# Factors affecting treatment outcomes following complicated crown fractures managed in primary and secondary care

Jackson NG, Waterhouse PJ, Maguire A. Factors affecting treatment outcomes following complicated crown fractures managed in primary and secondary care. © Blackwell Munksgaard, 2006.

Abstract – The aims of this retrospective observational study were to determine the factors which affect treatment provision and the Median Survival Time (MST) for maintenance of tooth vitality following complicated crown fracture. The survey was carried out for patients treated at Newcastle Dental Hospital (NDH) according to departmental guidelines over a 2-year period following the introduction of a new protocol for management of these types of injuries. Seventy-three cases of complicated crown fracture were identified in 69 children with a mean age of 10.3 years (SD = 2.5 years). Seventy-one percent of the fractures occurred in males (M:F ratio was 2.5:1). Fifty-one percent of the complicated crown fractures were in immature teeth. Of the 73 traumatised teeth, 45% presented initially in general dental practice (GDP), 37% at the dental hospital and 8% at local accident and emergency departments with the remaining 10% seen at other or unrecorded locations. Of the 41 fractures, which presented initially at a location other than the dental hospital, 38% were referred to the dental hospital without the provision of an emergency pulp bandage. The overall definitive treatments provided for the 37 open apex teeth included pulp cap (19%), partial pulpotomy (32%), cervical pulpotomy (8%) and pulpectomy (35%), while for the 36 closed apex teeth it was pulp cap (28%), pulpotomy (11%), and pulpectomy (61%). Of the 30 teeth, which underwent vital pulp therapy (18 open and 12 closed apex), the MST for the 15 teeth treated with pulp caps was 1460 days (95% CI: 1067, 1853) while for the 15 teeth treated with pulpotomies it was 1375 days (95% CI: 964, 1786). There was no statistically significant difference in the MST between teeth treated with pulp caps and pulpotomies. In conclusion, the proportion of patients referred to secondary care with complicated crown fractures without provision of a pulp bandage is of some concern. More conservative treatment of closed apex teeth sustaining complicated crown fractures, utilizing vital pulp therapy techniques would appear to be appropriate.

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This paper is dedicated to the memory of its first author, Nick Jackson, who was tragically lost at sea in a diving accident off the Northumbrian Coast in June 2005, aged 25.

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Trauma to the anterior teeth remains a common occurrence in children in the UK. The latest UK National Child Dental Health Survey carried out in 1993 (1) found 17% of 15-year old had received trauma to their incisors, with a greater prevalence in boys (21%) than girls (12%).

Complicated crown fractures result in the exposure of the tooth's pulp to the oral environment. It has long been known that bacteria are the primary aetiological agents of pulp necrosis following a pulp fracture. Histological studies in monkey teeth have shown that the inflammation and associated bacterial invasion is usually contained within the superficial 2 mm of an exposed pulp (2). These animal studies demonstrated the efficiency of the inflammatory reaction in containing the bacterial insult within the periphery of the exposed pulpal tissue and this finding has been pivotal in the trend towards more conservative clinical treatment of traumatically exposed pulps (3, 4). These new approaches involve the removal of only the superficial area of inflamed pulp tissue, enabling the preservation of deeper remaining healthy, vital tissue.

Complicated crown fractures usually result in exposures that permit salivary rinsing and prevent impaction of contaminated debris (5, 6). However, bacterial contamination from plaque, contaminated debris over the exposed pulp or leakage of a deficient temporary restoration allows bacteria to settle in the pulp. Therefore, the provision of a well intentioned but ultimately poor quality temporary restoration over an exposed pulp may actively reduce the tooth's prognosis, emphasizing the importance of optimum treatment quality from the outset.

The key factor in determining prognosis after any form of pulp exposure is minimizing the bacterial invasion of the pulp (7). Therefore, provision of a hermetic seal over exposed pulps to minimise invasion by bacteria and the removal of infected pulpal tissue as soon as possible following the injury is critical.

At present, direct pulp capping usually involves the use of calcium hydroxide, but this acts only on bacteria on the pulp's surface (8). Animal studies have shown the success of calcium hydroxide pulp capping in primates to be reduced from 93 to 56% when microbial exposure increased from 1 h to 7 days (9). It follows that pulp-capping using calcium hydroxide will be most successful if carried out in the initial 24 h after pulpal exposure.

