godine retrospektivnog kliničkog procjenjivanja u dentalnoj traumatologiji i kao takve treba ih smatrati “najboljom praksom”.

Društveno-ekonomsko opterećenje

Kad se dogodi nezgoda, potrebno je i s roditeljima i pacijentima razmotriti vrijeme potrebno za liječenje ozljeda u slučaju izbijenog zuba. U retrospektivnoj studiji Ngyena i suradnika (2004.) razmotrena su ta pitanja i troškovi (64).

study population of avulsed teeth. Although some of these medicaments show promising results their relative success needs to be weighed up by the alternative cheaper and more available alternatives which might effect similarly promising results e.g. Tetracycline, doxycycline and ledermix as an intracanal medicament.

Current International Association for Dental Traumatology (IADT) guidelines¹ recommend systemic antibiotics for all avulsions, minocycline microspheres for root surface treatments in open apex teeth which have been dry for < 60 mins, and immersion of all teeth in 2% sodium fluoride solution for 20 mins that have an extra-oral dry time of more than 60 minutes (after removal of periodontal ligament), (1).

Splinting

Current guidelines advise that avulsed teeth require a functional splint for up to 2 weeks to allow functional or physiological movement of the root (1,2). A recent well structured systematic review by Hinckfass & Messer (2009) (56) set strict election criteria and found few suitable studies so meta-analysis was not possible. Their conclusion was that the evidence for short term splinting was inconclusive but the current guidelines should be upheld. The use of shorter splinting times should reduce ankylosis. A functional splint retains the tooth in its socket, but is flexible enough to allow functional stimulation of the periodontium. In his prospective analyses of 400 avulsed and replanted teeth, Andreasen demonstrated no significance in the variables of either type of splint or length of splinting period (57,58). In fact, the evidence which supports the protocol for functional splinting is based on assumptions from animal studies where teeth were rigidly splinted, yet more favourable healing actually took place in an animal that had lost a splint (59). Other studies have challenged the current guidelines; Berude et al (1988) (60), demonstrated no significant difference in periodontal healing pattern (ankylosis, active and arrested resorption and periodontal ligament healing) for physiological, rigidly splinted or non splinted replanted teeth. Although it is not ideal to extrapolate animal studies this is an important study as it highlights the lack of real evidence for splinting times and types. The current trend for functional splints is supported by reviews collating clinical evidence over some 40 years (24,61–63). Attempts to analyse splinting data in an evidenced based systematic review process provides a SIGN evidence level of no greater than level 4, since by the nature of retrospective case analyses they are open to bias and no case controls were available. However, they do represent years of retrospective clinical evaluation in clinical dental traumatology and as such should be considered, ‘best practice’.

Socio economic burden

The time involved treating avulsion injuries needs to be considered and highlighted to parents and patients at the time of the injury. Ngyen et al (2004) (64) examined these issues and respective costs in a retrospective study. They

Zaključili su da se za svakog pacijenta u prvoj godini potroši 8,6 sati na liječenje složene traume. No, 86 posto roditelja i 67 posto pacijenata bilo je sretno zbog odluke da se zub replantira, što pokazuje psihološku komponentu te ozljede. Istraživani uzorak bio je mali, ali studija je vrijedna zato što daje uvid u vrijeme potrebno za liječenje i cijenu postupka. Wright i suradnici (2008.) objavili su podatke o 163 izbijena zuba kod 114 pacijenata te istaknuli da su prosječno tijekom cijelog liječenja, dakle u tri godine, 16 puta došli dentalnom liječniku radi replantacije zuba, a srednja vrijednost propotovane razdaljine iznosila je 558 milja (65).

Zaključci

Replantacija i održanje izbijenog sjekutića važna je za estetiku, funkciju i alveolarnu stabilnost. Nedostatak jednog ili više prednjih zuba vrlo je neprivlačno obilježje. Zadržati ih važno je i za alveolarnu stabilnost u svakoj fazi rasta, a uspjeh se mora mjeriti imajući na umu sva različita stajališta, pa i glede dugotrajnosti replantiranog zuba. Zub je, u najmanju ruku, "držač prostora" i, ako ne može dugoročno opstati, kupuje vrijeme da bi se mogla pripremiti planirana ortodontska ili protetička zamjena.

