

# Variations in the presenting and treatment features in reimplanted permanent incisors in children and their effect on the prevalence of root resorption

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**Objective** To examine variations in the presentation and treatment of reimplanted incisors in children and to determine the effect of these on the prevalence of external root resorption.

**Setting** Departments of Paediatric Dentistry, Belfast and Newcastle upon Tyne.

**Design** Recording of the timing of the injury and the storage mediums (including air) and of reimplantation, the stage of root development, the degree of contamination and the time of commencement of root treatment. Cases were reviewed clinically and radiographically at intervals of 3 months. Root resorption was classified as present or absent. Logistic regression and cross-tabulations were produced with the presence of resorption set as the outcome.

**Results** 128 reimplanted permanent incisor teeth, their median dry time prior to reimplantation being 15 minutes (range 4-52 mins), the median time in a liquid medium being 45 minutes (range 0-650 mins), with a median splinting time of 15 days (range 4-52 days) and a median pulp extirpation time of 15 days (range 0-612 days). There was a lower prevalence of resorption when the period of dryness was less than or equal to 5 minutes ( $p=0.025$ ). The prevalence of resorption in teeth with no visible contamination was 57.1%, for those with contamination which were washed clean it was 75%, in those rubbed clean it was 87.5%, and it was 100% for those reimplanted with visible contamination still present ( $p=0.014$ ). The corrected odds ratio for contamination was 2.99 and for an extension of 10 minutes of dryness it was 1.29.

**Conclusion** The degree of contamination and the period of dryness were the major risk factors for resorption in this study of reimplanted teeth in children.

Many teeth which are avulsed as a result of an injury are reimplanted and they may function satisfactorily for many years.<sup>1,2</sup> When compared to other tooth injuries, avulsion is a serious assault on the gingiva, the alveolus, the periodontium, the pulp and the cementum and it may cause damage to the dentine of the

root. It has been shown that in animals and under ideal conditions, complete healing of the dental and supporting tissues can occur.<sup>1</sup> Such ideal conditions rarely occur in humans and there is a wide range of outcomes which can result. The main reason for loss of teeth in the long term is external root resorption. There are methods of treatment for other complications such as pulpal necrosis but if root resorption becomes established the long term prognosis diminishes considerably. The main aims of treatment are directed at encouraging viability and repair of the periodontal ligament and the prevention or early treatment of any root resorption. It is known that immediate reimplantation or storage in a suitable liquid medium can increase periodontal healing,<sup>3-5</sup> but there has not been a specific study on the effects of the degree of root contamination and its management. Another factor thought to affect root resorption is the endodontic status, as a necrotic pulp can trigger root resorption.<sup>6</sup> However, the effect of variations in the pulpal extirpation times has not been established in humans although it is thought that 7-14 days is the optimum time for cases where revascularisation is unlikely to occur.<sup>7</sup> Similarly although very prolonged and rigid splinting can predispose to dento-alveolar ankylosis,<sup>8</sup> there are no studies that look specifically at less extreme variations in splinting times in humans. It has been reported that the survival of teeth with open apices is poorer than those with closed apices<sup>2</sup> and therefore this factor should be included in studies. It is known that the time of onset of resorption is very variable<sup>9</sup> and therefore for the same reason this measure should also be included.

The objectives of the present study were

- 1) To examine variations in the presentation and treatment of reimplanted incisors
- 2) To examine the effect of these variations on the prevalence of external root resorption
- 3) To determine those factors that are significantly associated with an increased prevalence of resorption

## Method

Presentation and treatment factors for cases of reimplanted incisors in children were recorded in the Dental Schools and Hospitals of Belfast and Newcastle upon Tyne. Cases had a minimum follow-up period of 2 years. Factors which may exert an influence on the occurrence of resorption were included as follows. The period when the tooth was dry prior to placement in a liquid medium was recorded. Both measures were recorded for each case and each factor was entered separately in the subsequent analysis. The period of time of storage in a liquid medium was also recorded. The period

