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Factors affecting the timing of pulp extirpation in a sample of 66 replanted avulsed teeth in children and adolescents

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Abstract – The management of 66 replanted avulsed permanent teeth in 46 patients over a 4-year period was studied. Treatment was compared with the recommendations in published guidelines for the management of avulsed permanent teeth. For total extra-alveolar times longer than 45 min, the pulps were extirpated in 96% of teeth. Extra-alveolar times longer than 45 min were associated with earlier pulp extirpation (median 16 days) compared with teeth with shorter extra-alveolar times (median 25 days). Endodontic treatment was postponed in teeth with open apices (median 27 days) compared with closed apices (median 15 days). Teeth in which pulps were removed within 10 days post-trauma had a lower prevalence of inflammatory root resorption compared with teeth in which pulps were removed later. Where inflammatory root resorption did occur, onset was significantly delayed when the pulp had been removed within the first 10 days. This study indicates that clinicians are following the guidelines in key areas of endodontic management of traumatized incisors resulting in more favourable outcomes.

Replanted avulsed teeth present a unique challenge to the clinician. There is injury to the periodontium and severance of the neurovascular bundle supplying the pulp. When there is a long extra-alveolar time prior to replantation, the cells of the pulp and periodontal ligament rapidly deteriorate due to loss of their blood supply as well as the effect of drying.

There are a number of guidelines on the management of the avulsed tooth, including those published by The American Association of Endodontists (1), American Academy of Pediatric Dentistry (2), International Association of Dental Traumatology (3) and Royal College of Surgeons of England (4).

These guidelines recommend that endodontic treatment decisions should be based on the stage of root development and the length of extra-alveolar times. For teeth with open apices and short extra-alveolar times, the guidelines suggest that endodontic intervention should be delayed as there is a possibility of pulpal revascularization. In contrast, the recommendation is to commence root canal treatment in all teeth with a closed or almost closed apex regardless of extra-alveolar time or in open apex teeth with long extra-alveolar time. In these cases, pulps should be removed as soon as the tooth is sufficiently stable.

The argument in favour of early extirpation of the pulp is based on the risk of developing inflammatory root resorption. This process starts with localized loss of cementum that allows toxic material from a necrotic pulp to reach the periodontium via dentinal tubules (5, 6). The most serious outcome for a replanted tooth is progressive root resorption that will inevitably lead to tooth loss (7, 8).

The aims of the present study were to:

1. Gain information about the extent to which operators adhere to the published guidelines when they make clinical decisions.
2. Examine the effect of extra-alveolar time and apical development on the timing of pulpal extirpation.
3. Determine the effect of pulpal extirpation on the prevalence and onset of inflammatory root resorption.

Materials and methods

The study was conducted as a review of clinical treatment provided for child and adolescent patients who had experienced replantation of one or more avulsed permanent teeth. Sixty-six replanted avulsed permanent incisor teeth in 46 child and adolescent patients treated at the Glasgow Dental Hospital during the period 2002–2005 were included. A standardized data entry form was used to record trauma details. Findings recorded were extra-alveolar time, prevalence and timing of pulp extirpation, status of apical development (open or closed) and prevalence of subsequent inflammatory resorption. Root apices were categorized as open if, on X-ray, the root canal walls were divergent or parallel. Root apices were considered closed if the canal walls were convergent. Cases were divided into two groups, the first having extra-alveolar times up to 45 min and the second having longer times. Pretreatment factors and clinical decisions were compared with a recognized faculty clinical

guideline for the management of avulsed teeth (4). The frequencies and values of measures in this study were tabulated according to the criteria in this guideline. The relationships concerning guideline recommendations among extra-alveolar time, apical status and pulpal extirpation were analysed. The effect of clinical decisions on the subsequent development of inflammatory root resorption was tested. Data were entered and analysed using NCSS statistical programme, cross-tabulations were constructed, and statistical significance tested using Fisher's exact tests or Mann–Whitney *U*-tests as appropriate. Median values are quoted and the non-parametric statistical test applied when data distribution was skewed and contained outliers. The confidence level was set at 95% ($P < 0.05$).

Results

The study sample of 46 patients consisted of 26 female and 20 male patients aged 6.3–21.4 years (mean 9.9). Of the 66 replanted avulsed permanent incisor teeth reviewed, 19 teeth had open apices and 47 had closed apices. Total extra-alveolar time ranged between 0 and 240 min (mean 85 ± 51.9). Pulps were extirpated in 58 of the 66 teeth with time to pulp removal from 4 to 79 days (mean 23 ± 18.8). The mean time to detection of inflammatory root resorption was 224 ± 224.3 days with a range of 14–886 days. Follow-up periods were from 191 to 3752 days with a mean time of 1098 ± 925.3 days.