U današnje informatičko doba, jedan od velikih problema za svakoga općeg stomatologa jest prevelika količina podataka u stručnoj literaturi. Trenutačno postoje dva protokola mlađa od četiri godine (1,2). Čak se i oni ponešto razlikuju u smjernicama, pa mnogi traumatološki centri moraju objaviti vlastite protokole na temelju iskustava. Idealno bi bili imati "cochrane" suradnički pregledni rad u kojem bi se usporedila relativna učinkovitost pojedinih strategija izvedenih prema strogim uvjetima randomiziranih kliničkih istraživanja. Protokol za takav rad objavljen je 2007. godine i možda će se pokazati korisnim u vezi sa strategijama liječenja na temelju istraživanja i dokaza koje bi svaki stomatolog morao slijediti želi li obaviti uspješnu replantaciju i sačuvati izbije zube (66).

Replantacija je dokazani klinički postupak s velikom stopom uspjeha u određenim uvjetima. Manje je važno je li replantacija vrijedna truda, a više kojim se kliničkim postupkom treba koristiti i kakva se prognoza može dati pacijentu i roditelju. Očekivanja trebaju biti realna i moraju se odnositi na prolongiranu održivost koja omogućuje planirani zahvat kad bude potrebno. Idealni klinički cilj jest održati širinu i visinu alveolarne kosti dok ne prestane rast i razvoj zuba nakon čega se, u idealnom slučaju, mogu razmotriti implantati. Uz vrlo malo iznimaka, najbolje je replantirati zub, a zatim ako smo u nedoumici, pacijenta odmah uputiti specijalistu.

Prognoza se može znatno poboljšati uz odgovarajuću pripremu, uzimajući u obzir zaposlenike laike i stručnu izobrazbu te dostupnost odgovarajućih medija za pohranu i lijekova na onim mjestima na kojima se mogu očekivati nezgode te u centrima za liječenje. Pokazalo se da brza i pravilna prva pomoć te odgovarajuća tehnika poboljšavaju prognozu, a ima i naznaka da se može nastaviti poboljšavati stopu održanja replantiranih zuba zahvaljujući edukaciji i vježbama namijenjenih medicinskom i stomatološkom osoblju te javnosti.

found that 8.6 hours were spent on treatment of complicated trauma for each patient in the first year. However 86% of parents and 67% of patients were happy with the decision to replant the tooth and this illustrates the important psychological aspect to this injury. The survey sample was small but the study is valuable in providing insight to the time commitment and fiscal aspects. Wright et al (2008) reported data from 163 avulsed teeth in 114 patients and found the mean number of visits for replanted teeth over 3 years was 16 while the mean distance travelled for an entire course of treatment was 558 miles (65).

Conclusions

Replantation and retention of an avulsed incisor is important for aesthetics, function and alveolar stability. Missing anterior teeth or anterior teeth of the wrong size and in the wrong position are very unattractive features. Retention is also vital for alveolar stability in any growth phase and success has to be measured with all these different aspects in mind as well as in terms of a replanted tooth lasting for a lifetime. At the very least the tooth is an effective space maintainer and buys time to allow for planned orthodontic or prosthetic replacement if long term viability is not possible.

One of the great problems for any general practitioner in this information age is the inordinate amount of information available in professional literature. At present, two current protocols are less than four years of age (1,2). Even these protocols vary slightly in their guidance and many trauma centres have to publish their own protocols from a collation of 'good practice'. Ideally, a Cochrane collaborated review is required which will compare relative effectiveness of individual strategies performed under strictly randomised control trials. A protocol for such a review was published in 2007 and hopefully this will prove useful in providing research / evidence based treatment strategies that every dental professional can follow to allow the maximum chance of successful replantation and retention of avulsed teeth (66).

