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Analysis of the crown fractures and factors affecting pulp survival due to dental trauma

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SUMMARY

Objectives. The aim of the present study was to investigate pulp survival following crown fracture with and without pulp exposure as well as with and without associated subluxation and in relation to stage of root development and type of enamel-dentine fracture.

Materials and methods. This study consisted of 83 patients with 116 crown fractured incisors without pulp exposure and 35 patients with 44 complicated crown fractures. The effect of variables on the maintenance of tooth vitality were explored using the Linear Regression analysis , which assumes the effects of different factors on the pulp vitality such as (age, stage of the root development, contaminant subluxation, fracture depth, emergency treatment).

Results. The general distribution was 59 (71%) boys and 24 (29%) girls with uncomplicated crown fractures aged 7-17 years, mean 10.7 years ±2.83SD and 24 (68.5%) boys and 11 (31%) girls with complicated crown fracture. From 78 uncomplicated crown fractures without subluxation PN (pulp necrosis) was evaluated in 4 (4.88%) cases but from 20 uncomplicated crown fractures with subluxation PN was 14 (56.52%) cases.

Univariate analysis showed that stage of root development $p<0.05$, subluxation $p<0.001$, fracture depth $p<0.001$ were significantly related to the pulp survival.

Conclusions. The primary factors related to pulp healing events after crown fracture appears to be compromised pulp circulation due to concomitant subluxation as well as the stage of root development and fracture depth.

For incisors with complicated crown fractures there were two more factors related to pulpal healing-time interval from injury until initial treatment and appropriate emergency treatment.

Key words: permanent teeth eruption, general factors, influence.

INTRODUCTION

Traumatic injuries to teeth and their supporting structures occur most commonly in young patients, and vary in severity from enamel fractures to avulsions [1, 2].

Crown fractures of the permanent dentition comprise the most frequent form of traumatic dental injuries and constitute between 26% and 76% of all traumatic injuries [3].

Crown fractures and complicated crown fractures deserve special attention, due to their prevalence, variety of causative factors, and the diversity of clinical solutions proposed for the treatment of these fractures [4, 5].

It has been reported that during childhood the main causes of traumatic dental injuries are falls [2, 3, 5, 6]. Among adolescents, the trauma is mainly due to accidents related to sports [7].

Restoration of such injuries as crown fractures is important both aesthetically and functionally [4, 8]. Besides the achievement of an optimal aesthetic result, preservation of pulp vitality is of a major importance [9, 10].

To prevent pulpal inflammation coverage of the exposed dentin is very important procedure [8]. However, the length of time of dentin exposure on pulpal response is controversial. On the one hand this assumption seems to be supported by a clinical study where pulpal necrosis was significantly increased in untreated crown fractured teeth with extensive dentin exposure [8]. But there are studies showing that in teeth with functional, vital pulp tissue (no contaminant luxation injury), dentin provides considerable resistance to bacterial ingress [11, 13]. Furthermore, clinically and experimentally it has been found that in teeth with an intact pulpal circulation, dentin can provide considerable resistance to bacterial invasion.

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Dentin that has been exposed to the oral environment for longer periods of time appears to less permeable than fresh dentinal wounds [13].

Presently there is limited information on the risk of the pulp necrosis related to this complication. The prognostic factors that have been shown to have a significant effect on pulpal survival include: concurrent periodontal injury [9], apical maturity [3, 9], time before emergency treatment [11], type of enamel dentine fracture, positive response to pulpal sensibility tests at the time of injury [14].

The key factor in determining prognosis after any form of pulp exposure is eliminate the bacterial invasion of the pulp [12, 17]. Therefore, the removal of infected pulpal tissue as soon as possible following the injury and hermetic seal of exposed pulps is critical prognostic value [11, 17, 15]. A number of procedures have been recommended for the treatment of exposed pulps. These include pulps capping, partial pulpotomy, cervical pulpotomy and pulpectomy procedures [15]. Pulpotomy procedures appear to be superior to pulp capping [16, 17].