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from the trauma to the last review was recorded as a measure of the time the tooth was at risk of developing resorption. The stage of root development at the time of reimplantation was assessed using an adaptation of the method of Moorees, Fanning and Hunt.<sup>10</sup> The stages of root development were classified on a five point scale ranging from roots which were less than one third formed to those fully formed. The earlier stages of crown and root formation were not applicable to the present study. The degree of visible contamination at the time of reimplantation was classified as 1) no visible contamination 2) visibly contaminated at the outset but successfully washed clean 3) visibly contaminated at the outset but successfully rubbed clean and 4) reimplanted incompletely clean. The period in days from reimplantation to pulpal extirpation was recorded, as was the total splinting period. Cases were reviewed clinically as required and standard intraoral radiographs were taken at intervals of three months. Root resorption was recorded if the tooth exhibited loss of root substance radiographically with concomitant loss of bony substance and associated radiolucency or if there was loss of root substance with concomitant bony replacement and loss of periodontal ligament space. If there was no radiographic evidence of root resorption but the tooth exhibited a high percussion note, showed no mobility and was clinically ankylosed then it was also classified as having replacement resorption. This would indicate that the replacement resorption process was taking place on the labial or palatal surface, and not on the mesial or distal surface and therefore it would not be visible on an intra-oral radiograph. Surface resorption is a reversible phenomenon and was not included in the present study.

Data were transferred to an N.C.S.S data base for analysis and a stepwise logistic regression model was constructed with the presence of resorption set as the outcome variable and after variable interaction the odds ratio for each prognostic factor was calculated. Numerical values of the factors found to significantly affect this outcome were tabulated and their significance tested using  $\chi^2$  tests.

**Table 2 Relationship between period when reimplanted teeth are stored dry and the subsequent prevalence of root resorption.**

Dry period in mins	Resorption present N (%)	Resorption absent N (%)	Total N (%)
0-5	18 (51.4%)	17 (48.6)	35 (100.0%)
6-20	20 (76.9%)	6 (23.1%)	26 (100.0%)
21-180	24 (80.0%)	6 (20.0%)	30 (100.0%)

$\chi^2 = 7.37$   
2df  
p=0.025

**Results**

There were 128 reimplanted permanent incisor teeth from 109 patients in the present study. There were 110 upper central incisors, 9 upper laterals, 6 lower incisors and three canines. The patients mean age at the time of reimplantation was 10.3 years with a range of 7.1 years to 18.0 years. There was considerable variations in the characteristics of the teeth noted at the time of reimplantation and these are summarised in Table 1. There was a wide range of stages of root development with 47 (36.7%) of the teeth having fully formed roots (stage5) 41(32.0%) with incomplete but convergent root ends (stage4), 25 (19.5%) with parallel root ends (stage 3) and 15 (11.7%) being divergent (stages 1 or 2). The degrees of contamination also varied with slightly more than half having no visible contamination at the time of reimplantation. There were considerable variations in the patterns of dry and wet storage. One hundred and four teeth (81.3%) had initial periods of dryness followed by periods of wet storage prior to reimplantation. Sixteen teeth (12.5%) were dry for varying periods of time and were reimplanted without wet storage. Eight teeth (6.3%) were immediately placed in a wet medium for varying periods of time prior to reimplantation The

**Table 1 Summary of variations in presentation and treatment factors for avulsed and reimplanted teeth.**

Factor	Median	Range
Stage of root development	Stage 4	Stages 1-5
Time dry	15 mins	4-52 mins
Time wet in mins	45 mins	0-650 mins
Splinting time	15 days	4-52 days
Pulp extirpation time	15 days	0-612 days
Time since reimplantation	5.1 years	2.1-13.3 years

median time for which the teeth were dry prior to reimplantation was 15 minutes and the median time for which the teeth were stored in a liquid medium was 45 minutes and there were wide ranges of values for both measures. As regards treatment methods, the median splinting time was 15 days and the median pulp extirpation time was also 15 days after reimplantation and again there were very large variations seen in both measures.

