Dental Traumatology 2004; 20: 327–333

DENTAL TRAUMATOLOGY

The cost of treating children and adolescents with injuries to their permanent incisors at a dental hospital in the United Kingdom

Wong FSL, Kolokotsa K. The cost of treating children and adolescents with injuries to their permanent incisors at a dental hospital in the United Kingdom. Dent Traumatol 2004; 20: 327–333. © Blackwell Munksgaard, 2004.

Abstract – The aim was to estimate the total cost, including the direct costs (outpatient costs) and indirect costs (missed working day) of treating children and adolescents with traumatic injuries to their incisors. Factors such as the number of treatment visits and the success of outcome were also investigated. The sample was taken from patients who attended the dental trauma clinic at a London teaching hospital between 1990 and 2001. Eighty-one patients, with 111 traumatized incisors were included in this study. The mean age was 9.9 (SD = 2.33) years and the male: female ratio was 3:2. The median number of visits and median treatment duration were eight visits and 21 months, respectively. Sixty-two per cent of the patients lived >5 miles and 25% lived >10 miles from the hospital; 44% of the patients had uncomplicated and 56% had complicated trauma to their incisors. Accidental falls, falls involving a second person, sport-related injuries and road accidents accounted for 30, 22, 22 and 17% of the total injuries. For uncomplicated trauma, 97% of the patients had a successful outcome but this was reduced to 58% for complicated trauma. The average total cost of treating a patient with one traumatic injury was £856. The best predictor for higher number of visits and unsuccessful outcome was complicated trauma with odd ratios of 4.5 and 24 (95% CI 1.5–13.7 and 2.9–194.2), respectively. It was concluded that the indirect cost was a considerably large proportion (39%) of the total cost. More specialists in paediatric dentistry are needed to improve access to care locally and thus reducing the indirect travelling cost.

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Key words: tooth injuries; cost; dental visits; distance; trauma severity

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Accepted 18 December, 2003

Traumatic dental injuries in children are a serious public health problem. The 1993 Children's Dental Health survey in the UK (1) showed that one in five children experienced dental injuries to their permanent anterior teeth before leaving school. The management of the injuries is often a challenge to the dentist and may involve a lengthy treatment plan including apexification of immature apex or management of progressive resorption. For the patients, apart from the emotional stress, they may have pain and discomfort relating to the injury. For the parents or carers, they may have to give up their

usual commitment in order to take the child to receive treatment.

A review of the literature on dental trauma revealed that there is a wealth of knowledge relating to its prevalence (1–4), classifications (5–8), aetiology and associated factors (9–13), treatment and outcome (14–18). A few studies reported the number of visits and duration of treatment time, but these were mainly related to treating non-vital immature teeth with apexification technique to induce apical barrier formation. There are very few studies investigating the financial cost of treating these children. Glendor et al. reported that apart from clinical time spent by dentist treating the patient (direct time), non-clinical time spent by the patients and carers in transport and waiting (indirect time) should also be included to reflect the true societal cost for the management of traumatic dental injuries (19). A subsequent study (20) showed that the average indirect cost for managing traumatized permanent teeth in Sweden was SEK 1286 (*c.* £100; £1 = SEK 13 in 2003). However, for patients with uncomplicated trauma, 35% only required one dental visit and 26% needed two dental visits (11). From the number of visits, it is possible to calculate the number of missed working days for the carers as an estimation of the indirect cost for a trauma episode. Hence, in this study, the aims were to investigate the number of dental visits for children attending the trauma clinic at a UK dental teaching hospital following traumatic injuries to their permanent incisors, and to ascertain the factors that may influence the number of visits. An estimation of the cost of treating these patients following the trauma episode would be calculated based on the number of visits.