The advantage of both pulp capping and partial pulpotomy procedures in young teeth, if they prove successful, is that a healthy pulp is maintained throughout the root canal system and apexogenesis is ensured. [12, 17].

The purpose of the present study was to analyze cases of uncomplicated and complicated crown fractures as a result of dentoalveolar trauma and to investigate the pulp survival following these injuries with or without pulp exposure as well as with and without associated subluxation injury in relation to the stage of the root development and type of the enamel-dentine fracture.

MATERIAL AND METHODS

The material comprise patients with crown fractures treated at the time of injury at the Department of Conservative dentistry, Riga Stradins University, Institute of Stomatology Riga, Latvia, between January 2005 and December 2006.

Follow up for each injury provided a minimum of 6 month to 2-years. There was no difference in observational periods between uncomplicated and complicated crown fracture groups.

Documentation of the clinical and radiographic examination procedures has been collected in special trauma forms.

Documentation of the extent and type of trauma at the time of injury included extent of fracture, tooth colour, possible displacement, loosening of the involved tooth, pulpal sensibility to cold test (dichlorodifluoromethane (DDM) -50°C).

The stage of root development at the time of injury was determined from radiographs and graded of the five points scale described by Cvek [18].

Treatment strategy

Of the teeth managed in the department during the study period, in 46% emergency treatment had been given elsewhere.

In 43 (50%) cases fractures without pulpal involvement, dentin was covered by a glass ionomer cement Fuji GL which during the second visit was replaced by the composite resin restoration usually 1-2 month after injury. In 54 (34%) cases composite build-up was made during emergency visit.

In the 34% cases of the pulp exposure, pulp capping or partial pulpotomy was performed using a calcium hydroxid. Thereafter treatment was identical to the first group.

Final pulpal diagnosis

The observation period ranged from a minimum of 6 month to 2 years. The final pulpal diagnosis was registered, based on clinical and radiographic findings. According to the diagnostic criteria published in studies and observed in Table 1 [20, 32, 27].

Groups of patients

In the statistical analysis the patients were divided into four groups according to severity of injury. Group A represented uncomplicated crown fractures without present subluxation, Group B uncomplicated crown fractures with present subluxation. In Group C complicated crown fractures without subluxation and in Group D complicated crown fractures with subluxation (Table 2).

Statistics

Coded variables from the completed data entry forms were entered into a relational database (Microsoft Access Version 9.0). The statistical program SPSS (Version 10.0) was used for analysis of results. Univariate and multivariate regression analysis and the Spearmen correlation coefficient was calculated to find out the influence of factors affecting pulp survival such as age, sex, stage of the root development, contaminant subluxation, fracture depth, emergency treatment.

RESULTS

During 2 year period from January 2005 to December 2006 treatment and data collection has been done for 118 patients with 160 crown fractured incisors.

The material consisted of 83 patients with 116 crown fractured incisors without pulp exposure and 35

Table 1. Final pulpal diagnostic criteria

Diagnosis	Clinical criteria	Radiographic criteria
Vital pulp	Normal color Normal sensibility to could test	No pathologic changes
Pulp necrosis	Discoloration Negative could test Percussion tenderness	Apical radiolucency Inflammatory resorption
Pulp canal obliteration	Yellow discoloration	Constriction of pulp canal
Formation of a hard tissue barrier over a pulp exposure	Clinical conformation of hard tissue barrier	Radiographic barrier in some cases
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Table 2. Systemic diseases associated with impaired dental eruption

Group	Description	Number of teeth	% of teeth	Age years	Sex				Treatment time (in weeks)
					Female		Male		
					Number	%	Number	%	
A	Crown fractures without pulpal involvement and no subluxation	82	51.25%	Mean: 11.2, Range 7-17, SD=3.14, N=59	16	27.12%	43	72.88%	Mean: 1.9, Range 0.1-11, SD=2.67, N=56
B	Crown fractures without pulpal involvement and with subluxation	34	21.25%	Mean: 9.9, Range 7-16, SD=2.99, N=24	8	33.30%	16	66.70%	Mean: 14.7, Range 0.1-60, SD=2.99, N=25
									Number of visits
C	Crown fractures with pulpal involvement and no subluxation	33	20.63%	Mean: 10.9, Range 7-17, SD=2.87, N=26	9	34.60%	17	65.40%	Mean: 3.7, Range 2-8, N=33
D	Crown fractures with pulpal involvement and with subluxation	11	6.88%	Mean: 10.0, Range 7-15, SD=2.74, N=9	2	22.20%	7	77.80%	Mean: 4.5, Range 2-7, N=11
Total number of injured teeth		160							