The relationship between the time the tooth was dry and the prevalence of root resorption is shown in Table 2. There was resorption in 51.4% of teeth when the period of dryness was less than or equal to 5 minutes and this rose to 76.9% for teeth with a dry period of 6-20 minutes and to 80% for those with a longer period. There was a significant relationship between the period of dryness and the prevalence of resorption (p=0.025). The relationship between the contamination status of the teeth and the prevalence of resorption is shown in Table 3. The lowest prevalence of resorption was seen in teeth with no visible contamination at the outset (57.1%) intermediate levels were seen for those that had visible contamination but were subsequently washed clean (75%) while higher levels were seen in those rubbed clean (87.5%) and the highest (100%) in those reimplanted with visible contamination still present. There was a statistically significant relationship between the degree of contamination and the prevalence of resorption (p=0.014). Table 4 shows the final logistic regression model with the presence of resorption set as the outcome variable. The two factors which emerged as being most related to the presence of resorption were the contamination status and the period of dryness prior to reimplantation. Teeth assessed as being contaminated were almost three times as likely to suffer resorption than uncontaminated teeth. An extra 10 minutes of dryness increased the probability of resorption by 29% while the effect of extending the period in wet storage was less marked. None of the other factors significantly affected the resorption outcome.

**Discussion**

One of the difficulties in many studies of avulsed and reimplanted incisors from a single centre is the restricted numbers in many reports, due to the relative rareness of these injuries. Many reports are based on less than fifty teeth and the vast majority include less than 100.<sup>11</sup> In the present study this problem has been overcome by the combination of the results from two centres using the same criteria. The considerable variations in both the presenting and treatment factors allowed us to make an examination of the effects of these on the prevalence of resorption. This is an option which may become less available as standardised clinical guidelines are more widely introduced and used.<sup>12</sup> It is difficult to strictly control the presenting factors such as periods of dryness and wet storage although increased education of the public should bring some improvements in this regard. Increasing use of guidelines may also lead to a more standardised management of contamination prior to reimplantation as well as pulpal extirpation times and durations of splinting. However the variations in the present study are helpful in investigating the factors which may affect resorption.

In the present study many cases were almost immediately reimplanted or put into a wet medium or had only a short period of dryness but there were also a significant number of cases where the

**Table 3 Relationship between the visible contamination status of the roots of reimplanted teeth and the subsequent prevalence of root resorption.**

Contamination	Resorption present	Resorption absent	Total
	N (%)	N (%)	N (%)
None	40 (57.1%)	30 (42.9%)	70 (100.0%)
Washed clean	33 (75.0%)	11 (25.0%)	44 (100.0%)
Rubbed clean*	7 (87.5%)	1 (12.5%)	8 (100.0%)
Not clean*	6 (100.0%)	0 (0.0%)	6 (100.0%)

$\chi^2 = 8.61$   
2df

p = 0.014

\* combined for statistical analysis

period of dryness was greater than 20 minutes. It has already been reported that the period of dryness is critically related to the chances of periodontal ligament healing and that immediate reimplantation within 5 minutes offered the best chance of success.<sup>1</sup> A delay as short as 8 minutes decreased the possibility of periodontal healing to less than 50%.<sup>1</sup> The findings of the present study indicate that the risk of resorption increases dramatically after 5 minutes of dryness while the increase after 20 minutes appears to be of a lower order. Therefore teeth stored dry for any appreciable time have a poorer prognosis and a very low rate of success for such teeth has been reported.<sup>13</sup> The regression analysis in the present study indicated that an additional 10 minutes of dryness increased the probability of resorption by 29% while the risk associated with extended periods of storage in a wet medium was of a lower order. It has been reported previously that the length of time the tooth spends out of the mouth significantly affects root resorption.<sup>14</sup> A more recent study found that teeth that were kept dry were significantly more likely to become resorbed while the total extra-alveolar time had less effect on the outcome.<sup>13</sup> This was confirmed by the results of the present study and the delay in reimplanting the tooth was less critical providing the tooth had been kept in a wet medium. Thus it appears that the ill effect of delayed reimplantation is mainly due to the drying of the tooth. In the circumstances in which these accidents happen it is easy to understand that some period of dryness may occur but every effort should be made to minimise this by storing the tooth in an available wet medium even as a temporary measure until placement in an optimal medium or reimplantation is possible.

