Recent developments in dental traumatology

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Role of the pediatric dentist

Most pediatric dentists provide clinical and after-hours care for dental injuries in their private offices, clinics and hospitals. They are trained and capable to perform the surgery, fracture reduction, splinting and single root endodontic treatment that are part and parcel of dental trauma management. However, for many clinicians, specialists included, dental trauma cases present infrequently and unexpectedly, with diagnosis and management continually evolving with advances in scientific information. Treatment that was current the last time they treated an injury may be out of date the next time clinicians are presented with similar cases.

Trauma research is scattered among specialty-specific journals that focus on pediatric dentistry, endodontics, oral and maxillofacial surgery, sports medicine and even periodontics. One trauma-specific journal, *Endodontics and Dental Traumatology* was renamed *Dental Traumatology* in January 2001 to reflect the multidisciplinary nature of dental trauma research and to encourage contributions from a broader range of specialties. This update is based on a number of developments in traumatology over the past five to seven years but is focused on trends. Unfortunately, trauma research is concentrated in only a few centers and they are mainly outside the United States. Editorial calls to action for dental trauma research seem to be hampered by overworked front-line clinicians or scarce resources.[1]

Prevention: sports dentistry

A recent systematic review clearly identifies children with overjets greater than 3 mm as twice as likely to sustain incisor injuries.[2] Since falls cause more dental injuries than organized sports,[3] children with extreme overjets need to be identified as persons at risk for trauma and early orthodontic intervention undertaken. Their risk further increases if they have seizures, motor disturbances or are active participants in sports.

The value of mouthguards is largely unknown from a scientific point of view and is currently receiving considerable attention. Investigators are attempting to identify important parameters for protection by standardizing testing (impact) devices and tooth-jaw models. Both swing-arm[4] and gravity projectile devices[5] have been used to generate reproducible forces. Regardless of the method of testing, laboratory-produced mouthguards of similar thickness provide better cushioning and dissipation of forces than user-fitted boil and bite mouthguards, yet even laboratory-produced mouthguards show considerable variation.[6]

Currently, investigations are focused on the appropriateness of testing devices and properties of materials for mouthguard construction. New materials and legislation to increase compliance will likely lead to increased use of custom mouthguards in amateur sports over the next decade. Surveys of parental and dentists' attitudes toward mouthguards showed that parents perceive a shared responsibility with coaches to ensure compliance with mouthguard use.[7]

One study showed that approximately 60 percent of dentists favored a custom mouthguard, but the remaining 40 percent favored stock or 'boil and bite' mouthguards even though they have been demonstrated to be inferior.[8] Dentists who supported non-custom mouthguards were those who questioned their professional role in mouthguard construction and distribution.[8] Parallel investigations that focus on athlete's needs during the mixed dentition period, their concerns about airway compromise[9] and the unknown role of mouthguards in the prevention of concussions[10] will likely be active areas of research.

Observational epidemiology (primary teeth)

In 1998 a landmark paper by Borum and Andreasen[11] described the outcomes of trauma to primary incisors. It was remarkable because the sample focused on maxillary incisors, the site of 90 percent of injuries, and the sample of 287 children with 545 traumatized incisors were followed until age 10. Parameters included crown color changes, pulp canal obliteration, pulp necrosis, gingival retraction, displacement of permanent successor teeth following luxation, root resorption and premature loss.

Multivariate analysis showed the predisposing factors for pulp canal obliteration were displacement of the incisor and evidence of physiologic root resorption at the time of injury. Predisposing factors for pulp necrosis were patient age at the time of injury, degree of displacement, tooth mobility and presence of crown fracture. In addition, this paper provided valuable information on initial treatment and outcomes of primary tooth trauma.

Avulsion/replantation (primary teeth)

A recent review showed that the literature on primary tooth replantation consists entirely of case reports that provide limited and often incomplete information on the teeth involved, the extent of radiographic examinations, splint usage, extra-alveolar time of the avulsed tooth and follow-up protocols.[12]

Received November 21, 2001 Accepted November 29, 2001

All of the evidence for replantation is level IV (non-experimental, descriptive and opinion).