Table 3. Distribution of the uncomplicated crown fractured teeth by stage of root development and final examination

Group	Description	Root development	Vital		Non vital	
			Number	%	Number	%
A	Crown fractures without pulpal involvement and no subluxation	Stage [1] – complete	47	60.26%	4	7.84%
		Stage [2] – uncomplete	24	30.77%	0	0.00%
		Stage [3] – uncomplete	7	8.97%	0	0.00%
Total number of injured teeth		78	Pulp survival		Pulp necrosis	
			95.12%		4,88%	
B	Crown fractures without pulpal involvement and with subluxation	Stage [1] – complete	4	10.18%	9	64.29%
		Stage [2] – uncomplete	2	20.00%	4	28.50%
		Stage [3] – uncomplete	11	55.00	1	7.14
Total number of injured teeth		34	Pulp survival		Pulp necrosis	
			20	58.82%	14	41.18%

Crown fractures witout subluxation showed PS [pulp survival] in 95.12% and PN 4.88%. Crown factures with concomitant subluxation showed PS [58.82%] and PN [41.18%]. An associated damage to the periodontal ligament significantly increased the likehood of pulp necrosis from 4.88% to 41.18% [p<0.002].
Apical maturity had no effect on pulp survival unless there is concomitant periodont injury.

patients with 44 complicated crown fractures. The final treatment, data collection and all radiographs related to the dental injuries were studied by the same author (dr. I. Viduskalne).

The general distribution was 59 (71%) boys and 24 (29%) girls with uncomplicated crown fractures aged 7-17 years, mean 10,7 years ±2.83 SD and 24 (68.5%) boys and 11 (31%) girls with complicated crown fractures, mean 10.9 years ±2.87 SD. Demographic and treatment characteristics of the study group (Table 2).

The most frequently observed cause of trauma was found to be falls at the rate of 30, sports injuries 14%, falls from bicycle – 11%, fights – 10%, and road accidents 3%.

In Group A (crown fractures without subluxation) in teeth with immature root n 31 (39.6%) there were no teeth developed pulp necrosis during observation period. In teeth with completed root development n=47 (60.26%) non vital teeth has been observed in 4 cases (4.88%).

An associated damage to the periodontal ligament significantly increased the likelihood observing non vital teeth in Group B (crown fractures with subluxation) from 4.88% to 41.18% ($p<0.002$) (Table 3).

For statistical analysis the teeth were divided into five groups according to root development at the time of injury. In Group B (uncomplicated crown fractures with subluxation) it was found that the more mature the root was the more frequent pulp necrosis 9 (64.29%) was observed if to compare with the teeth with incomplete apical development where pulp necrosis was observed only for one tooth (Table 3). Linear regression analysis of factors affecting pulp vitality after uncomplicated crown fractures shows that general factors such as age, gender, emergency treatment received, time before referral have no significant influence on pulp survival (Table 4).

Table 4. Linear regression analysis of factors of affecting pulp vitality after uncomplicated crown fractures

General factors	Coef.	t	p> ItI
Sex	0.2	0.5	0.96
Age	0.3	1.11	0.26
Emergency treatment received	0.4	1.05	0.39
Time before referal	0.6	1.43	0.15

We can conclude that such factors as age, emergency treatment received, time before referral have no significant influence on pulp survival.

Table 5. Linear regression analysis of factors of affecting pulp vitality after uncomplicated crown fractures

Local factors	Coef.	t	p> ItI
Stage of root development	0.2	4.8	0.05
Fracture depth	0.3	6.2	0.001
Contaminant subluxation	0.3	5.4	0.001

The prognostic factors that have been shown to have a significant $p<0.005$ effect.

