PULP FICTION
A Quarterly Newletter
By Westside Endodonics
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Happy Spring everyone!!!
Hopefully that wet winter is well behind us and we can start looking forward to warmer days! 2016 has already started off with a bang. We had our long time assistant Melissa retired from dentistry and we welcomed Briar, from Great Falls Montana to our practice. A sincere thanks to all of you, we have been extremely busy and my team has become even more so efficient at accepting your emergencies. The team enjoys the adrenaline filled days!!! I have always extended an open door policy to doctors and assistant, for anyone that wants to observe and learn or sharpen their endodontic skills. It has been fun hosting those of you that have come over! Enjoy the tran sition into the 2nd quarter….and as always…enjoy your edition of Pulp Fiction!!!

Pulp–Dentin Regeneration: An Overview
Tissue regeneration in the dental pulp entails the resolution of acute and chronic inflammation, pulp necrosis and infection, followed by the restoration of damaged dentoalveolar tissues, including the organized pulp–dentin complex. The rationale for endodontic regeneration is to reinstate normal physiologic function in an otherwise necrotic pulp, including the protective mechanisms—e.g., innate pulp immunity, pulp repair through tertiary dentin mineralization, and sensation of occlusal pressure and pain.

Cao et al from the UCLA School of Dentistry, California, conducted a literature search to establish the current state of research and develop a novel regenerative approach that would restore not only pulp vitality but an organized pulp–dentin structure with the full spectrum of normal physiologic functions. In general, tissue engineering encompasses 3 requirements: a scaffold, growth differentiation signals and stem cells.

Because of the root canal system's unique environment, successful endodontic regeneration requires coordination of infection control, biomaterials and stem cells, the triad of pulp tissue engineering. Elimination of root canal infection is the primary objective in regenerative therapies to resolve apical periodontitis and is achieved by chemomechanical debridement and intracanal medicaments.

Such therapies eliminate elements that interfere with the differentiation and maturation of apical papilla cells. In the interest of salvaging the apical papilla cells, canal irrigation is recommended with lower-strength sodium hypochlorite solutions at 1.5%, while irrigation with 17% ethylenediaminetetraacetic acid (EDTA) has been shown to promote the release of growth factors, resulting in hard tissue formation. Intracanal disinfection is primarily achieved by use of calcium hydroxide (CH) or a mixture of antibiotics known as triple antibiotic paste (TAP), composed of ciprofloxacin, metronidazole and doxycycline.

The American Association of Endodontics recommends placement of CH or low concentrations of TAP during the first appointment of regenerative procedures, although this recommendation is supported only by limited case reports. CH appears to promote proliferation of periapical pulpal mesenchymal stem cells (MSCs); a high concentration of antibiotics, on the other hand, has a detrimental effect.

- A dental material suitable for pulp regeneration must satisfy the following criteria
- be biocompatible, since it will be in direct contact with the regenerated dental pulp
- be hard enough to withstand repeated masticatory pressure
- provide an excellent seal against the dentinal wall to prevent leakage of oral microorganisms into the pulp space

Mineral trioxide aggregate (MTA), a calcium silicate cement-based material, has been the preferred material for endodontic regeneration because of its exceptional biocompatibility, hardness and enhanced marginal adaptation against dentin. However, due to its reduced washout strength because of its extended setting period, MTA is less than ideal in the context of pulp tissue engineering. Since pulp–dentin regeneration cases would require direct contact between the restorative material and the intracanal medium in forms of a blood clot, hydrated scaffold and/or cellular suspensions, fast-setting material may be preferred for regenerative endodontics.

MSCs are represented by stromal cell populations demonstrating stem characteristics and multipotent differentiation. They are generally thought to be immunomodulatory and immunosuppressive, supporting the concept of allotransplantation for therapeutic purposes. Some reports indicate the potential for immunogenicity.

While revascularization appears successful in resolving apical periodontitis and revitalization of pulpless teeth in limited cases, the revascularized tissues may not truly represent pulp–dentin regeneration, which requires the formation of an organized odontoblastic layer. Several preclinical and large animal studies have refuted the notion that revascularization is bona fide tissue regeneration.

Progress with the cell-based approach for pulp–dentin regeneration has been hampered because of safety and regulatory issues regarding pulpal MSC production and transplantation in patients. Clinical translation of the cell-based approach must also overcome the challenge of MSC expansion in vitro and the regulatory requirements of good manufacturing practice facilities to ensure reliable cell production.

As an alternative, allogeneic pulpal MSCs can be mass produced, enabling a rapid turnaround to generate potent MSCs ready to be used for transplantation. Another alternative, developed at the researchers' laboratory, generates MSCs from primary normal human epidermal keratinocytes by inducing epithelial–mesenchymal transition. The authors coined the term induced MSCs (iMSCs) to describe these cells, which are distinct from induced pluripotent stem cells that are generated by the transduction of defined reprogramming factors. These iMSCs may represent an alternative for patients who lack adequate tissue sources for endogenous MSCs.

Conclusion

More studies are needed to determine the potency of these iMSCs and assess their transdifferentiation capacities into functional odontoblasts when transplanted into the root canal microenvironment.

Cao Y, Song M, Kim E, et al. Pulp-dentin regeneration: current state and future prospects. J Dent Res 2015;doi:10.1177/0022034515601658.