Replantation is a proven clinical technique with a good success rate in certain conditions. The question is less about whether it is worthwhile replanting but more about what clinical technique is to be used and what prognosis can be given to the patient and parent. The definition of success needs to be realistic and viewed in terms of prolonged survival allowing planned intervention when required. The ideal clinical aim is maintenance of the alveolar bone width and height until bone growth ceases and ideally implants can be considered. With very few exceptions, the best policy is to replant the tooth and then, if in doubt refer immediately.

Prognosis can be dramatically improved by preparation in advance with regards to lay personnel and professional education and the availability of appropriate storage mediums and medicaments at likely accident sights and treatment centres. Correct first aid and appropriate technique have been shown to improve prognosis and there is considerable potential to continue to improve survival rates of replanted teeth through appropriate education and training of medical and dental health personnel and the general public.

Abstract

Avulsion is a serious assault on both dental tissues and the surrounding periodontium and in consequence the process of replantation creates a wide range of outcomes. The main aim of replantation is to maintain periodontal cell viability and the possibility of functional healing of the periodontal ligament (PDL) and maximise the possibility of pulpal revascularisation. To identify whether replantation is worthwhile requires analysis of the evidence in two areas: whether the replanted tooth can be retained indefinitely (successful periodontal healing), or whether even in the presence of replacement resorption (ankylosis) relatively normal growth and maintenance of alveolar ridge contour can occur until utilisation of a prosthesis to fill the space when the tooth is lost in late teenage years.

Received: March 14, 2011

Accepted: May 10, 2011

Address for correspondence

Richard Welbury
Department of Paediatric Dentistry,
University of Glasgow Dental School
378 Sauchiehall Street
Glasgow G2 3JZ, Scotland
Richard.Welbury@glasgow.ac.uk

Key words

Tooth Avulsion; Tooth Replantation;
Tissue Conditioning (Dental); Periodontal
Ligament

