Treatment time of traumatic dental injuries in a cohort of 16-year-olds in northern Sweden

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The aim of the present study was to account for treatment time and number of visits required for treatment of traumatic dental injuries in a cohort of 16-year-olds, born in 1975, and residing in the county of Västerbotten, Sweden, and to analyze the correlation between total treatment time and background factors. The study material comprised 1012 dental records from the Public Dental Health Service containing information on dental injuries to primary and/or permanent incisors or canines. The mean total treatment time per individual was 1.3 h, with a range of 0.1 to 27.5 h. For injuries to the primary dentition, the mean number of visits per individual was 2.2. One visit was sufficient in 21% of the trauma episodes. In the permanent dentition, each trauma episode required a mean of 3.4 visits, and 90% of the patients had to return for follow-up visits. The correlation between explanatory variables and total treatment time was described and analyzed by linear multiple regression analyses. Degree of severity and number of injured teeth were two parameters of major significance to treatment time. Treatment by a specialist had an impact on time in the permanent but not in the primary dentition. In the permanent dentition, the treatment time increased if the dental injury occurred before the age of 11 years. Treatment time was not dependent on where the clinic was located or on gender of the injured child. Different diagnoses could explain 33% of the variation in treatment time in the permanent dentition. □ *Dental trauma; permanent dentition; primary dentition; regression analysis*

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Physical injuries are common in childhood and adolescence. In Sweden, at least 150,000 accidents are registered yearly (1). The reason why children more than adults are exposed to trauma is probably due to their inability to evaluate dangerous situations in their physical activity. Further, small children lack fully developed physical coordination.

In a study performed during a 1-year period in a Swedish county (2), oral injuries caused by trauma accounted for 5% of all registered injuries among patients who visited a physician or dentist for consultation and treatment. In pre-schoolers, oral injuries were the second most common of the physical injuries. Oral injuries were dominated by dental injuries, followed by oral soft tissue injuries and injuries to the jaw bone.

In a retrospective study (3) of the prevalence and yearly incidence of traumatic tooth injury in a cohort of 16-year-olds in northern Sweden, 35% of the children had, on one or more occasions, sustained injury to their primary or permanent teeth. The frequency of injuries was nearly twice as high for boys as for girls. Traumatic dental injuries were most frequent when the children were about 4 years old and between the ages of 8 and 10. In the primary dentition, the majority of dental injuries had affected the supporting tissues, while in the permanent dentition fractures of varying severity constituted 60% of all registered diagnoses. The type of dental injuries considered to be most prone to later complications included intrusive and extrusive luxation, lateral luxation and avulsion. These represented less than 3% of the total number of injuries to the permanent teeth.

The treatment of dental injuries often involves many visits to the child's regular dentist and/or a specialist. Glendor et al. (4) calculated treatment time retrospectively in a selected sample of Danish children and adolescents born in 1970. Permanent teeth with uncomplicated trauma required on average 9.2 visits or a mean of 3.2 h of treatment time, while the most extensive treatment time per individual was found for children and adolescents who suffered complicated trauma to permanent teeth (8.5 h).

Josefsson & Lilja Karlander (5) carried out a cross-sectional investigation of traumatized permanent teeth in children between 7 and 17 years living in a rural area in southern Sweden, and found that the mean treatment time was 74 min for each dental incident, and in more than one-third of the cases only one dental visit was required.

On analyzing the time spent on treatment of dental injuries in 1098 Norwegians, aged 6–18 years, during a 1-year period, Solli et al. (6) reported a mean treatment time of 51 min per individual.

In all of the above studies it is concluded that degree of severity is of great importance to treatment time, but there are few data available on the relation between specific diagnosis and treatment time. The aim of the present study was to account for treatment time and number of visits required for treatment of traumatic dental injuries and to analyze the association between total treatment time and background factors.

