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Pedialyte to Temporarily Store and Preserve Avulsed Teeth

Traumatic tooth avulsion is the complete displacement of a tooth from its alveolar socket. Ideally, the avulsed tooth should be replanted back into its alveolus as soon as possible. The longer the extra-alveolar time, the greater the amount of periodontal ligament (PDL) damage, and the long-term success of the replanted tooth dramatically decreases. If immediate replantation cannot be accomplished, the avulsed tooth should be placed in a suitable storage medium to help preserve a vital PDL. Two of the most critical factors affecting the prognosis of an avulsed tooth after replantation are extra-oral dry time and the storage medium in which the tooth is placed before treatment is rendered.

Various storage media such as Hank's balanced salt solution (HBSS), milk and saline have been used with some success, but an ideal storage medium has not been found. Apart from its osmolality and neutral pH, an ideal storage medium should

also be readily accessible, especially to families with young children, school personnel and athletic coaches.

Recently, Ricetral, an oral rehydrating solution not available in the United States, also has been reported to retain PDL cell vitality. Pedialyte, a popular oral electrolyte maintenance solution in the United States that replenishes lost fluids and essential cell nutrients, has a composition similar to Ricetral. It is readily available over the counter and is commonly available in households with young children. Nevertheless, no previous study has investigated the in vitro effectiveness of PDL cell viability after storage in Pedialyte. Thus, Macway-Gomez and Lallier from the Louisiana State University Health Science Center undertook a study

- to determine whether Pedialyte is a viable alternative storage solution for avulsed teeth by assessing its ability to preserve human PDL cell viability
- to see whether the viable PDL cells are able to migrate after storage in Pedialyte
- to evaluate bacterial growth in Pedialyte

Human PDL cells were exposed to 6 different storage solutions (minimal essential medium, HBSS, nonfat milk, coconut water, Pedialyte or tap water) for 2, 6, 24 or 48 hours at 4°C or 25°C. Cell viability was quantified im-

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mediately or 1 week after exposure. The effects of these storage solutions on PDL cell motility and bacterial proliferation were also examined.

Pedialyte (like HBSS, nonfat milk and coconut water) showed significantly higher cell survival ($p < .001$) compared with tap water at both temperatures immediately after storage in various solutions for 2, 6, 24 or 48 hours. Pedialyte supported PDL cell migration as well as any of the other storage solutions. Unlike nonfat milk and control medium, HBSS, coconut water and Pedialyte supported much less bacterial growth.

Conclusion

Pedialyte supported PDL cell survival at 25°C for up to 48 hours and is a viable alternative to HBSS and milk to store avulsed teeth. Further studies are needed to assess the response of PDL cells to Pedialyte in vivo.

Macway-Gomez S, Lallier TE. Pedialyte promotes periodontal ligament cell survival and motility. *J Endod* 2013;39:202-207.

Root Canal Debridement and Final Irrigation Protocols

Complete root canal debridement and disinfection is a goal of endodontic treatment but thus far has been clinically unattainable. Inflamed and necrotic tissue remaining inside the root canal system following cleaning and shaping procedures may provide nutrition for intraradicular microorganisms. This infection may compromise root canal

Table 1. Mean percentages of surface area covered by remaining soft tissue

Rinsing protocol	n	Mean %	SE
Manual	7	17.49	2.68
CanalBrush	7	12.84	2.64
H ₂ O ₂	6	7.24	2.53
PUI	12	8.70	1.77

n, number of histological sections examined; SE, standard error.

treatment outcome, if the quantity and pathogenicity of the microbial flora exceeds a certain threshold level.

Techniques to enhance effectiveness of irrigation procedures currently being investigated include agitation/activation of irrigating solutions with various techniques and devices; the introduction of new irrigants and surfactants; alternating various irrigants during the procedure; and the introduction of the CanalBrush (Coltène Whaledent, Langenau, Germany).

The CanalBrush is made from flexible polypropylene. It can be used manually or attached to a contra-angle slow-speed handpiece and has been shown to be as effective as passive ultrasonic irrigation (PUI) in curved canals of mandibular molars. However, another study reported that in terms of debris and smear layer removal, the CanalBrush was not shown to be different from conventional agitation in straight roots.