References

- Flores MT, Andersson L, Andreasen JO, Bakland LK, Malmgren B, Barnett F et al. Guidelines for the management of traumatic dental injuries. I. Fractures and luxations of permanent teeth. *Dent Traumatol.* 2007 Apr;23(2):66-71.
- American Academy of Paediatric Dentistry. Guideline on management of acute dental trauma. *Paediatric Dentistry* 2010; 32 Reference Manual 2002-2012.
- Hussain K, Wijetunge DB, Grubnic S, Jackson IT. A comprehensive analysis of craniofacial trauma. *J Trauma.* 1994 Jan;36(1):34-47.
- Kling M, Cvek M, Mejare I. Rate and predictability of pulp revascularization in therapeutically reimplanted permanent incisors. *Endod Dent Traumatol.* 1986 Jun;2(3):83-9.
- Andreasen JO, Andreasen FM, Andersson L. Textbook and colour atlas of traumatic injuries to the teeth. Copenhagen: Blackwell Munksgaard; 2007.
- Kinirons MJ, Gregg TA, Welbury RR, Cole BO. Variations in the presenting and treatment features in reimplanted permanent incisors in children and their effect on the prevalence of root resorption. *Br Dent J.* 2000 Sep 9;189(5):263-6.
- Cvek M, Cleaton-Jones P, Austin J, Lownie J, Kling M, Fatti P. Pulp revascularization in reimplanted immature monkey incisors--predictability and the effect of antibiotic systemic prophylaxis. *Endod Dent Traumatol.* 1990 Aug;6(4):157-69.
- Ritter AL, Ritter AV, Murrah V, Sigurdsson A, Trope M. Pulp revascularization of replanted immature dog teeth after treatment with minocycline and doxycycline assessed by laser Doppler flowmetry, radiography, and histology. *Dent Traumatol.* 2004 Apr;20(2):75-84.
- Cvek M, Granath LE, Hollender L. Treatment of non-vital permanent incisors with calcium hydroxide. 3. Variation of occurrence of ankylosis of reimplanted teeth with duration of extra-alveolar period and storage environment. *Odontol Revy.* 1974;25(1):43-56.
- Matsson L, Andreasen JO, Cvek M, Granath LE. Ankylosis of experimentally reimplanted teeth related to extra-alveolar period and storage environment. *Pediatr Dent.* 1982;4:327-9.
- Sigalas E, Regan JD, Kramer PR, Witherspoon DE, Opperman LA. Survival of human periodontal ligament cells in media proposed for transport of avulsed teeth. *Dent Traumatol.* 2004 Feb;20(1):21-8.
- Sigalas E, Regan JD, Kramer PR, Witherspoon DE, Opperman LA. Survival of human periodontal ligament cells in media proposed for transport of avulsed teeth. *Dent Traumatol.* 2004 Feb;20(1):21-8.
- Blomlöf L, Otteskog P. Viability of human periodontal ligament cells after storage in milk or saliva. *Scand J Dent Res.* 1980 Oct;88(5):436-40.
- de Sousa HA, de Alencar AH, Bruno KF, Batista AC, de Carvalho AC. Microscopic evaluation of the effect of different storage media on the periodontal ligament of surgically extracted human teeth. *Dent Traumatol.* 2008 Dec;24(6):628-32.
- Filippi C, Kirschner H, Filippi A, Pohl Y. Practicability of a tooth rescue concept--the use of a tooth rescue box. *Dent Traumatol.* 2008 Aug;24(4):422-9.
- Andreasen JO, Hjørtting-Hansen E. Replantation of teeth. II. Histological study of 22 replanted anterior teeth in humans. *Acta Odontol Scand.* 1966 Nov;24(3):287-306.