Table 1. Registered diagnoses on individual level in the primary and permanent dentition

Diagnosis	Primary dentition ($n = 600$)	Permanent dentition ($n = 575$)
Infraction	3	14
Uncomplicated crown fracture	29	331
Complicated crown fracture	5	8
Uncomplicated crown-root fracture	0	3
Complicated crown-root fracture	0	5
Root fracture	10	8
Concussion	12	42
Subluxation	267	71
Extrusive luxation	21	5
Lateral luxation	31	10
Intrusive luxation	56	3
Combination crown fracture/luxation	4	45
Avulsion	44	4
Injuries to the gingiva or oral mucosa	5	7
Fracture of alveolar process	1	0
Unknown	112	19

Materials and methods

The material comprised 3007 dental records of 16-year-olds, born in 1975, residing in the county of Västerbotten, which constitutes 91% of the total number of 16-year-olds in this age cohort. More detailed information on the material has been given in a previous paper (3). About 35% of the teenagers were residing in a community with more than 100,000 inhabitants, and the rest in small communities in the county. They are probably representative of most Swedish teenagers living in rural areas.

The 3007 records, including all radiographs related to dental injuries, were carefully read by one of the authors (EB), and all information regarding any kind of dental injury was transferred to the computer. Information on emergency treatment in the University Hospital or referral to a specialist clinic for treatment was also included.

Treatment time was given in notes made by the dentists. This was accurately recorded, probably because Swedish dentists by that time were paid on a fee-for-service basis, and the notes in the records were used to calculate the dentist's monthly remuneration.

Of the 3007 dental records, 1040 contained information on dental injuries. Twenty-eight records were excluded for various reasons. The final material therefore comprised the dental records of 1012 16-year-olds who had sustained trauma to primary and/or permanent incisors or canines, a total of 1352 tooth injury episodes. The registered diagnoses per individual are given in Table 1. Classification on the individual level was determined by the most complicated diagnosis.

Statistical methods

The relation between explanatory variables and total treatment time per individual in the primary and permanent dentition, i.e. the outcome variables, was analyzed by linear multiple regression analysis. The outcome variables were skewed and therefore transformed to logarithmic values before the analyses. Explanatory variables were: location of the clinic (urban, rural area); gender; age at the time of injury (6–10 years, 11–16 years); treatment performed by a specialist (yes, no); degree of severity (uncomplicated versus complicated trauma as defined by Glendor et al. (7) with the modification that a combined crown fracture and luxation injury was classified as a complicated trauma—injuries with unknown diagnoses were classified as uncomplicated trauma); number of injured teeth (1 tooth injured, 2 or more teeth injured).

After screening each set of explanatory variables by univariate regression analyses, some were excluded as they showed no association with the outcome variable. The remaining explanatory variables were included in a multiple regression model analysis. The same method was used for type of injury, diagnoses according to ICD-DA WHO (8). The significance level was set to $P < 0.05$. All calculation was done with SPSS 10.0.

Results

Number of visits

For injuries in the *primary dentition* the mean number of visits per individual was 2.2 (range 0–12). One dental visit was sufficient in 21% of the trauma episodes. In the *permanent dentition*, each trauma episode required a mean of 3.4 visits with a range of 1 to 34 visits, and 90% of the patients needed to return for follow-up visits. The mean number of visits per individual in the permanent dentition was 4.1 (range 1–41). These figures include visits for specialized dental care except for orthodontic treatment.

Treatment time

The mean total treatment time per individual was 1.3 h, with a range of 0.1 to 27.5 h (median 0.7 h). Total treatment time related to gender is shown in Fig. 1. Of children with a treatment time exceeding 5 h, 22 out of 38 were girls. Mean treatment time per individual in the *primary dentition* was 0.6 h, with a range of 0.1 to 4 h. Treatment time and gender distribution are given in Table 2. Children with a treatment time exceeding 2 h were all under the age of 4. In this group, boys were highly predominant. The mean treatment time per injury episode was 0.5 h.