Materials and methods

The clinical records of patients who attended the dental trauma clinic at the Dental Hospital of The Royal London Hospital, Barts and The London NHS Trust, between 1990 and 2001 were inspected. Only records of patients that fulfilled the criteria listed in Table 1 were included in this study. Information was extracted from the selected records and the data (Table 2) were collected and transferred to a personal computer for analysis using SPSS 11.5 for Windows. Distance travelled to the Royal London Hospital was calculated using the patients' residential postal codes and a web-based route planner software (http://www.theaa.com). For those patients who had their teeth extracted, the date when the tooth was extracted was recorded as the final treatment date. Subsequent visits for prosthetic replacement were not included in the counting of treatment visits. For patient who sustained a subsequent second injury, the final treatment date was the date of treatment visit just prior to the second accident. The duration of treatment time was calculated from the date of initial presentation to the final treatment date. The number of visits included all the visits that the patients attended for treatment of the injured teeth within this period. The visits that the patient attended for other treatment such as oral hygiene instruction or treatment of other teeth were excluded. To investigate the relationship between variables, chi-square or Fisher's exact tests were used and $P < 0.05$ was taken as being statistically significant. To ascertain the factors that had an influence on the number of treatment visits, logistic regression methods were used to calculate the odds ratios and their 95% confidence intervals.

Table 1. Clinical record selection criteria

The clinical record was selected if the patient:
- had trauma injuries on at least one of the permanent upper central incisors;
- was discharged from dental trauma clinic after all treatment was completed;
- was under annual review only;
- had or was planned to have the traumatized tooth extracted;
- had attended at least 15 visits but treatment was not completed;
- had a second injury during the treatment/observation period of initial injury.

Table 2. Data collection information

The following data were collected from the clinical record for each patient:
- personal details;
- place of residence;
- age at the time of trauma;
- cause of injury;
- location where trauma occurred;
- date of the trauma;
- traumatized tooth type;
- type of dental injury [classified according to Andreasen (6)];
- the final treatment date – this was defined as the date when the patient was discharged, or had the final definitive treatment, or the date of the last visit in the record;
- root development at the time of trauma – this was assessed from radiographs taken at the time of trauma (if available) and was grouped as having convergent, parallel divergent root canal wall;
- outcome of the treatment;
- number of visits to the dental hospital – this was counted from the initial presentation following the trauma to the final treatment date.

Results

The records of 81 patients fulfilled the selection criteria and were included in this study. In these patients, 111 upper incisors were traumatized. Sixty-six teeth had only hard tissue injury, 31 had only periodontal injury and 14 had a combination of both injuries. In order to maintain an individual as the unit for the analysis, especially for calculation of number of visits, only one tooth per patient was

chosen from the data. If a patient had more than one damaged tooth, the tooth that required the highest number of treatment visits was chosen. When the damaged teeth required equal number of treatment visits, a random number table was used to choose only one tooth for the analysis.

Age and sex

The ages of the patients at the time of injury ranged from 7 to 18 years. The mean was 9.9 (SD = 2.33) years and the median was 9 years. There were 50 males and 31 females with a male:female ratio of 3:2.

Number of visits

The patients attended three to 27 visits for treatment with a mean of 10.4 (SD = 5.78). The median was eight visits and 25% of the patients had to attend more than 14 visits (Fig. 1).

Treatment duration

The mean treatment time was 24.6 (SD = 18.78) months and the median was 21 months. The treatment duration for 25% of the patients was longer than 36 months. One patient attended for 81 months due to an intrusive injury of an incisor with divergent apical opening. This tooth was eventually extracted because of replacement resorption. A composite chart (Fig. 2) showed that the number of visits is correlated to the length of treatment time ($P < 0.001$).

Distance of travel

The mean distance that the patients had to travel for treatment was 8.8 (SD = 7.6) miles. The median

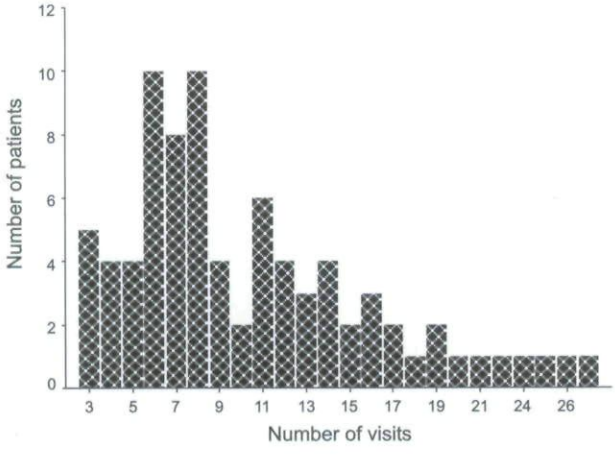

Fig. 1. Histogram of number of visits that patients had to attend for treatment.