There are no guidelines for replantation of primary teeth. Consequently, clinicians who are faced with parents who urge them to replant avulsed primary teeth have only opinion and a few case reports on which to base their decision. Pathological outcomes described in the reports reviewed include dental abscesses, root resorption, ankylosis, deflection of permanent incisors and hypoplastic and morphological changes to permanent incisor crowns.[12] Given the downside risk for the child, the time and cost to the parents and lack of any scientific evidence, any dentist who chooses to undertake replantation of a primary incisor must ensure informed consent is documented and ongoing.

Avulsion/replantation (permanent teeth)

Extra-alveolar storage

Over three quarters of school teachers, coaches and caregivers are reluctant to replant an avulsed incisor[13,14] despite evidence that immediate (<5 minute) replantation is decisive for periodontal ligament (PL) regeneration.[15] Reasons given by respondents included inadequate training, inducing pain or fear in the child, fear of personal blood-borne infection and possible legal consequences of their intervention.[14] Recently, attention has been focused on the fact that the avulsed tooth (at this time a free graft) is often stored 'dry', in air or tissue paper while searching for milk. Recent *in vitro* studies have supported earlier outcome studies and show that by 15 minutes the progenitor cells on the root-side PL are unable to differentiate into fibroblasts, shortly after that they are unable to reproduce themselves, and, by 30 minutes of desiccation, most or all PL cells are dead.[16-20]

Furthermore, *in vitro* studies of human PL cells demonstrated that Balanced Salt Solution was equivalent, not superior to milk.[17,21] Milk is ubiquitous and ice, always available where milk is found, can be used to keep the milk container cool. Cool milk will maintain cell function for almost twice as long as milk that is allowed to warm to room temperature.[17]

If the tooth is transferred to a liquid medium such as saliva, milk or saline within the first 15 minutes, some of the progenitor cells present in the PL and cementum will survive and may play a role in repair, a form of wound healing that may lead to inflammatory root resorption and inevitably ankylosis and replacement root resorption.[22] If the tooth is transferred to liquid media beyond 15 minutes of desiccation, the surviving cells will be increasingly limited in both numbers and functional ability.[19]

Finally, *in vitro* experiments have proven that root-side cells that are already dead cannot be resurrected by rehydrating in media such as Balanced Salt Solution or milk.[21] Pre-replantation 'treatment' of the root surface with fluoride is directed towards the elimination of inflammatory root resorption and increasing the resistance of the root to replacement root resorption through the formation of fluorapatite on the root surface as shown in earlier studies.[23,24]

The underlying assumption for the use of fluorides is that there is no potential for regeneration of the PL and that replacement root resorption is inevitable. Root surface treatment with fluoride has made its way into the guidelines of the American Academy of Endodontics[25] even though it is based on animal studies and there are still no human investigations to support it.

A precise and accurate post-trauma, pre-replantation history is paramount as extra-alveolar management (media and time) is directly related to post-replantation outcomes.[20] If the window of opportunity for periodontal regeneration has lapsed (beyond 5-10 minutes), then the clinician must plan for the inevitable outcomes of root resorption, ankylosis and tooth loss. Replacement resorption and ankylosis may be considered acceptable outcomes as replanted teeth may be retained for a number of years. If, in addition, the patient has achieved physical maturity, infraocclusion due to surrounding alveolar growth will be minimal.

Root resorption/ankylosis

Infraocclusion produced by ankylosis poses problems during the adolescent growth spurt. Adolescents and parents often do not want submerged incisor(s) extracted, yet the alveolar and gingival architecture becomes increasingly distorted with growth. These developmental changes pose clinical problems that may include the need for bone grafting in conjunction with single tooth implants and crowns. Indeed, the decision to replant a permanent tooth carries a number of sequelae that include the socioeconomic aspects of family life.[26-28]

Prognosis

As a result of treatment guidelines and personal hopes, dentists are often overly optimistic in their outcome projections for replantation. There is a need to report outcome information in a manner that is clinically applicable and communicable to parents and patients. Further, dentists should include an estimate of the health and cost outcomes for the recommended treatment as well as comparisons to alternative treatments.[29] Recent adoption of the statistical methods of survival analysis has resulted in the publication of clinically useful outcome information.