In the *permanent dentition* the mean treatment time was 1.6 h per individual and 1.4 h per injury episode, with a range of 0.3 to 27.5 h. Six percent of these children had a treatment time of more than 5 h. The treatment time per child and gender distribution are given in Table 3.

Children ($n = 42$) treated by their regular dentist as well as by a specialist had a mean treatment time of 8 h,

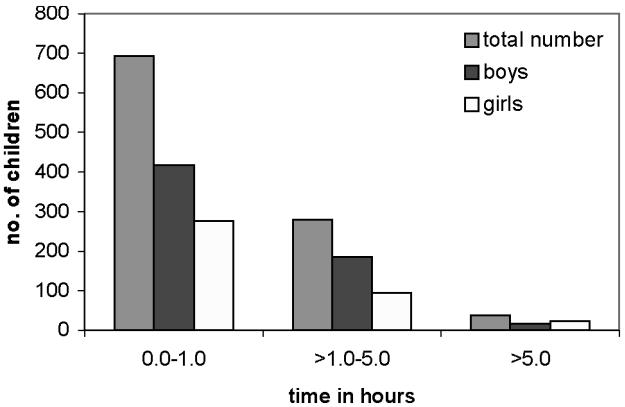

Fig. 1. Total treatment time for children with traumatic dental injuries related to gender.

indicating severe dental injury requiring complex treatment.

Treatment time in relation to diagnoses

In the *primary dentition*, the majority of dental injuries had affected the supporting tissue. Treatment time per individual related to subluxation, extrusive, lateral, intrusive, and total luxation is shown in Fig. 2. Each box represents the interquartile range, which contains 50% of the values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. The line across the box indicates the median. An asterisk stands for an extreme value.

In the *permanent dentition*, fractures were predominant, followed by subluxation. A combination of crown fracture and luxation injury increased the risk of treatment complications. Among 4 patients, 6 teeth were avulsed. These teeth were replanted and splinted and within the first month after the trauma episode treated endodontically. The treatment time per individual relating to different diagnoses is shown in Fig. 3.

Regression analysis

The regression analysis showed that degree of severity (complicated versus uncomplicated) and the number of injured teeth were parameters of major significance to the treatment time (Table 4). Gender could not explain treatment time in the permanent ($P = 0.445$) or in the primary ($P = 0.526$) dentition. In the *permanent dentition* the treatment time showed an increase if the injury occurred before the age of 11.

Table 2. Treatment time in hours after trauma episodes to the primary dentition related to gender

Treatment time	No. of children	Boys	Girls
<1 h	489 (81%)	292 (60%)	197 (40%)
1–2 h	96 (16%)	52 (54%)	44 (46%)
>2 h	15 (3%)	14 (93%)	1 (7%)
Total	600	358	242

Table 3. Treatment time in hours after trauma episodes to the permanent dentition related to gender.

Treatment time	No. of children	Boys	Girls
<1 h	330 (57%)	218 (66%)	112 (34%)
1–5 h	211 (37%)	146 (69%)	65 (31%)
>5 h	34 (6%)	14 (41%)	20 (59%)
Total	575	378	197

Treatment by a specialist had an impact on time in the permanent but not in the primary dentition (Table 4). The situation was the reverse regarding the location of the clinic. The degree of explanation was low for each specific variable in the univariate analyses. In a multivariate analysis the degree of explanation was 25% in the permanent dentition compared to 8% in the primary dentition (Table 5). We have checked for multi-colinearity and found no association between the explanatory variables in the primary dentition. In the permanent dentition the explanatory variables were associated, however weak.