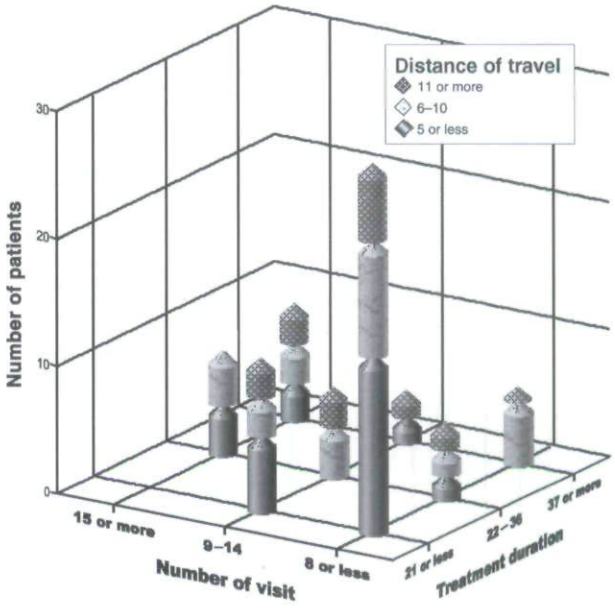

Fig. 2. Composite chart showing patient's number of visit, distance of travel and duration of treatment.

was 7 miles and 25% of the patient had to travel more than 10 miles to receive treatment (Fig. 3). The longest distance that a patient had to travel was 42 miles. Figure 2 showed that the travelling distance is not related to the number of visits or the duration of treatment. Eleven patients (14%) who lived more than 10 miles away attended the hospital for more than eight visits for treatment.

Cause of injury

The main cause of injury was accidental falls, which accounted for 30% of the total injuries. Sport-related injuries (excluding bicycle accident which was included in the road accident) and falls that involved a second person, e.g. playing hide-and-seek, chasing after one another, or play-fight, had equal frequencies of 22%. Road accidents (including bicycle accident) and assaults accounted

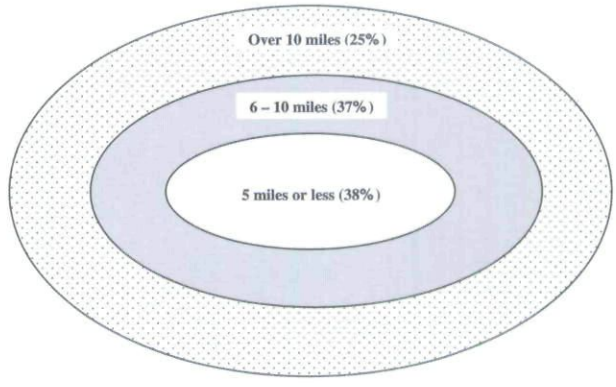

Fig. 3. Distance of travel.115.9817mm.

for 17 and 5% of the total injuries, respectively. The cause for a small percentage (4%) of the injuries could not be ascertained from the records. When grouping the causes of the injuries according to sex (Fig. 4), more boys seemed to have more accidents that involved a second person such as falls involving others, sports or assaults, whereas there was a higher percentage of girls whose injuries appeared to be purely accidental (accidental falls or road accident). However, the difference was not statistically significant ($P = 0.07$, Table 3).

Type of injury

Fifty-two (64%) patients had hard tissue injuries only, 20 (25%) patients had periodontal injuries only, and nine (11%) had a combination of both injuries in their upper incisors. The types of hard tissue and periodontal injuries were shown in Figs 5 and 6. A majority (62%) suffered from simple supragingival crown fracture but 26% suffered from severe periodontal injury such as intrusion and avulsion.

The types of injuries can be grouped into uncomplicated and complicated trauma according to Glendor et al. (21). The uncomplicated trauma included hard tissue injury that had no pulpal exposure and periodontal injury that did not have severe dislocation of tooth (concussion and subluxation). The complicated trauma included hard tissue injury that had pulpal exposure and periodontal injury that had severe dislocation of the tooth from its socket (intrusion, extrusion, avulsion and lateral luxation). In this study, when the patient had both periodontal and hard tissue injuries, the more severe injury was used for the grouping. It was found that 36 (44%) patients had uncomplicated trauma and 45 (56%) patients had complicated trauma.