In the case of replantation of avulsed permanent incisors, virtually all teeth will be lost prematurely. This may take a couple of decades if the patient was a young adult who achieved full growth before avulsion/replantation or it may be less than a year if an immature tooth with incomplete apex formation prevents early endodontic obturation.[30] Three recent studies now guide the clinician on survival of replanted permanent incisors.

Barrett and Kenny[31] used survival analysis to report outcomes for replanted permanent incisors following prolonged extra-alveolar storage. They demonstrated that survival of replanted incisors is significantly related to root maturity at the time of replantation. The survival curves reported by Barrett and Kenny permit clinicians to quantitatively describe the survival prospects for an avulsed incisor based on the degree of root maturity at the time of replantation.

For example, if a patient presents with an avulsed permanent incisor with an immature apex that has been stored dry for 60 minutes, the dentist can inform the parent that the 5-year survival for the tooth is estimated to be 0.56. This means that if the replanted tooth is retained for 5 years there is a probability of 0.56 that the tooth will be retained beyond that point. It does not, however, mean that there is a 56 percent chance

the tooth will be retained for 5 years. Recently, a paper by Boyd *et al*[32] used survival analysis to describe the effects of desiccation and extra-alveolar time on the onset of root resorption. The presence of crown damage at the time of avulsion was also shown by survival analysis to increase the risk of early root resorption.[22]

Intrusions (permanent teeth)

Intrusions remain the most complicated and controversial of luxation injuries. The prognosis of incisors with severe (>6mm) intrusions is hopeless.[33] Treatment strategies include waiting for re-eruption, surgical repositioning and repositioning with elastic traction. Investigations of the relationships between clinical outcomes and variables such as severity of injury, concurrent crown fractures and even treatment methods have not employed appropriate statistical methods. Clinicians who apply traction or wait for re-eruption of teeth intruded more than 5-6 mm must ensure that they can obtain endodontic access within 1-2 weeks in order to remove the dental pulp and prevent inflammatory root resorption.[34] Clinicians should inform parents/patients that severe intrusions inevitably lead to loss of the permanent tooth.[33]

Root fractures (permanent teeth)

Currently, splinting seems to be the principal source of controversy in root fracture management. The repositioning of luxated coronal fragments continues to be advocated but there is a trend towards reducing the duration and rigidity of splinting and allowing the pulp the opportunity to recover rather than institute early endodontic intervention. Cvek *et al* [35] recently reported that there was no significant effect of splinting type or duration on healing in a sample of 208 teeth with intra-alveolar root fractures. The authors also reported that for root-fractured teeth with slightly displaced coronal fragments, short-term splinting might be more appropriate than current recommendations for rigid splinting for three months.

This study places the recommendation that root-fractured teeth be rigidly immobilized for prolonged periods into question. In fact, the investigators called into question the need for any splinting of root-fractured teeth with minimal or no mobility of the coronal fragment.[35] Further research is necessary in order to develop guidelines for optimal PL and pulp healing for teeth with root fractures.

Bioactive substances

Some investigators are currently working with an enamel matrix derivative, Emdogain®, that may facilitate PL regeneration and thus inhibit the development of replacement and inflammatory root resorption. To date, one group is involved in a prospective outcome case series[36] while others have produced animal studies[37] and described unconventional applications.[38] Emdogain® is still in the early stages of evaluation for use in the management of dental trauma, and there is presently no outcome data.

It has long been argued that therapeutic approaches that regulate and promote PL cell proliferation and differentiation such as the use of growth factors, surface adhesion molecules and/or extracellular matrix components might improve healing outcomes for replanted teeth. For this reason, coating the root surface of avulsed teeth with a differentiation factor such as Emdogain® could promote migration, proliferation and differentiation of PL fibroblasts.[39]

Indeed, the presence of viable PL cells within the alveolar socket and the roots of replanted teeth is essential for the repopulation of PL, connective tissue attachment and alveolar bone and cementum remodeling and regeneration.[40] While the long-term performance of Emdogain® on replanted permanent incisors is still unknown, the use of such bioactive substances in clinical trials marks the beginnings of the use of pharmacotherapeutics in the management of dental trauma.