Frequency of Root Resorption Following Trauma

The prevalence of traumatic injuries to the teeth and their supporting structures is significant. Causes include sports injuries, falls and automobile accidents. Most injuries occur in children between the ages of 8 and 15 years; the anterior teeth are affected most frequently. In addition to the teeth, the periodontal tissues, gingiva, alveolar bone and pulp are often adversely affected. Healing depends on the stage of root development (open or closed apex), the extent of damage to periodontal tissues and the effects of bacterial contamination from the oral cavity. Since complications may occur after injury, dental trauma requires long-term follow-up. One of the most frequent complications of dentoalveolar trauma is root resorption.

Soares et al from the State University of Campinas, Brazil, evaluated the frequency of root resorption in cases of dental trauma involving the supporting tissues. From the files of patients who were treated for dental trauma between April 2010 and June 2012, 249 traumatized teeth from 125 patients (age range, 7 to 51 years) were identified. Patient data analyzed included sex and age, the type of tooth injured, the type of trauma and the length of time from dental injury to initial examination (Table 1).

Radiographic parameters pertaining to root resorption included the presence of external and/or internal inflammatory root resorption, replacement resorption, and canal calcification. Analyses included the chi-square test and Fisher's exact test, followed by a linear logistic regression analysis. Results revealed that 84.9% of the pathological resorption was represented by external inflammatory root resorption and was present more frequently in cases of intrusive luxation. A higher frequency of external inflammatory resorption (70%) than replacement resorption (30%) was also evident.

Conclusion

This study concluded that root resorption is observed more frequently and its risk of development is higher in cases of severe trauma, especially avulsion and luxation.

Soares AJ, Souza GA, Pereira AC, et al. Frequency of root resorption following trauma to permanent teeth. J Oral Sci 2015;57:73-78.

Outcomes of Repaired Root Perforation

Root perforation is a mechanical, iatrogenic or pathologic communication between the root canal system and the external tooth surface. An iatrogenic perforation often results from misalignment of burs or engine-driven instruments during endodontic access preparation, canal negotiation or root canal preparation. Some iatrogenic perforations are created during prosthodontic treatment, in particular when pre paring a post space.

One study stated that 47% of perforations were noted or created during endodontic treatment, while 53% were due to prosthodontic treatment; maxillary teeth (74.5%) were more often affected than were mandibular teeth (25.5%). Root perforation may lead to complications that necessitate extraction of the involved tooth.

A 2011 prospective study suggested that 4.2% of endodontically treated teeth were extracted because of iatrogenic perforations and stripping. Bacterial infection emanating from the root canal, the periodontal tissues or both prevents healing and brings about inflammatory sequelae including pain, swelling, suppuration and bone resorption. Down-growth of the gingival epithelium to the perforation site can follow, re sulting in accelerated periodontal breakdown.

Siew et al from the University of Hong Kong, China, conducted a systematic review of reported treatment outcomes of repaired root perforations to identify any preoperative factors that may influence the outcome of such repair. A comprehensive search was conducted using 4 electronic databases (PubMed, Web of Knowledge, EMBASE and SCOPUS) as well as a manual search of cited references to identify reports related to root perforation. All relevant articles published from 1950 to the middle of 2014 that evaluated the outcome of repaired root perforations were identified. Studies were further screened for similar characteristics so that pooling of data could be used for meta-analysis.

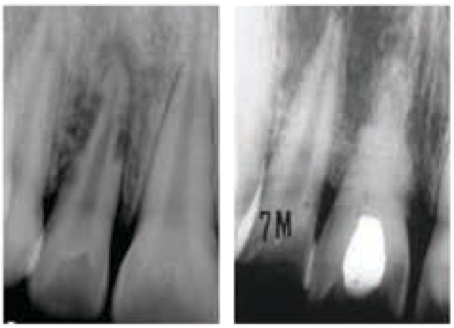

Figure 1. (Left) Periapical radiograph of tooth with external inflammatory root resorption showing radiolucent areas on the root and the alveolar bone. (Right) Periapical radiograph of tooth #8 with replacement resorption. The periodontal ligament space is not visible, and the root has been partially resorbed. (*Images courtesy of Dr. Frederic Barnett.*)

Table 1. *Relationship between patient age and period from the date of injury until initial examination*

Age	Time interval 21–90 days	3–12 months	>12 months	Total
≤14 years	73 (66.4%)	17 (15.5%)	20 (18.2%)	110 (44.2%)
15–20 years	42 (60.9%)	7 (10.1%)	20 (29.0%)	69 (27.7%)
21–26 years	12 (38.7%)	5 (16.1%)	14 (45.1%)	31 (12.4%)
>26 years	15 (38.5%)	15 (38.4%)	9 (23.1%)	39 (15.7%)
Total	142 (57.0%)	44 (17.7%)	63 (25.3%)	249 (100%)

A total of 17 studies were included in the systematic review; 12 studies were included in the meta-analysis. An overall pooled success rate of 72.5% (95% confidence interval [CI], 61.9% to 81.0%) was estimated for repair of root perforations. The use of mineral trioxide aggregate appeared to enhance the success rate to 80.9% (95% CI, 67.1% to 89.8%), but the difference was insignificant. The presence of preexisting radiolucency adjacent to the perforation site predicted a lower chance of success after repair (p less than .021). Maxillary teeth demonstrated a significantly higher success rate than did mandibular teeth (p less than .05).

Conclusion

The overall success rate of greater than 70% led the authors to conclude that nonsurgical repair of root perforation should be the preferred treatment option when this complication arises during root canal therapy. Teeth in the maxillary arch and absence of preoperative radiolucency adjacent to the perforation are favorable factors for healing after perforation repair.

Siew KL, Lee AHC, Cheung GSP. Treatment outcome of repaired root perforation: a systematic review and meta-analysis. J Endod 2015;41:1795-1804.