There has been much attention paid to the irrigation of the socket and the removal of contaminated blood clot<sup>11</sup> and the effects of socket irrigation in dogs have been investigated.<sup>5,15</sup> There has been remarkably little attention paid to the role of contamination and cleaning of the root surface in reimplanted teeth. The present authors were unable to find any studies in humans on the effect of variations in this factor prior to reimplantation. The treatments recommended for contamination and their effects have not been tested in the clinical setting. It has been suggested that the tooth be placed in saline if there is visible contamination and that the tooth be rinsed in a continuous stream of saline until it is free of visible material. Alternatively if this is not effective, dirt can be carefully removed using gauze soaked in saline. In every case it is recommended that the socket be irrigated with saline and suction be used to remove contaminated clot.<sup>16</sup> In the present study because of some variability in the management of the contamination, it has been possible to examine the relationship between this factor and the subsequent prevalence of resorption. There was a steady increase in resorption with the least seen in cases without visible contamination, intermediate levels in those washed clean, higher levels in those which were rubbed or wiped clean and the highest in those not fully cleaned prior to reimplantation. In addition the regression analysis indicates that contaminated teeth are almost three times more likely to develop resorption, confirming the importance of this factor. The results of the present study confirms the advice on this issue contained in guidelines on the treatment of

**Table 4 Logistic regression analysis showing factors associated with resorption in reimplanted incisors. The presence or absence of resorption is set as the dependent variable and the prognostic factors are entered as independent variables.**

Prognostic factor	Odds ratio for resorption	95% confidence interval	
		Lower	Upper
Presence of contamination	2.99	1.09	8.20
Time dry (each additional 10 mins)	1.29	0.99	1.69
Time wet (each additional 10 mins)	1.11	0.90	1.42
Splinting time (each additional day)	1.08	0.95	1.24
Stage of root development (each increase in stage)	1.04	0.75	1.49
Time since reimplantation (each additional year)	1.03	0.99	1.09
Extirpation time (each additional day)	1.00	0.99	1.00

avulsed incisors<sup>11,12</sup> and this aspect may be worthy of increased emphasis in the future.

It has been recommended that the time of pulp extirpation be 1 week in most cases but that this be delayed for 2 or 3 weeks in cases where revascularisation is possible. It is said that the timing of extirpation and endodontic treatment is critical as the speed of root resorption can be very rapid especially in teeth with incomplete root formation. Mackie *et al.* could not establish a significant relationship between pulpal extirpation times and success in their study of 46 reimplanted teeth.<sup>13</sup> This aspect was also examined in the present somewhat larger study and again the effect of varying the timing of initiation of endodontic treatment could not be demonstrated.

It is suggested that prolonged periods of splinting may increase the risk of resorption and ankylosis<sup>1</sup> and the considerable variation in splinting times in the present study allowed us to demonstrate this effect, which occurred to a modest extent. The time since the reimplantation was included in the present study and its effect was not marked as the minimum follow up period for inclusion in the study was 2 years and the onset of resorption could be expected in most cases prior to the end of this period.

It was not possible to obtain reliable information on storage media and antibiotics in the present study, although these are likely to be important factors affecting the outcomes. The need to identify variables such as extra-oral periods and maturity of roots to determine treatment, has been identified.<sup>17</sup> In mature teeth with prolonged dry extra-alveolar periods the periodontal ligament is likely to be necrotic and resorption is inevitable. In these cases the tooth may be placed in a sodium fluoride solution prior to reimplantation in order to reduce the progression of resorption.<sup>1</sup> The use of tetracyclines as an anti-osteoclastic agent, has been reported to result in improved periodontal healing in experimentally reimplanted teeth in dogs<sup>18,19</sup> and the use of anti-inflammatory agents may also be a way forward in controlling the initial inflammatory response after attachment loss.<sup>20</sup>

Further reductions in the occurrence of root resorption could be obtained by educating all those involved about the necessity of rapidly placing the avulsed tooth in an appropriate medium in order to minimise drying of the root and concerning the correct management of contamination of the root. As clinical guidelines become more widely used, there will be less variation in the management of these injuries and paradoxically, research of the type presented here will become more difficult.

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