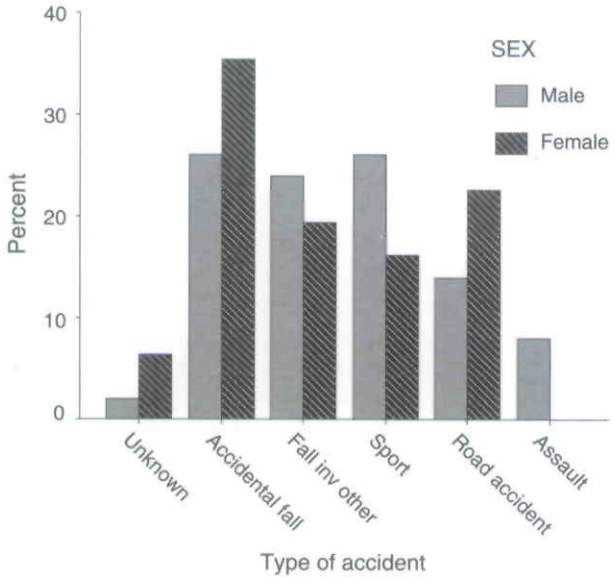

Fig. 4. Causes of injuries according to sex.

Table 3. Sex vs. cause of injury

	Falls involving others/sport/assault	Accidental falls/road accident	Total	*P*-value
Male	29	20	49	0.07
Female	11	18	29	
Total	40	38	78	

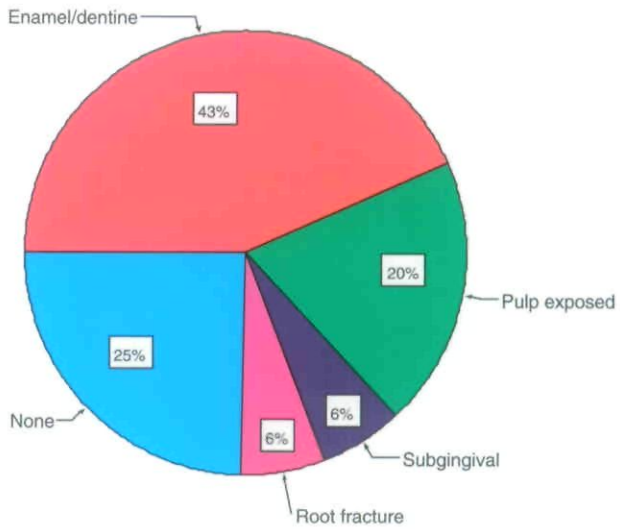

Fig. 5. Type of hard tissue injuries.

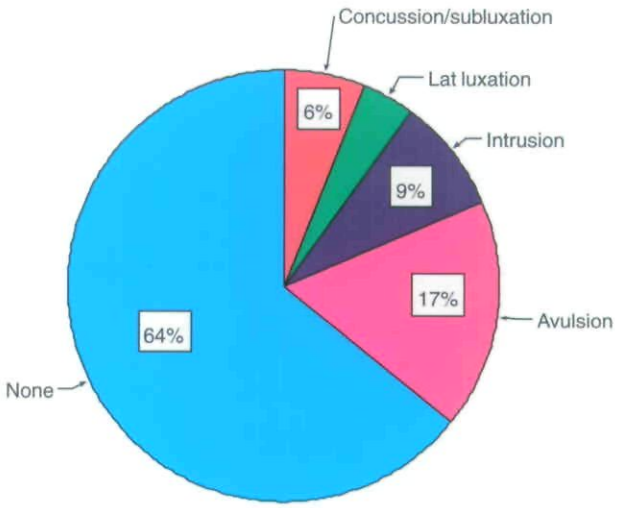

Fig. 6. Type of periodontal injury.

Root development

Forty-eight per cent of the patients had converging root apices, and 26 and 12% had parallel and

diverging root canal walls, respectively. Fourteen per cent of the patients did not have radiographs at the time of the injuries, so their root development could not be assessed. The root development corresponded well with the patient's age as 28% of the patients were below 8 years old and 50% were below 10 years.