The multiple regression analysis of the importance of different diagnoses on treatment time in the permanent dentition is given in Table 6. Uncomplicated crown fracture, the dominant diagnosis in the permanent dentition, served as a reference variable. Crown-root fractures caused treatment problems that had a strong impact on time ($P < 0.001$). Luxation injuries with

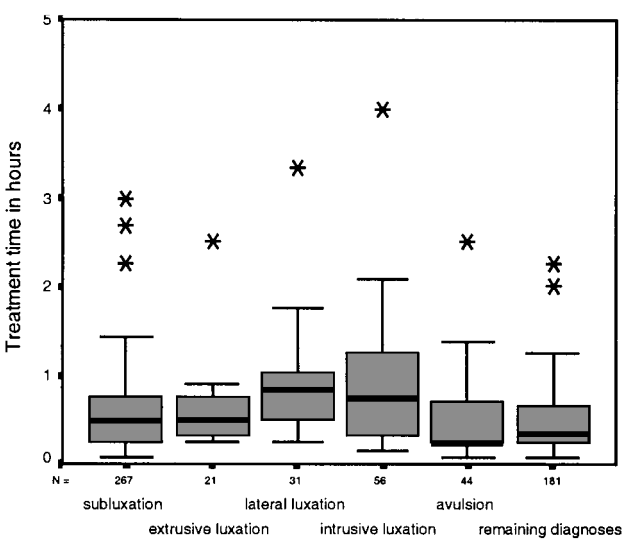

Fig. 2. Total treatment time per individual in the primary dentition related to diagnoses. Each box represents the interquartile range, which contains 50% of the values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. The line across the box indicates the median. An asterisk stands for an extreme value.

Table 4. Linear univariate analyses of treatment time in the primary and permanent dentition

Variables	Primary dentition ($n = 600$) β (regr. coeff.)	R^2 (degree of explanation)	Permanent dentition ($n = 575$) β (regr. coeff.)	R^2 (degree of explanation)
Clinic located in urban area	−0.136*	$R^2 = 0.02$	−0.061	$R^2 = 0.04$
No ($n = 679$)				
Yes (reference) ($n = 496$)				
Treatment by a specialist	0.069	$R^2 = 0.01$	0.345*	$R^2 = 0.12$
Yes ($n = 42$)				
No (reference) ($n = 1133$)				
Complicated trauma	0.172*	$R^2 = 0.03$	0.414*	$R^2 = 0.17$
Yes ($n = 260$)				
No (reference) ($n = 915$)				
More than one injured tooth	0.146*	$R^2 = 0.02$	0.190*	$R^2 = 0.04$
Yes ($n = 434$)				
No (reference) ($n = 741$)				
Age at the time of injury to the permanent dentition			0.170*	$R^2 = 0.03$
6–10 years ($n = 314$)				
11–16 years (reference) ($n = 261$)				

* Explanatory variable differs from 1.0 (the reference parameter) at $P < 0.05$.

displacement resulted in most cases in extensive and time-consuming treatment in the permanent dentition. In this material, lateral luxation and avulsion had a strong positive impact on treatment time ($P < 0.05$, $P < 0.001$) but there was no statistical significance regarding extrusive ($P = 0.79$) and intrusive ($P = 0.58$) luxation, indicating that less treatment was required. The combination of crown fracture and luxation injury significantly increased the treatment time. The variables in Table 6 explained 33% of the variation in treatment time.

When treatment time of subluxation (reference value) in the *primary dentition* was related to lateral luxation ($\beta = 0.124$) and intrusion ($\beta = 0.142$), the positive regression coefficients indicated an increased treatment time. Comparisons with uncomplicated crown fractures ($\beta = -0.163$) and avulsion ($\beta = -0.109$) showed a significantly lower treatment time. In several episodes of trauma in the primary dentition the diagnoses were omitted. Treatment times of these 'unknown' diagnoses ($\beta = -0.150$) indicate that these trauma episodes were of minor degree (data not shown).