Cvek (10) found pulpotomies which remove the superficial area of infected pulp to have very high success rates, regardless of the size of the exposure or the time elapsed since injury, providing the pulp was previously healthy. Teeth with substantial treatment delay healed as well as teeth treated immediately (10), indicating that time since the injury, in itself, is not a contraindication to undertaking a pulpotomy.

Advances in pulpal treatments and improvements in materials have lead to improvements in prognosis following dental injuries (7, 10–15). These treatments are completely dependent on correct initial management of the patient and during the protracted periods of follow up that are often necessary. It is therefore crucial that the clinicians to whom these patients present are competent in at least the emergency management of dental trauma and able to provide appropriate follow up or, if necessary, refer to an appropriate specialist centre.

Removal of exposed pulps, which prior to trauma were healthy and symptom-free, may constitute overly aggressive management. A report produced as part of the Royal College of Surgeons (RCS) Clinical Guidelines (16) suggested that 92% of root treatments for permanent incisor teeth in children and adolescents were unsatisfactory. Reported success rates for completion of apexification in immature teeth, or the avoidance of periapical pathology following pulpectomies and subsequent root filling varies from 80 to 96% (7, 17). Pulpectomy is not an infallible treatment. It requires substantial treatment time and may compromise the tooth's strength, making it liable to further fractures. Previously, in cases of substantial coronal tooth structure loss, limitations in restorative materials and techniques may have required the use of full coverage crowns with anchorage in the root canal. Recent developments in composite materials mean this can now be avoided in many cases. Where possible, even in mature teeth, preservation of a healthy vital pulp should be regarded as the prime management objective and considered as 'Best Practice'.

Agreed standards and management protocols for complicated crown fractures are available (4). Management of dental trauma often crosses the primary and secondary care divide and effective communication is vital between different care providers responsible for the patient's treatment to ensure optimum provision of care.

The aims of this study were to determine the factors which affect treatment provision for patients and the Median Survival Time (MST) for tooth vitality following complicated crown fracture (involving the tooth pulp) for patients treated at Newcastle Dental Hospital (NDH) according to departmental guidelines between October 1998 and September 2000.

#### **Materials and methods**

A retrospective observational survey of all patients attending the department's Trauma Clinic with

complicated crown fractures between October 1998 and September 2000 was carried out. This time period followed the adoption of a new departmental treatment protocol for management of these injuries and provided a minimum of 2-year follow up for each injury identified. Ethical approval was not required. The hospital notes of each patient identified were assessed using a numerically coded data collection form.

The data collected include the following.

- General identification data including: hospital number, date of birth, gender, post code.
- Source of patient's referral.
- Date of trauma.
- Cause of trauma.
- Place of patient's initial presentation.
- Date of initial presentation.
- Date of presentation at the Dental Hospital.
- Tooth with complicated crown fracture.
- Grade of apexification of tooth.
- Other concomitant injuries to same tooth.
- Other associated non-dental injuries.
- Location of traumatic event.
- Other teeth injured in incident.
- Treatment at patients' initial presentation.
- Treatment at presentation at the Dental Hospital.
- Time from initial dressing to placement of definitive composite restoration.

The stage of root development at injury was determined from radiographs and graded on a one to five scale based on the classification described by Cvek (18). Since completion of root development was likely to occur between review appointments, the date for root end completion was recorded as the first date where a complete root was observed radiographically. Each individual case of a complicated crown fracture was considered separately.

A prepilot study was carried out to test the coding on the data collection sheet, identifying and eliminating any ambiguities in coding.

The data collection form was then piloted on ten sets of records (10% of the expected study population), selected by computer randomization. To measure reliability of the data recording, the patients' notes were assessed independently by two examiners. Inter-examiner agreement was then assessed using Kappa analysis.

In the main study, data collection was made by a single examiner (NJ). Intraexaminer reproducibility (internal consistency) was determined by reevaluating a randomly selected 10% sample of patient notes using the Kappa analysis.

Coded variables from the completed data entry forms were entered into a relational database (Microsoft Access Version 9.0).

The statistical programme SPSS (Version 10.0) was used for analysis of results. The MSTs for the

maintenance of tooth vitality were determined using the Kaplan–Meier technique.

#### Results

#### Demographic results

Seventy-three teeth with complicated crown fracture were identified in 69 children. The mean age of the patients was 10.3 years (SD = 2.5 years, range: 7.3–23.5 years) at the time of trauma with 52 (71%) of the 73 complicated crown fractures occurring in boys and 21 (29%) in girls.