Al-Ali et al from the University of Melbourne, Australia, evaluated the effectiveness of the CanalBrush in root canal debridement in comparison with PUI and manual agitation. Additionally, the effectiveness of alternating hydrogen peroxide (H₂O₂) with sodium hypochlorite (NaOCl) in root canal debridement was investigated.

The mesial roots of mandibular molars and mesiobuccal roots of maxillary molars were stored in 1% chloramine-T solution. Teeth were decoronated, and canals were instrumented with the Mtwo rotary nickel-titanium instruments (VDW, Munich, Germany). Irrigation with 1 mL of 1% NaOCl between each instrument was performed. The root apices were covered with greenstick wax. Roots were then assigned randomly to 1 of 4 groups:

- Group 1 (n = 28): Final rinse by manual “jiggling” agitation of a 27-gauge conventional notched needle and syringe at a rate of 5 mL/min; 1% NaOCl (5 mL) was used, followed by 15% ethylenediaminetetraacetic acid (EDTA) (3 mL, pH 7–7.4). EDTA remained in the canal for 1 minute prior to a final rinse with 5 mL 1% NaOCl.
- Group 2 (n = 26): The same as group 1, but 1% NaOCl and 15% EDTA were agitated using a CanalBrush operated on a contra-angle slow-speed handpiece at 600 rpm for 30 seconds. A rinse with 1% NaOCl followed without agitation; 1 CanalBrush/root was used at full working length with a gentle up-and-down motion.
- Group 3 (n = 26): Following the first rinse of 1% NaOCl and 15% EDTA (as in group 1), 1 mL

NaOCl alternated with 1 mL of 3% H₂O₂ to a total of 5 mL of each solution. The canal was then rinsed with 5 mL of 1% NaOCl.

- **Group 4 (n = 27):** Same as group 2, but solutions were agitated by PUI. An Irrisafe tip (Satelec Acteon; VDW, Munich, Germany) of size 25 attached to a P5 Newtron XS Ultrasonic device (Satelec Acteon, Merignac-Cedex, France) was used according to the manufacturer's instructions at a power setting of 10. Each Irrisafe tip was advanced to 1 mm short of its binding point.

The histological component of the study comprised 11 roots/group, leaving ≥15 roots/group for evaluation with a scanning electron microscope. Two CanalBrush tips fractured in the apical third of 2 specimens.

CanalBrush and PUI were equally effective with significantly less smear layer and debris than manual agitation and H₂O₂ alternated with NaOCl (*p* < .05). The H₂O₂ alternated with NaOCl protocol was significantly more effective in removing pulp tissue remnants in the apical level than were manual agitation (*p* = .009) and PUI (*p* = .01; Table 1).

Conclusion

Within the study limitations, CanalBrush showed effectiveness similar to PUI in removing smear layer and debris when operated for 30 seconds. Alternating H₂O₂ with NaOCl showed significantly cleaner canals than did PUI and manual agitation in terms of remaining soft tissues in isthmuses. Further studies are required to evaluate the effectiveness of this regimen controlling for irrigant volume differences.

Al-Ali M, Sathom C, Parashos P. Root canal debridement efficacy of different final irrigation protocols. Int Endod J 2012;45:898-906.

Mineral Trioxide Aggregate to Treat Open Apex Teeth

Mineral trioxide aggregate (MTA) is a root canal repair material developed in the early 1990s. The biocompatibility of MTA and its satisfactory sealing ability in the presence of moisture, including blood, support its successful application for the ortho-

grade obturation of nonvital teeth with open apices.

In a case series, Mente et al from Ruprecht-Karls-University, Germany, demonstrated that 84% of the 56 teeth treated with MTA apical plugs healed. Teeth with or without preoperative periapical radiolucencies exhibited healed rates of 100% and 78%, respectively. None of the analyzed potential outcome factors showed a significant effect on the outcome, suggesting that the study was underpowered.

To reinvestigate the potential outcome predictors with a larger sample size than that used in the first phase, 221 patients treated between 2000 and 2010 were contacted for follow-up 12 to 128 months (median, 21 months) after treatment. A total of 252 teeth (88% recall rate) presented with open apices caused by apical root resorption or excessive apical enlargement or with immature apices from arrested development. The investigated outcome relied on clinical and radiographic criteria and was dichotomized as healed or diseased.