- Andreasen JO. Relationship between surface and inflammatory resorption and changes in the pulp after replantation of permanent incisors in monkeys. *J Endod.* 1981 Jul;7(7):294-301.
- Andreasen JO. Periodontal healing after replantation and autotransplantation of incisors in monkeys. *Int J Oral Surg.* 1981 Feb;10(1):54-61.
- Andreasen JO. Effect of extra-alveolar period and storage media upon periodontal and pulpal healing after replantation of mature permanent incisors in monkeys. *Int J Oral Surg.* 1981 Feb;10(1):43-53.
- Andreasen JO, Kristerson L. The effect of limited drying or removal of the periodontal ligament. Periodontal healing after replantation of mature permanent incisors in monkeys. *Acta Odontol Scand.* 1981;39(1):1-13.
- Stewart CJ, Elledge RO, Kinirons MJ, Welbury RR. Factors affecting the timing of pulp extirpation in a sample of 66 replanted avulsed teeth in children and adolescents. *Dent Traumatol.* 2008 Dec;24(6):625-7.
- Hinckfuss SE, Messer LB. An evidence-based assessment of the clinical guidelines for replanted avulsed teeth. Part I: Timing of pulp extirpation. *Dent Traumatol.* 2009 Feb;25(1):32-42.
- Ehnevid H, Jansson L, Lindskog S, Weintraub A, Blomlöf L. Endodontic pathogens: propagation of infection through patent dentinal tubules in traumatized monkey teeth. *Endod Dent Traumatol.* 1995 Oct;11(5):229-34.
- Trope M. Clinical management of the avulsed tooth: present strategies and future directions. *Dent Traumatol.* 2002 Feb;18(1):1-11.
- Pohl Y, Filippi A, Kirschner H. Results after replantation of avulsed permanent teeth. I. Endodontic considerations. *Dent Traumatol.* 2005 Apr;21(2):80-92.
- Sheehy EC, Roberts GJ. Use of calcium hydroxide for apical barrier formation and healing in non-vital immature permanent teeth: a review. *Br Dent J.* 1997 Oct 11;183(7):241-6.
- Dominguez Reyes A, Muñoz Muñoz L, Aznar Martín T. Study of calcium hydroxide apexification in 26 young permanent incisors. *Dent Traumatol.* 2005 Jun;21(3):141-5.
- Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. *Dent Traumatol.* 2002 Jun;18(3):134-7.
- Rosenberg B, Murray PE, Namerow K. The effect of calcium hydroxide root filling on dentin fracture strength. *Dent Traumatol.* 2007 Feb;23(1):26-9.
- Mooney GC, North S. The current opinions and use of MTA for apical barrier formation of non-vital immature permanent incisors by consultants in paediatric dentistry in the UK. *Dent Traumatol.* 2008 Feb;24(1):65-9.
- Andreasen JO, Munksgaard EC, Bakland LK. Comparison of fracture resistance in root canals of immature sheep teeth after filling with calcium hydroxide or MTA. *Dent Traumatol.* 2006 Jun;22(3):154-6.
- Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 4. Factors related to periodontal ligament healing. *Endod Dent Traumatol.* 1995 Apr;11(2):76-89.
- Trope M, Hupp JG, Mesaros SV. The role of the socket in the periodontal healing of replanted dogs' teeth stored in ViaSpan for extended periods. *Endod Dent Traumatol.* 1997 Aug;13(4):171-5.