Table 1 shows the relationship between total extra-alveolar time and prevalence of pulp extirpation in the 66 replanted avulsed teeth. In teeth with extra-alveolar times more than 45 min, pulps were removed in the large majority of cases. In contrast, when the extra-alveolar times were 45 min or less, pulps were removed less frequently. The difference between the prevalence of pulp removal in the two total extra-alveolar time groups was significant ($P = 0.003$).

The median time of pulp extirpation was 25 days in the group with shorter extra-alveolar times compared with 16 days for teeth with longer extra-alveolar times. However, this difference in time was not significant ($P = 0.058$). The timing of endodontic intervention between teeth with open apices ($n = 16$) and those with closed apices ($n = 42$) was significantly different (median 27 and 15 days, respectively) ($P = 0.005$).

Table 2 shows the relationship between the time of pulp removal and the number of teeth with inflammatory root resorption and its time of onset. The difference in prevalence of inflammatory resorption between the two groups was not significant (Fisher's exact test $P = 0.155$). In those cases where resorption did occur, the onset of inflammatory root resorption was significantly delayed in the ≤10 days group (median onset 608 days) compared with the >10 days group (median onset 132 days) ($P = 0.003$).

Table 1. Relationship between total extra-alveolar time and prevalence of pulp extirpation

	Extra-alveolar time ≤ 45 min	Extra-alveolar time > 45 min
Pulp not removed ($n = 8$)	6 (35.3%)	2 (4.1%)
Pulp removed ($n = 58$)	11 (64.7%)	47 (95.9%)
Total ($n = 66$)	17 (100%)	49 (100%)

There was a significantly lower incidence of pulp removal in the ≤ 45 min extra-alveolar time group as compared with the > 45 min extra-alveolar time group (Fisher's exact test, $P = 0.003$).

Table 2. Relationship between the time of pulp removal and the occurrence and time of onset of inflammatory root resorption

Inflamatory root resorption status	Pulp removed ≤10 days	Pulp removed >10 days	Total
Absent	14 teeth (38%)	23 teeth (62%)	37 teeth (100%)
Present	4 teeth (19%)	17 teeth (81%)	21 teeth (100%)
Median days to inflammatory resorption (range)	608* (383–886)	132 (14–304)	

*The difference in the time of onset of inflammatory root resorption between the ≤ 10 days pulp removal group and the > 10 days group was significant: Mann–Whitney *U*-test, $z = 3.00$, $P = 0.003$.

Discussion

There are published guidelines available to assist practitioners in their management of avulsed teeth (1–4). The consensus from these guidelines is that the pulp should be removed 7–14 days after replantation. This guidance appears to be based on the known high risk of inflammatory root resorption in replanted teeth in cases where the pulp has not been extirpated (9). In addition, inflammatory root resorption can be stimulated by infecting pulps after replantation (10, 11). Highly alkaline conditions can exist on the root surface and in the periodontium when calcium hydroxide is placed in the root canal, especially if there are areas of denuded cementum. Therefore, placement of calcium hydroxide should be delayed until 10–14 days after replantation to allow initial periodontal healing (12–14).

For teeth with open apices and short extra-alveolar time, the guidelines suggest that it is acceptable to delay endodontic treatment to allow for the possibility of pulpal revascularization. Recently revised International Association of Dental Traumatology guidelines (3) re-affirm the possibility of revascluarization in teeth with open apices that have been replanted immediately or stored in an appropriate storage medium. For such teeth the guidelines state that root canal treatment should be avoided unless there is clinical and radiographic evidence of pulpal necrosis. Studies show that between 18% and 34% of replanted teeth with open apices and limited extra-alveolar time undergoes revascularization (15, 16). In an animal study, pulpal revascularization rates as high as 60% have been reported in immature replanted teeth (17).

For teeth with closed apices, the avulsion guidelines recommend that the pulp be extirpated without delay (7–14 days) to reduce the risk of inflammatory root resorption (18). Current guidelines indicate that an

extra-alveolar time of longer than 30–45 min significantly increases the risk of pulpal necrosis. Our study, which used the upper time limit of 45 min, indicates that teeth with longer extra-alveolar times have a higher prevalence of pulpal extirpation. There was a marked pattern of earlier endodontic intervention in cases with closed apices. In contrast, clinicians tended to delay pulpal extirpation when apices were open and there was a possibility of pulpal revascularization.

The most serious consequence for a replanted tooth is root resorption, which is the major reason for tooth loss in these cases (15, 16). Our finding of less early inflammatory root resorption, in cases where the pulps were removed within the first 10 days, supports the recommendation in published guidelines and emphasizes the importance of undertaking endodontic interventions at the optimal time to ensure the best possible outcome.

In conclusion, within the limits of this retrospective study, the published guidelines appear to provide sound advice to the clinician for improving longer-term outcomes for this category of dental trauma. Adherence to these guidelines carries with it the increased potential for improving and maintaining the quality of life for a large proportion of patients who incur avulsion injuries.

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