The results from the multiple survival analysis can be seen in Table 2. Of the 252 teeth, 90% were healed.

Table 2. Multiple survival analysis after model selection to identify relevant prognostic factors

Factor	Teeth		Healed		Diseased		p value	HR (95% CI)
	n	%	n	%	n	%		
Apical periodontitis (preoperative)								
Absent	114	96	4	4			.005*	Reference
Present	138	85	21	15				
Treatment provider								
Supervised undergraduate student	30	90	3	10			.03*	0.41 (0.12–1.41)
General dentist	124	85	18	15				
Experienced treatment provider (practice limited to endodontics)	98	96	4	4			0.25 (0.09–0.75)	

HR, hazard ratio; CI, confidence interval. *Statistical significance at 5% confidence level.

Teeth with and without preoperative periapical radiolucencies demonstrated healed rates of 85% and 96%, respectively; 113 teeth (45%) were followed for ≥ 2 years and 53 (21%) for ≥ 4 years. Univariate survival analyses identified 4 prognostic factors: presence of preoperative apical periodontitis (most significant); the experience of the treatment providers; the number of treatment sessions; and the apical extrusion of MTA (borderline significance).

Conclusion

The success rates of teeth with open apices suggest that the orthograde placement of MTA apical plugs is a highly successful option to treat such teeth. The presence of preoperative apical periodontitis was the most important prognostic factor, and success rates remained consistently high, even after follow-up periods of >4 years.

Mente J, Leo M, Panagidis D, et al. Treatment outcome of mineral trioxide aggregate in open apex teeth. *J Endod* 2013;39:20-26.

Treating Intrusive Luxation of Permanent Incisors

Intrusive luxation in the permanent dentition, the dislocation of the tooth in an apical direction into the alveolar socket, comprises 0.5% to 1.9% of all dental injuries. However, it is considered one of the most severe types of dental injuries because when the tooth is forced apically into the alveolar socket, the periodontal ligament (PDL) and the blood supply to the dental

pulp through the apical foramen tend to be crushed by the bone. Complications such as pulp necrosis; infection-related (inflammatory) root resorption, ankylosis-related resorption (replacement resorption) and marginal bone loss are frequent.

Most significant for the long-term outcome of this trauma are the type of treatment rendered, the degree of root development and the degree of intrusion. Tsilingaridis et al from the Eastman Institute, Sweden, evaluated pulp survival and periodontal healing in intrusive luxated permanent teeth as related to treatment alternatives, degree of intrusion and degree of root development.

Sixty intruded permanent teeth in 48 patients (32 boys, 16 girls) aged 6 to 16 years (mean, 9.4 years) were observed for 6 to 130 months (mean, 47.8 months). The treatments were

- spontaneous reeruption (17 teeth)
- orthodontic extrusion (12 teeth)
- surgical repositioning (31 teeth)

The degree of intrusion was registered as mild (1–3 mm), moderate (4–6 mm) and severe (≥ 7 mm). Root development was categorized into 4 stages:

- one-quarter to three-quarters root formation
- full root formation with open apex
- full root formation with half-closed apex
- full root formation with closed apex

Pulp revitalization with complete healing occurred in 17 teeth. In all but 1, the apex was open at the accident, and during the follow-up period, continuous root development

and/or obliteration was seen. Ankylosis-related resorption with pulp necrosis was diagnosed in 20 teeth, 11 of which were lost. This type of resorption is the most serious complication in growing individuals. If the tooth is left in situ, infra-position will occur and surrounding alveolar bone growth will be arrested. Teeth with open apices have the best prognosis regarding healing of the PDL.

Conclusion

Treatment type significantly correlated to healing outcome: Spontaneous reeruption was the most favorable, and surgical repositioning the least favorable. In teeth with immature root development, spontaneous repositioning appears to result in fewer healing complications.

Tsilingaridis G, Malmgren B, Andreassen JO, Malmgren O. Intrusive luxation of 60 permanent incisors: a retrospective study of treatment and outcome. *Dent Traumatol* 2012;28:416-422.

In the next issue:

- Regenerative potential after revascularization
- Morphological study of complex root canal systems

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