Accidents (38%) and playing (19%) were the commonest cause of complicated crown fracture, with sports (15%) and bicycles (14%) accounting for the majority of the remaining fractured teeth. Six injuries (8%) were 'non-accidental' in origin, caused, for example, by fights. One injury (1%) was a result of a road traffic accident. The cause of injury was unrecorded for three cases (4%).

#### Accuracy of radiographic interpretation

Of the 73 teeth in the study, 37 (51%) were classed radiographically as immature with the remaining 36 (49%) classified as having completed root development (18).

The Cohen's Kappa score for inter-examiner agreement in radiographic determination of root development for 10% of the expected sample (10 teeth) was 0.84 (P < 0.001) i.e. the two examiners agreed for 9 of 10 teeth. This level of agreement was considered acceptable. When eight sets of records were reassessed for consistency in data collection on completion of the study, Cohen's Kappa for intra-examiner agreement was also acceptable at 0.81 (P < 0.001).

#### Initial management

Of the 73 teeth with complicated crown fracture managed in the department during the study period, 45% presented initially in General Dental Practice (GDP), 37% at NDH with eight percent presenting at Hospital Accident and Emergency departments (A&E) and three percent initially presenting in the Community Dental Service (CDS). The place of initial presentation was unrecorded in 7% of injuries (Fig. 1).

The type of treatment at the initial presentation of the patient was recorded. It was possible to determine treatment provision for all 27 fractured teeth when the patient presented initially to NDH. Where patients initially presented elsewhere the completeness of data available depended on information provided in referral forms and letters.



*Fig. 1.* Place of initial presentation of 73 cases of complicated crown fracture.

Data were available for 41 of the fractured teeth where initial presentation was at a location other than NDH, of these 15 (38%) were referred to NDH without provision of an emergency pulp bandage. Only one of the six cases presenting at A&E was provided with a pulp bandage before referral to the Dental Hospital. Of the 33 cases presenting initially at GDP, eight (24%) were referred to NDH without provision of an emergency bandage. The remaining two cases referred to NDH without provision of a bandage presented initially in the CDS.

Data were available for the time elapsed between injury occurring and the date of initial presentation for 49 fractured teeth. Twenty-one (43%) teeth were seen the same day that the injury occurred, while 43 (88%) were seen within 48 h of the injury. The mean time to presentation was 7 days (SD  $\pm$  37 days). The data were significantly skewed by the two outliers of 73 and 250 days before initial presentation. Removal of these outliers produced a mean time to presentation of 1 day (SD  $\pm$  1 day).

## Definitive coronal restoration

Definitive coronal restoration comprised composite in 59 cases although in seven teeth with a composite restoration a later need to extract the tooth superseded the original definitive treatment. There was substantial variability in the time taken to provide this definitive treatment: in 34% of cases definitive restoration was an initial treatment, but 22% of cases were left with a temporary bandage for over 6 months (Table 1).

#### Definitive pulpal treatment

Open apex and closed apex teeth were considered separately regarding definitive pulp treatment provision. The 37 teeth with a grade of apexification of four or less, according to Cvek's classification (18) at the time of initial presentation, were categorised as

Table 1. Time period from date of trauma to placement of definitive composite restoration for the 59 cases, where information was available

	No. of cases	%
Same day as initial presentation	20	34
<1 month	4	7
1–3 months	5	9
3–6 months	11	19
>6 months	13	22
Definitive treatment other than composite used (e.g. tooth crowned)	6	10
Total	59	100

'open apex', the 36 teeth graded five were classed as 'closed apex'.

Definitive pulp treatment provision was either pulp capping using calcium hydroxide, partial pulpotomy and complete pulpotomy or pulp extirpation. Dressings, which did not conform to these treatments, were classified as 'other dressings'.

The definitive pulp treatment of the 37 open apex teeth and 36 closed apex teeth with complicated crown fractures treated at NDH during the study period is described in Figs 2 and 3. These figures show the type of definitive treatment and where this was carried out. Injuries, which attended NDH initially, are shown separately from cases, which were referred to NDH from other care providers for definitive pulpal treatment to be undertaken.