Outcome of treatment

The outcome of the injured teeth is summarized in Table 4. Forty per cent of the patients had vital pulps after treatment. Root fillings were carried out in 28% of the patients but 11% of the teeth were extracted. When pulp survival and completed root canal treatment were considered as successful outcome and extraction or plan for extraction as unsuccessful outcome, the success rate of the patients treated was 68%.

Influencing factors on the number of visits

Using the median, the number of visits was dichotomized into those who attended eight visits or less and those who attended more than eight visits. The factors that may have an influence on a prolonged number of visits are summarized in Table 5. Severity of the trauma and the outcome had a significant influence on the number of visits, but root development and the cause of the accident did not prolong the number of visit significantly. However, the table showed that there might be a trend for those who had road accident to need more visits.

When the significant factors were included in the logistic regression models, the bivariate analysis showed that the odds ratios for complicated trauma and successful outcome were 5.2 and 4.9, respectively (Table 6) in prolonging the treatment to more than eight visits. However, when multivariate analysis was used, only the severity had a significant influence on the number of visits with an odds ratio of 4.5 (Table 6).

Influencing factors on outcome

Table 7 showed that the only factor that had a significant influence on the success of treatment was the severity of trauma. The risk for a patient with complicated trauma to have an unsuccessful outcome was 24 (95% CI 2.9–194.2, $P = 0.03$) times compared with the patients with uncomplicated injury. The outcome success was shown not to be dependant on the patient's age, the root development and the cause of the injury.

Estimation of cost

The mean distance that a patient had to travel was 8.8 miles. Considering the time taken on a return journey to travel this distance in London, and the time spent in the hospital (treatment and waiting time), it can be assumed that the parent/carer would have to take half a day off work to accompany the child to receive treatment. The

Table 4. Outcome of treatment

Outcome	No. of patients (%)	Success (%)
Pulp survived	32 (40)	Successful (68)
Completed RCT	23 (28)	
Teeth planned for extraction)	8 (10)	Unsuccessful (21)
Teeth extracted	9 (11)	
Dressing with $Ca(OH)_2$	3 (4)	Unknown (11)
Second injury	6 (7)	
Total	81 (100)	

Table 5. Influencing factors on the number of visits

Influencing factors	Number of visits: 8 visits or less	>8 visits	Total	*P*-value
Severity				0.001
Uncomplicated	26	10	36	
Complicated	15	30	45	
Root development				0.470
Convergent	18	21	39	
Parallel or divergent	17	14	31	
Outcome				0.009
Successful	33	22	55	
Unsuccessful	4	13	17	
Cause of accident				0.07
Non-road	37	30	67	
Road	4	10	14	

Table 6. Bivariate and multivariate analyses of the influencing factors on number of visits

	Bivariate			Multivariate		
	Odds ratio	95% CI	*P*-value	Odds ratio	95% CI	*P*-value
Severity	5.2	2.0–13.5	0.001	4.5	1.5–13.7	0.008
Outcome	4.9	1.4–16.9	0.013	2.3	0.6–9.2	0.233

Table 7. Influencing factors of outcome

	Successful	Unsuccessful	*P*-value
Age group			0.273
9 years or less	31	7	
>9 years	24	10	
Root development			0.592
Convergent	27	9	
Parallel or divergent	21	5	
Causes of accident			0.107
Non-road	48	12	
Road	7	5	
Severity of trauma			<0.001
Uncomplicated	33	1	
Complicated	22	16	

weekly average earnings of a full-time employee in Britain was £420 in 2000 (22), therefore, the earnings for one half day would be £42 assuming five working days per week. The average outpatient cost in the dental hospital was about £65 per visit in 1999/2000 (23). Hence, the average cost for treating a patient with a traumatic incisor would be £856 using the median of eight visits per patient. This estimation did not include travelling cost and other expenses that the parent/carer might incur due to the absence in work or at home.