Autotransplantation

Interest continues in the surgical procedure of autotransplantation also referred to as autogenous transplantation (same person). Single case reports,[41] case series[42] and textbooks[43] describe techniques, candidates and sites for tooth transplantation and outcomes. Usually autotransplantation is used to replace (maxillary) incisors[41,44] but other sites receive transplanted teeth as well.[42] The transplanted teeth have conventional endodontic treatment either immediately or within weeks of transplantation. The majority of interest and development of autotransplantation is outside of North America. North American clinicians have concentrated their efforts on the development and use of osseointegrated implants to replace missing teeth.

Treatment guidelines

Much has been written in the past few years about evidence-based dental practice. The integration of a clinician's expertise, the best available evidence and the patient's/parents' values and expectations should guide each and every trauma intervention. Yet, often as a result of the rarity of dental trauma, even specialists are 'rusty' in both the techniques and application of research information. Clinical guidelines should provide access to the best research evidence and techniques as well as means to explore patient/parent expectations prior to replantation.

Guidelines for replantation of avulsed teeth have been published by a number of authors and organizations, including AAE,[25] RCSE[45] and IADT.[46] While most guidelines are similar, it is obvious that personal opinion, anecdotal data and caprice are woven into these documents.[47] They have not addressed outcomes, the drive for normalcy that produces requests for hopeless replantations, the abnormal overjet and associated malocclusion that increase the risk of avulsion and the direct and indirect costs associated with the replantation decision. Current guidelines have uniformly failed to assess and incorporate research results from the past 3-5 years. It is clear that guidelines are 'trailing edge' documents that at best provide interpretation of already published evidence. Consequently, they have no stifling effect on research, technology transfer or the legal aspects of patient management.

However, consensus statements known as clinical guidelines provide a source of information for clinicians who do not treat trauma on a regular basis. While the effect of such guidelines is never as great as their authors wish, they can reduce the number of inappropriate treatments and increase the number of correct treatments.[48] The advent of computer-assisted training packages provides still another means of disseminating consensus-based treatment methods.[49] Such programs have the added bonus of being accessible over the internet.

Near future

The authors are encouraged that faculty of several hospital-based dental programs have recognized the need for additional outcome studies that utilize appropriate statistical methods. This will require sharing of information and acceptance of the discipline of protocol-based treatment from a number of programs. Internet database technology and videoconferencing could enable staff of such units to cooperate on outcome studies that will produce stronger evidence, more precise guidelines and, most importantly, better treatment for our patients and their parents.

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Letter to the Editor

Year One Dental Visit, Another Perspective

After reading the letter from Dr. Doykos *et al.* concerning one-year dental visits (*Pediatr Dent* 23: 195, May/June), I felt compelled to respond. As a private practitioner and retired military pediatric dentist, I must explain that I was extremely shocked when I saw the statistics from the aforementioned letter. The extremely low rate of decay noted for three-year-olds did not match my experience in either the military or in private practice. Our practice in Sioux Falls, South Dakota, is a medium-sized metropolitan area that services an extremely large geographic area. There are only two pediatric dental offices in the eastern half of South Dakota.

We also service a large area of southwest Minnesota and northwest Iowa. It is not uncommon for our patients to drive two hundred miles one way to receive treatment. Our findings for twelve-month well-baby checkups differ extremely from those offices in Boston, as almost 50 percent of the children referred to us have some type of dental anomaly or significant early caries.

Our practice is 70 percent fee-for-service patients and about 30 percent Medicaid and Indian Public Health Service. Twenty percent of our practice is composed of Native Americans or other minorities, which includes an extremely large population of European and African refugees. In this population, the decay rate approaches 60 to 70 percent. We see approximately four hundred new patient referrals per month of which 75 percent are for caries. A majority of these patients have never received any dental care other than a screening examination by the referring dentist.

We find that an extremely large number of the patients referred to us have been to a physician numerous times, yet no one had ever alerted the family that their child had significant caries. In many of these cases, the caries is non-restorable by the time we treat these patients.

We, in South Dakota, strongly applaud the continued efforts of the Academy to develop dental awareness and fully support the twelve-month well-baby checkup. It is our finding that thus far none of our twelve-month patients who were caries-free at the initial visit have developed caries. We have been successful in keeping them decay-free.

We appreciate the Academy's progress in this area, and hope that ongoing efforts convince our physician friends that children need a dental visit between the ages of twelve and twenty-four months. This visit should be for the purpose of an initial examination and to develop a dental home where the family feels comfortable.

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