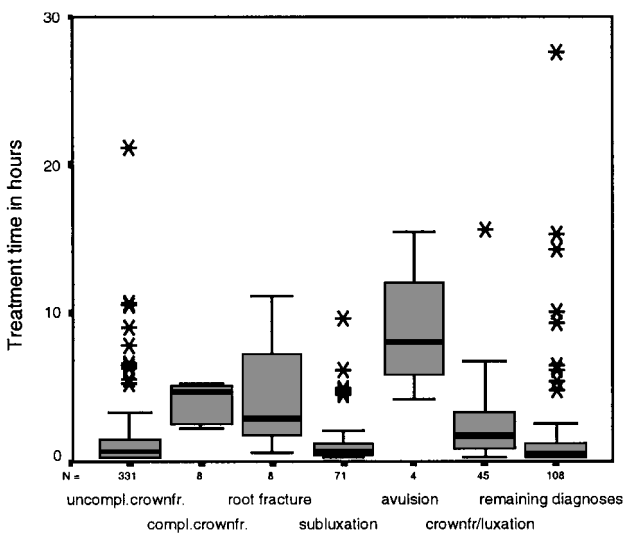

Fig. 3. Total treatment time per individual in the permanent dentition related to diagnoses. Each box represents the interquartile range, which contains 50% of the values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. The line across the box indicates the median. An asterisk stands for an extreme value.

Table 5. Linear multiple regression analysis of treatment time in the primary and permanent dentition

Variables primary dentition	β	Variables permanent dentition	β
Location of the clinic	−0.140	Treatment by a specialist	0.262
Degree of severity	0.172	Degree of severity	0.344
Number of injured teeth	0.147	Number of injured teeth	0.077
	$R^2 = 0.08$		$R^2 = 0.25$

Table 6. Linear multiple regression analyses of the impact of diagnosis on treatment time in the permanent dentition. Reference variable = uncomplicated crown fracture. β = multiple regr. coeff. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Variables	β
Infraction	−0.105**
Complicated crown fracture	0.174***
Uncomplicated crown-root fracture	0.122***
Complicated crown-root fracture	0.141***
Root fracture	0.118***
Concussion	−0.174***
Lateral luxation	0.073*
Avulsion	0.157***
Combination of crown fracture and luxation injury	0.200***
	$R^2 = 0.33$

Discussion

The mean treatment time per individual in the primary dentition was 0.6 h. Out of 600 children with injuries to their primary teeth, only 2% had a treatment time exceeding 2 h. They were all under the age of 4, and the length of treatment time could probably be explained by the need of sedation before any treatment was performed. In the majority of cases, the dentist had to decide whether the tooth was best treated by extraction, or whether it could be maintained without jeopardizing the developing tooth bud. If extraction was the treatment of choice, a majority (92%) was performed at the first or second follow-up. As treatment options are limited and complications often diagnosed soon after the injury, the need for recall visits are limited. In our study, one dental visit was sufficient in 21% of the trauma episodes and the mean number of visits was 2.2. This was in agreement with the findings by Glendor et al. (4), who showed a number of 3.0 visits or 1.0 h of total treatment time to primary teeth.

The mean treatment time in the permanent dentition was 1.6 h per individual. In the permanent dentition, the knowledge and options of relevant treatment methods have increased during the past 20–25 years (9). The range in number of visits (1–34) indicates that the treatment panorama is much wider than in the primary dentition, and that a few patients with complicated injuries required complex treatment. Since uncomplicated traumas accounted for almost 80% of the injuries, the mean number of visits was confined to 3.4. Glendor et al. (4) reported a much higher value, 10.6 visits per individual. In their study 6.3 follow-ups were spent on uncomplicated trauma to permanent teeth in spite of the fact that the risk for complications was quite low. This leads Glendor to recommend a reduction of follow-ups for uncomplicated trauma (10). Glendor et al. (4) also reported a treatment time (4.2 h) that was almost three times as high as in the present study (1.6 h). This difference could to some extent be explained by the fact that they followed the patients up to the age of 18. Josefsson & Lilja Karlander (5) showed a mean treatment time of 1.2 h, a figure similar to ours.