## Outcomes of treatment

Of the 73 teeth in the study, eight were either lost to follow up after referral back to the GDP (six teeth) or the patient failing to reattend (two teeth). From the 65 teeth that were followed up, 12 remained vital at the time of the survey, representing a time period of between 2.6 and 9.1 years. The teeth remaining vital were treated by pulp capping or



Fig. 2. Definitive pulp treatment of 37 open apex teeth.



Fig. 3. Definitive pulp treatment of 36 closed apex teeth.

pulpotomies (partial or complete) (Fig. 4). Of these 12 vital teeth, seven had closed apices at the time of trauma. Nine of the cases remaining vital presented initially at NDH, three cases initially presented in GDP.

Seven teeth (10%) required extraction during the study. Four cases were provided with a partial denture as a means of replacement, two teeth were replaced with auto-transplantation and one with an osseo-integrated implant.

The Kaplan–Meier survival analysis was undertaken for the 30 (18 open apex, 12 closed apex) teeth that received vital pulp therapy as their definitive treatment. Due to the small sample size, open and closed apex teeth undergoing vital therapy were grouped together for survival analysis. This was considered feasible, as it has been demonstrated that healing rates following vital pulp therapy in open and closed apex teeth are comparable (19). Fifteen of these teeth received pulp-caps and 15 received pulpotomies. The MSTs for maintenance of tooth vitality are shown in Table 2. A survival plot of tooth vitality for teeth treated using vital pulp therapy is shown in Fig. 5.



Fig. 4. Maintenance of vitality related to treatment provided.

## Treatment outcomes following complicated crown fractures

Table 2. Median survival times [with standard error (SE) and 95% confidence intervals] for pulp vitality in 30 teeth (18 open apex and 12 closed apex)

	Median Survival time (days)	SE (days)	95% CI (days)
All 30 teeth undergoing vital pulp therapy	1375	71	1235–1515
15 teeth with pulp caps 7 open, 8 closed)	1460	200	1067–1853
15 teeth with pulpotomies (11 open, 4 closed)	1375	210	964–1786



*Fig. 5.* Loss of vitality over time for 30 teeth undergoing vital pulp therapy following complicated crown fracture (census date = date study carried out).

# Discussion

This study determined treatment provision for 69 patients with a mean age of 10.9 years seen in a Dental Hospital's Child Dental Health Department following complicated crown fracture.

# Demographic factors

The higher incidence of boys (71%) compared to girls (29%) presenting with complicated crown fractures correspond with other investigations, which have all indicated a higher prevalence of dental injuries in boys (1, 20–24). These differences can probably be related to boys' more active participation in games and sports and the generally rougher nature of their play.

The peak age incidence for complicated crown fracture in this study was 10-years for boys, with a more consistent age spread in girls. This is similar to other studies that show a peak incidence of trauma to the permanent dentition at 8–10 years in boys and a relatively stable incidence in girls throughout the age range (20, 25).

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# Initial management

The majority of complicated crown fractures, which were treated in NDH during the study period had presented initially to a GDP (45%). However, it was disappointing that only 43% of cases presented to their GDP on the same day as the injury occurred. This failure to present immediately may be due to patients being unaware of, or unable to access, out-of-hours emergency dental care facilities.

The quality of referral letters to the Dental Hospital from the health professional to which the patient initially presented was very variable. Often details of initial treatment provision were missing or inadequate. This lack of information can be problematic for the receiving clinician when the referred patient presents in a secondary care environment. These difficulties could be reduced through the use of a standardized trauma referral sheet (26). GDPs have stated their enthusiasm for such an aid in a questionnaire survey of GDPs in the northeast of England (27). Developments such as these could aid communication between primary and secondary care providers, both with crucial roles in the management of dental trauma.

Assessment of treatment provision at initial presentation showed that 59% of teeth had a delay of over 1 month before a composite bandage was placed. The remaining teeth were left with pulpal coverage that relied upon a dubious coronal seal. This was mainly due to the use of glass-ionomer cement as a pulp bandage even though the departmental management protocol advised the use of a bonded material to provide the initial pulp bandage.

The high incidence of cases of complicated crown fracture referred to NDH without the provision of a dressing over the exposed pulp is of concern. It is vital that, despite possible barriers to the provision of more extensive dental trauma treatment in primary dental care, all GDPs provide basic emergency treatment for dental trauma cases. Hospital accident and emergency departments (A&E) were poor at providing an initial bandage for these injuries, while an investigation of lay person knowledge of the provision of dental trauma emergency care in northwest England, showed that 11% of respondents would send a child with dental trauma to A&E (28). Given these beliefs, treatment provision in A&E departments for dental trauma could be improved, and the public educated in alternative resources for the emergency management of dental trauma such as out-of-hours dental services. The nature and priorities of A&E departments can make them unsuitable for the management of dental trauma. It follows therefore that, as an alternative, the availability of out-of-hours dental services and public knowledge of these resources should be improved.