34. Hinckfuss SE, Messer LB. An evidence-based assessment of the clinical guidelines for replanted avulsed teeth. Part II: prescription of systemic antibiotics. *Dent Traumatol.* 2009 Apr;25(2):158-64.
35. Panzarini SR, Gulinelli JL, Poi WR, Sonoda CK, Pedrini D, Brandini DA. Treatment of root surface in delayed tooth replantation: a review of literature. *Dent Traumatol.* 2008 Jun;24(3):277-82.
36. Cvek M, Cleaton-Jones P, Austin J, Lownie J, Kling M, Fatti P. Effect of topical application of doxycycline on pulp revascularization and periodontal healing in reimplanted monkey incisors. *Endod Dent Traumatol.* 1990 Aug;6(4):170-6.
37. Yanpiset K, Trope M. Pulp revascularization of replanted immature dog teeth after different treatment methods. *Endod Dent Traumatol.* 2000 Oct;16(5):211-7.
38. Bryson EC, Levin L, Banchs F, Trope M. Effect of minocycline on healing of replanted dog teeth after extended dry times. *Dent Traumatol.* 2003 Apr;19(2):90-5.
39. Ma KM, Sae-Lim V. The effect of topical minocycline on replacement resorption of replanted monkeys' teeth. *Dent Traumatol.* 2003 Apr;19(2):96-102.
40. Esper HR, Panzarini SR, Poi WR, Sonoda CK, Casatti CA. Mechanical removal of necrotic periodontal ligament by either Robinson bristle brush with pumice or scalpel blade. Histomorphometric analysis and scanning electron microscopy. *Dent Traumatol.* 2007 Dec;23(6):333-9.
41. Nyman S, Houston F, Sarhed G, Lindhe J, Karring T. Healing following reimplantation of teeth subjected to root planing and citric acid treatment. *J Clin Periodontol.* 1985 Apr;12(4):294-305.
42. Kanno CM, Saad Neto M, de Oliveira JA, Escobar CA, Saito CT. The effects of one percent sodium hypochlorite solution upon the periodontal ligament on rat incisors. *Arq Odontol.* 2001;37:35-43.
43. Sonoda CK, Poi WR, Okamoto T, Toyota E, Takeda RH. Immediate teeth replantation after root treatment with 1%, 2.5%, 5% and 10% sodium hypochlorite solution. *Rev Bras Odontol.* 2000;57:293-6.
44. Shulman LB, Gedalia I, Feingold RM. Fluoride concentration in root surfaces and alveolar bone of fluoride-immersed monkey incisors three weeks after replantation. *J Dent Res.* 1973 Nov-Dec;52(6):1314-6.
45. Bjorvatn K, Massler M. Effect of fluorides on root resorption in replanted rat molars. *Acta Odontol Scand.* 1971 Apr;29(1):17-29.
46. Barbakow FH, Cleaton-Jones PE, Austin JC, Vieira E. Effects of thyrocalcitonin, acidulated sodium fluoride, and neutral sodium fluoride on the mobility of experimentally replanted teeth. *J Endod.* 1980 Nov;6(11):823-8.
47. Selvig KA, Zander HA. Chemical analysis and microradiography of cementum and dentine from periodontally diseased human teeth. *J Periodontol.* 1962; 33:301-10.
48. Coccia CT. A clinical investigation of root resorption rates in reimplanted young permanent incisors: a five-year study. *J Endod.* 1980 Jan;6(1):413-20.
49. Saad Neto M, Santos Pinto R, Holland R, Callestini EA. Effect of antibiotics and corticosteroid association on dental replantation: histological study in rats. *Rev Odontologica UNESP.* 1991;20:155-162.
50. Reeve CM, Sather AH, Parker JA. Resorption pattern of formalin fixed replanted teeth in dogs. *J Dent Res.* 1968;43:825.
51. Hammarström L. Enamel matrix, cementum development and regeneration. *J Clin Periodontol.* 1997 Sep;24(9 Pt 2):658-68.
52. Filippi A, Pohl Y, von Arx T. Treatment of replacement resorption with Emdogain—a prospective clinical study. *Dent Traumatol.* 2002 Jun;18(3):138-43.
53. Pohl Y, Filippi A, Kirschner H. Results after replantation of avulsed permanent teeth. II. Periodontal healing and the role of physiologic storage and antiresorptive-regenerative therapy. *Dent Traumatol.* 2005 Apr;21(2):93-101.
54. Lustosa-Pereira A, Garcia RB, de Moraes IG, Bernardineli N, Bramante CM, Bortoluzzi EA. Evaluation of the topical effect of alendronate on the root surface of extracted and replanted teeth. Microscopic analysis on rats' teeth. *Dent Traumatol.* 2006 Feb;22(1):30-5.
55. Loo WT, Dou YD, Chou WK, Wang M. Thymosin alpha 1 provides short-term and long-term benefits in the reimplantation of avulsed teeth: a double-blind randomized control pilot study. *Am J Emerg Med.* 2008 Jun;26(5):574-7.
56. Hinckfuss SE, Messer LB. Splinting duration and periodontal outcomes for replanted avulsed teeth: a systematic review. *Dent Traumatol.* 2009 Apr;25(2):150-7.
57. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 2. Factors related to pulpal healing. *Endod Dent Traumatol.* 1995 Apr;11(2):59-68.
58. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 4. Factors related to periodontal ligament healing. *Endod Dent Traumatol.* 1995 Apr;11(2):76-89.
59. Morley RS, Malloy RB, Hurst RV, James R. Analysis of functional splinting upon autologously replanted teeth. *J Dent Res.* 1978: 571 IADR abstract no 593.
60. Berude JA, Hicks ML, Sauber JJ, Li SH. Resorption after physiological and rigid splinting of replanted permanent incisors in monkeys. *J Endod.* 1988 Dec;14(12):592-600.
61. Barrett EJ, Kenny DJ. Avulsed permanent teeth: a review of the literature and treatment guidelines. *Endod Dent Traumatol.* 1997 Aug;13(4):153-63.
62. Bakland LK, Andreasen JO. Dental traumatology: essential diagnosis and treatment planning. *Endodontic Topics.* 2004;7:14-34.
63. Kahler B, Heithersay GS. An evidence-based appraisal of splinting luxated, avulsed and root-fractured teeth. *Dent Traumatol.* 2008 Feb;24(1):2-10.
64. Nguyen PM, Kenny DJ, Barrett EJ. Socio-economic burden of permanent incisor replantation on children and parents. *Dent Traumatol.* 2004 Jun;20(3):123-33.
65. Wright G, Young A, Auld D, Welbury RR. The socioeconomic burden of treating dental avulsion. *Eur Arch Paediatr Dent.* 2008;9:10.
66. Day P, Duggal M. Interventions for treating traumatised permanent front teeth: avulsed (knocked out) and replanted. *Cochrane Database Syst Rev.* 2010 Jan 20;(1):CD006542.