Discussion

Treating dental injuries is a complex problem in the management of health care in children and adolescents because their parents, carers and sometimes the whole family might be involved. This study showed that the average cost for treating a young patient with a dental injury was £856. This was a rough estimate because we used the averages of number of visits, outpatient cost and loss of working days to calculate the costs. The cost of transport, medicine, disturbance to home life, other dental visits outside the hospital and further long-term treatment after discharge were not included. Hence, this cost could be considered as an under-estimation of the actual cost for providing care for a child who had an injury to the permanent incisor. The only other study found in the literature for comparison was a 2-year prospective Swedish study (20). They reported that the total cost for treating dental injury to permanent teeth was SEK 4569 (*c.* £350) but their follow-up time was less than that of this study (maximum follow-up time – 81 months). In the USA, it has been estimated that the lifetime rehabilitation treatment cost (i.e. direct cost) was US$15 000 (*c.* £9000; £1 = US$1.65) per tooth for loss of permanent teeth in children (24).

This study highlights that the indirect cost was 39% of the total cost. The Swedish study (20) showed that the indirect cost was 28% of the total cost but they included the cost of the loss of property, medicine and transport in the direct cost. When these components were excluded, the indirect cost increased to 30% of the total cost. The high proportion of indirect cost in this study might be due a comparatively lower cost of a dental visit in the UK.

The results showed that the mean number of visits was 10.4 and complicated trauma increased the risk of attending more than eight visits by 4.5-folds. The influence of the severity of injuries on number of visits is in agreement with Glendor et al. (20) who found that mean numbers of visits for uncomplicated and complicated trauma were 4.1 and 8.9 visits, respectively. In a cohort of 16-year olds, the mean number of visits was 3.4 for those with injuries to their permanent teeth (25). The higher number of visits in this study might be attributed to the clinical protocol to review the vitalities of the injured teeth at 1, 3, 6 and 12 months. The other main reason was attributed to the three monthly change of calcium hydroxide dressing to promote an apical barrier formation prior to obturation of the canal. This apexification technique is highly successful (93%) but can take as long as 122 months over several visits (26). Craig et al. (26) reported that the mean number of visits was five with a mean treatment duration of 31 months. However, other authors reported that shorter apical closure time of 6 months over three visits (17) and 8 months over 1.9 visits (27) could be achieved. The longer treatment duration in our study (mean =24.6 months) could be attributed to the dental trauma clinic being a teaching clinic, therefore, the treatment could be carried out by undergraduate or postgraduate students, or junior hospital staff under the supervision of a consultant. In addition, this study included the visits for root canal obturations, crown build-ups and long-term reviews of teeth with replacement resorption but not ready to be extracted. New endodontic technique using mineral trioxide aggregate for sealing immature apex show promise and may help to reduce the number of visits in the future, thus reducing the indirect cost to the parent/carer.

The Royal London Hospital is a major referral centre for dental trauma and the patients were not deterred by the distance they had to travel in order to receive treatment (Fig. 2). For the 25% of the patients who lived more than 10 miles away, the loss of working day might increase to one full day per visit if the appointments were not in the early part of the morning. Hence, more specialists who are competent in treating dental trauma should be available locally in order to reduce the indirect cost, especially for patients who only had uncomplicated trauma as 97% could be treated successfully.

Conclusion

The estimated total (direct and indirect) cost for treating a child or adolescent with injury to one or more anterior teeth at a dental hospital was £856 excluding long-term follow up. The main influencing factor on both the number of visits and the successful outcome was the severity of the injury. For uncomplicated trauma, 97% could be treated successfully but this rate was reduced to 58% for complicated trauma. In order to reduce the indirect cost, which accounted for 39% of the total cost, more specialists are needed to provide access to treatment locally to where the patients live.

Acknowledgements – The authors wish to thank Dr J. Fearne and Professor W. Marcenes of Barts and The London Queen Mary's School of Medicine and Dentistry for their help and advice for this study.