#### Definitive treatment

For the teeth with open apices, the majority were provided with definitive pulp management in locations other than the Dental Hospital. Within this group 44% had their pulps extirpated, although this form of treatment does not reflect the more conservative approach advocated by current management guidelines (3, 4). However, it must be remembered that this study was conducted in a secondary care setting with many of the cases being referred due to management complications such as pulpal necrosis or pulp canal obliteration, which may have necessitated the extirpation of the pulp. It is therefore not appropriate to draw conclusions about management suitability in primary practice on the basis of this finding. A more detailed assessment of treatment provision in primary practice would be useful to determine treatment provision in this environment.

Open apex teeth treated initially at NDH were all provided with conservative definitive pulp therapy. All six open apex teeth treated by pulp extirpation at NDH had other associated signs and symptoms, which indicated pulp removal as a treatment. However, definitive pulp treatment for closed apex teeth was less conservative. Half of the closed apex teeth presenting initially to NDH were treated by pulp extirpation. It has been demonstrated that conservative management strategies in mature teeth can successfully preserve the pulp (19), and there may be a need to communicate the benefits of vital pulp therapy for mature teeth with complicated crown fractures to both primary and secondary care providers.

#### Outcomes of treatment

Long-term maintenance of vitality for teeth treated by pulp caps and pulpotomies in this study was poor in comparison with results reported by other authors (15, 29, 30–32). However, the majority of the subjects in the present study were referred from primary care, often due to treatment complications.

Figure 5 shows the pattern of loss of vitality of the teeth treated using vital pulp therapy over time. It is unclear what proportion of teeth losing vitality within the first 250 days could be attributed to elective extirpations following completion of root development.

Current consensus suggests that, where no evidence of pulpal pathology occurs, efforts should be made to preserve vital pulp tissue wherever possible. The 100% success rate of pulpotomies for closed apex teeth observed in the present study indicates the feasibility of adopting this management approach following complicated crown fracture.

#### Treatment outcomes following complicated crown fractures

The large MSTs in this study demonstrated the effectiveness of the vital therapy procedures.

When pulp capping and pulpotomies were compared as definitive pulp therapies in teeth with open and closed apices, no statistically significant difference was demonstrated between the use of pulp capping and pulpotomy. This is understandable considering the small sample size.

## Conclusions

The number of patients with complicated crown fractures referred to the dental hospital without provision of a pulp bandage by primary care providers represents a concern. Financial or time constraints should not limit provision of this basic emergency management in primary care.

Although there is some evidence that open apex teeth are being treated more conservatively, following trauma, there is increasing evidence to suggest that more conservative management of closed apex teeth would also be appropriate, where possible utilizing vital pulp therapy techniques.

#### References

- O'Brien M. Children's dental health in the United Kingdom 1993. Office of Population Statistics Census Surveys, Social Survey Division, London: HMSO; 1993
- Cvek M, Cleaton-Jones PE, Austin JC, Andreasen JO. Pulp reactions to exposure after experimental crown fractures or grinding in adult monkeys. J Endod 1982;8:391–7.
- Andreasen FM, Andreasen JO, Bakland LK, Flores MT. Traumatic Dental injuries; a manual. Copenhagen: Munksgaard; 1999.
- Flores MT, Andreasen JO, Bakland LK, Feiglin B, Gutmann JL, Oikarinen K et al. The International Association of Dental Traumatology. Guidelines for the evaluation and management of traumatic dental injuries. Dent Traumatol 2001;17:1–4.
- Cox CF, Bergenholtz G, Heys DR, Syed SA, Fitzgerald M, Heys RJ. Pulp capping of dental pulp mechanically exposed to oral microflora: a 1-2 year observation of wound healing in the monkey. J Oral Pathol 1985; 14:156–68.
- 6. Cvek M, Lundberg M. Histological appearance of pulps after exposure by a crown fracture, partial pulpotomy, and clinical diagnosis of healing. J Endod 1983;9:8–11.
- Andreasen JO, Andreasen FM. Textbook and Colour Atlas of Traumatic Injuries to the Teeth. Copenhagen: Mosby; 1994.
- Foreman PC, Barnes IE. Review of calcium hydroxide. Int Endod J 1990;23:283–97.
- Cox CF, Bergenholtz G, Fitzgerald M, Heys DR, Heys RJ, Avery JK et al. Capping of the dental pulp mechanically exposed to the oral microflora – a 5 week observation of wound healing in the monkey. J Oral Pathol 1982;11:327– 39.
- Cvek M. A clinical report on partial pulpotomy and capping with calcium hydroxide in permanent incisors with complicated crown fracture. J Endod 1978;4:232–7.