The location of the clinic was of importance for treatment time in the primary but not in the permanent dentition. In rural areas, with long transportation time to the clinic, it may seem less important to have several follow-ups of injuries to primary teeth.

Solli et al. (6) stated that cost differences in the treatment of dental injuries between two counties in Norway could be explained by the direct involvement of specialists in Oslo (urban area), leading to more advanced treatment in this county than in the other more rural areas. In our study, where a specialist treated 4% of the patients, preference to send referrals for specialist treatment was not dependent on location of the home clinic (= distance to the specialist involved). Patients treated by a specialist had a significantly increased treatment time, indicating either complications or more complex treatment. In many cases the referral was preceded by a high number of visits to the child's regular dentist. Immediate referrals of these patients to a dentist specially trained to treat complicated dental injuries could probably have helped to prevent some of the late complications and to reduce treatment time.

Dental injuries to more than one injured tooth resulted in a significant increase in treatment time in both dentitions. Glendor et al. (11) showed elevated estimates, although of no statistical significance, for time spent on treatment of three or more injured teeth compared to a lower number of teeth in the permanent dentition.

Treatment time in the permanent dentition increased if the dental injury occurred before the age of 11. Complications to teeth with immature root formation often give rise to complex treatment. Non-vital pulp of an immature tooth includes a great risk of cervical fracture of the tooth because of a wide pulpal lumen and short root with a thin wall. Our results are contrary to the findings of Glendor et al. (11), who showed no statistically significant time difference when comparing children before and after the age of 10.

In the linear regression analyses, the variables used could explain 25% of the variation in treatment time in the permanent but only 8% in the primary dentition. The difference is probably due to the limited number of treatment options in the primary dentition. The low degree of explanation in the univariate analyses can probably be explained by the fact that it was not possible to take experience and skill of the specific dentist into consideration.

In the multiple regression analyses of the impact of diagnosis on treatment time in the permanent dentition, uncomplicated crown fracture served as a reference value. Injuries with extensive loss of tooth structure need technically advanced and often time-consuming treatment. The analyses show that complicated crown fractures, as well as crown-root fractures, require significantly longer treatment time. Considerable time is also usually necessary to achieve a successful result in the case of severely dislocated teeth.

From the regression analyses it is also concluded that the combination of crown fracture and luxation injury significantly increased the treatment time. In the present material, 28% of these teeth required endodontic treatment, compared to 2% of the teeth with crown fractures only (12). The type of injury explained 33% of the variation in treatment time in the permanent dentition. The experience and competence of the individual dentist have not been taken into consideration in these analyses, factors that are of vital importance for treatment time.

In the present study, only treatment time has been accounted for. The cost for professional health care can be calculated using the cost per hour that is relevant for any time period. In this cohort of 16-year-olds, the mean total treatment time was 1012×1.3 h. If distributed among the approximately 150 dentists working in the Public Dental Health in the county of Västerbotten, each dentist would be treating traumatized teeth for about 9 h every year.

Estimated costs for professional health care per hour to the Swedish Public Dental Health in 1999 are USD 109 (13). This means a total cost of about USD 980 per dentist per year for treatment of dental injuries in children and adolescents up to the age of 16. It should be noted, however, that the treatment of dental injuries includes a number of other indirect costs.

In conclusion, this study has shown that the time spent on treatment of dental injuries was not dependent on where the clinic was located or on the gender of the injured child. Diagnosis had a great impact on treatment time as well as on whether a specialist rendered treatment when the dental injury had affected the permanent teeth. If the injury occurred to a young, immature permanent tooth, the treatment time increased significantly. Considering the low number of patients with complicated injuries, and that a time-consuming procedure was often performed before referral, immediate referral to a dentist specially trained to treat complicated dental injuries could reduce treatment time. The knowledge and experience of individual dentists are important in the treatment of dental injuries. Guidelines concerning registration, treatment and follow-up would probably improve efficiency.

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