References

1. O'Brien M. Children's Dental Health in the United Kingdom 1993. Office of population censuses and surveys. London: Her Majesty's Stationary Office; 1994.
2. Andreasen JO, Andreasen FM. Classification, etiology and epidemiology of traumatic dental injuries. In: Andreasen JO, Andreasen FM, eds. Textbook and Color Atlas of Traumatic Injuries to the Teeth. 3rd edn. Copenhagen: Munksgaard; 1994; pp. 151–155.
3. Hamilton FA, Hill FJ, Holloway PJ. An investigation of dento-alveolar trauma and its treatment in an adolescent population. Part 1: The prevalence and incidence of injuries and the extent and adequacy of treatment received. Br Dent J 1997;182:91–5.
4. Bastone E, Freer T, McNamara J. Epidemiology of dental trauma: a review of the literature. Aust Dent J 2000;45:2–9.
5. Ellis RG. The classification and treatment of injuries to the teeth of children, 5th edn. Chicago: Year Book Medical Publishers; 1970.
6. Andreasen JO. Traumatic injuries of the teeth. 2nd edn. Copenhagen: Munksgaard; 1981.
7. Garcia-Godoy F. A classification for traumatic injuries to primary and permanent teeth. J Pedod 1981;5:295–7.
8. Cortes MIS. Traumatic injury to permanent teeth in Brazilian children, PhD thesis. London: Department of Epidemiology and Public Health, University College London, University of London; 2001.
9. Stockwell AJ. Incidence of dental trauma in the Western Australian School Dental service. Community Dent Oral Epidemiol 1988;16:294–8.
10. Forsberg CM, Tedestam G. Traumatic injuries to teeth in Swedish children living in an urban area. Swed Dent J 1990;14:115–22.
11. Josefsson E, Karlander E. Traumatic injuries to permanent teeth among Swedish school children living in a rural area. Swed Dent J 1994;18:87–94.
12. Burden DJ. An investigation of the association between over jet size, lip coverage, and traumatic injury to maxillary incisors. Eur J Orthod 1995;17:513–7.
13. Marcenes W, Murray S. Social deprivation and traumatic dental injuries among 14-year-old schoolchildren in Newham, London. Dent Traumatol 2001;17:17–21.
14. Andreasen FM, Vestergaard-Pedersen B. Prognosis of luxated permanent teeth – the development of pulp necrosis. Endod Dent Traumatol 1985;1:207–20.
15. Hayrinen-Immonen R, Sane J, Perkki K, Malmstrom M. A six year follow up study of sports related dental injuries in children and adolescents. Endod Dent Traumatol 1990;6:208–12.
16. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 1. Diagnosis of healing complications; 2. Factors related to pulpal healing; 4. Factors related to periodontal ligament healing. Endod Dent Traumatol 1995;11:51–78.
17. Mackie I, Bentley E, Worthington H. The closure of open apices in non vital immature incisor teeth. Br Dent J 1988;165:169–73.
18. Welbury R, Kinirons M, Day P, Humphreys K, Gregg T. Outcomes for root fractured permanent incisors: a retrospective study. Pediatr Dent 2002;24:98–101.
19. Glendor U, Halling A, Bodin L, Andersson L, Nygren A, Karlsson G et al. Direct and indirect time spent on care of dental trauma: a 2 year prospective study of children and adolescents. Endod Dent Traumatol 2000;16:16–23.
20. Glendor U, Jonsson D, Halling A, Lindqvist K. Direct and indirect costs of dental trauma in Sweden: a 2-year prospective study of children and adolescents. Community Dent Oral Epidemiol 2001;29:150–60.
21. Glendor U, Halling A, Andersson L, Eilert-Petersson E. Incidence of traumatic tooth injuries in children and adolescents in the county of Vastmanland, Sweden. Swed Dent J 1996;20:15–28.
22. Revision to New Earnings Survey. National statistics, London; 2000. Available at: http://www.statistics.gov.uk/pdfdir/nes1201.pdf.
23. National Purchasing Unit Dental SIFT Accountability Report. Sheffield, UK: National Purchasing Unit for Dental SIFT; 1999/2000.
24. McTigue DJ. Diagnosis and management of dental injuries in children. Pediatr Clin N Am 2000;47:1067–84.
25. Borssen E, Kallestal C, Holm AK. Treatment time of traumatic dental injuries in a cohort of 16-year-olds in northern Sweden. Acta Odontol Scand 2002;60:265–70.
26. Craig S, Rana K, Rodd H. Apical barrier formation: how many more visits? Int J Paediatr Dent 2001;11:392–3 (abstract).
27. Finucane D, Kinirons MJ. Non-vital immature permanent incisors: factors that may influence treatment outcome. Endod Dent Traumatol 1999;15:273–7.