- Andreasen FM, Andreasen JO. Dental traumatology: quo vardis. Opening remarks at the second International Conference on Oral Trauma, Stokholm, Sweden. Endod Dent Traumatol 1990a;6:78–80.
- Andreasen FM, Andreasen JO. Treatment of traumatic dental injuries. Shift in strategy. Int J Technol Assess Health Care 1990b;6:588–602.
- Andreasen JO. Challenges in clinical dental traumatology. Endod Dent Traumatol 1985;1:45–55.
- 14. Andreasen JO. The paradoxes of dental traumatology (editorial). Int J Paediatr Dent 2000;10:181.
- Fuks AB, Cosack A, Klein H, Eidelman E. Partial pulpotomy as a treatment alternative for exposed pulps in crown-fractured permanent incisors. Endod Dent Traumatol 1987;3:100–2.
- Mackie IC. In national clinical guidelines for paediatric dentistry. UK: Royal College of Surgeons of England; 1997.
- Adenubi JO, Rule DC. Success rate for root fillings in young patients. A retrospective analysis of treated cases. Br Dent J 1976;141:237–41.
- Cvek M. Treatment of non-vital permanent incisors with calcium hydroxide. I. Follow-up of periapical repair and apical closure of immature roots. Odontologisk Revy 1972;23:27–44.
- Haskell EW, Stanley HR, Chellemi J, Stringfellow H. Direct pulp capping treatment: a long-term follow-up. J Am Dent Assoc 1978;97:607–12.
- Andreasen JO, Ravn JJ. Epidemiology of traumatic dental injuries to primary and permanent teeth in a Danish population sample. Int J Oral Surg 1972;1:235–9.
- Clarkson BH, Longhurst P, Sheiham A. The prevalence of injured anterior teeth in English school children and adults. J Int Assoc Dent Child 1973;4:21–4.
- Fosberg CM, Tedestam G. Etiological and predisposing factors related to traumatic injuries to permanent teeth. Swedish Dent J 1993;17:183–90.
- Holland T, O'Mullane D, Clarkson J, O'Hickey S, Whelton H. Trauma to permanent teeth of children, aged 8, 12 and 15 years, in Ireland. J Paediatr Dent 1988;4:13–6.
- Hunter ML, Hunter B, Kingdon A, Addy M, Dummer PM, Shaw WC. Traumatic injury to maxillary incisor teeth in a group of south Wales school children. Endod Dent Traumatol 1990;6:260–4.
- Ravn JJ. Dental injuries in Copenhagen school children, school years 1967–1972. Community Dent Oral Epidemiol 1974;2:231–45.
- 26. Jackson NG. An investigation into the management of dental trauma in primary and secondary care. BMedSci Thesis, University of Newcastle upon Tyne, 2003.
- Jackson NG, Waterhouse PJ, Maguire A. Management of dental trauma in primary care: A postal survey of General Dental Practitioners in northeast England. Br Dent J 2005;198:293–7.
- Hamilton FA, Hill FJ, Makie IC. Investigation of lay knowledge of the management of avulsed permanent incisors. Endod Dent Traumatol 1997;13:19–23.
- 29. Blanco L. Treatment of crown fractures with pulp exposure. Oral Surg Oral Med Oral Pathol 1996;82:564–67.
- Fuks AB, Bielak S, Chosak A. Clinical and radiographic assessment of direct pulp capping and pulpotomy in young permanent teeth. Pediatr Dent 1982;4:240–4.
- Gelbier MJ, Winter GB. Traumatised incisors treated by vital pulpotomy: a retrospective study. Br Dent J 1988;164:319–23.
- Hallet GEM, Porteous JR. Fractured incisors treated by vital pulpotomy: a report on 100 clinical cases. Br Dent J 1963;115:279–87.

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