The prognostic factors that have a significant effect were found to be fracture depth, contaminant subluxation, stage of root development ($p<0.005$) (Table 5).

First multivariate regression model of general factors affecting pulp survival after crown fractures show that patients age in association with fracture depth in dentin have a significant effect (Table 6).In second multivariate model of injury factors when they interact together such as associated subluxation, stage of root development and fracture depth have a significant influence upon the risk of losing pulp vitality (Table 7).

For complicated crown fractures the definitive treatment was pulp capping (20% of cases) and pulpotomy (14%). Pulpectomy was performed for all teeth with closed apices 31 (70%).

Loosing of vitality in a group of complicated crown fractured incisors has been observed in (72%) cases. Those teeth which have been treated with vital pulp therapy methods (pulp cap and partial or cervical pulpotomy) vitality of the pulp was preserved in 98%.

Unvariate linear regression analysis of factors affecting pulp vitality after complicated crown fractures shows two more impacting factors – emergency treatment received and time interval between injury and provided treatment (Table 8).

Multivariate analysis explains the importance of investigated factors – time before referral, age, stage of root development if they interact together (Table 9).

DISCUSSION

This study determined treatment provision for 118 patients with mean age of 10.5 years treated in two year period in Riga Stradins University Institute of Stomatology in Department of Conservative dentistry following uncomplicated and complicated crown fractures.

Demographic characteristics

The higher incidence of boys 71% compared to girls 29% with uncomplicated crown fractures and 68.5% boys and 31% girls with complicated crown fractures. The frequency was nearly twice as high for boys (69.5%) as for girls (30.5%) $p<0.001$. This approximated proportion of 2:1 is supported by the majority of previous studies [3, 5]. In addition, it was observed that school children under 12 years old were the group most affected [6, 19, 21]. For crown fractures without pulpal involvement and without subluxation

mean age of patients was 11.2 years, but for uncomplicated crown fractures with subluxation mean age of patients were observed 9.9 years. We can conclude that the mean age of patients range from 9.9 – 11.2 years. This is in agreement with other studies – epidemiological as well as trauma center reports [2, 3, 7].

The lifestyle and the general tendency of taking great risks and the ignorance of preventive measures can explain the high incidence for this group [5, 30].

Causes of crown fractures

Non accidental falls were the most common cause of crown fractures reported by Skaare AB [22].

Identifying the etiologic factors makes it possible to establish preventive measures aimed at avoiding future injuries. In this particular study the mean reason were falls and collisions which usually are unpredictable.

Final vitality of traumatized teeth

In present study, in teeth with crown fractures and no present subluxation loss of vitality has been found in 4,88%, this finding is to be according with other studies were the absence of contaminant luxation injury, complications resulting from injuries involving both the enamel and the dentin are also infrequent (0-6 percent) [2]. In the absence of simultaneous luxation injuries, complications are also believed to develop from bacterial penetration into open dentinal tubules, especially in teeth with deep angular fractures and in deep fractures that are left untreated for more than 24 hours [8]. As prognosis is related to time before treatment, dentine-covering procedures should be urgently instituted as soon as possible for fractures involving the dentine, particularly for deep and angular fractures, and when there has been an associated luxation injury [13, 4, 29]. This typically involves re-attachment of the fractured segment or restoration of lost tooth structure with composite resin [25, 26, 28,].

In particular study there were no teeth restored with fractured segment re-attachment method because of having no fragments of injured teeth. That might be explained with the fact that in Latvia we do not have any social education program about dental trauma, and patients are not informed about necessity of finding and bringing up the lost tooth fragment.

If pulps problems are to arise, they will generally occur within the first six month after injury [11, 12, 41]. However, it has also been suggested that inflammatory changes are of a transient nature if the pulpal vascular supply remains intact [35]. The in growth of bacteria is to a certain degree inhibited by an outward flow of dentinal fluid within the tubules due to a positive pulpal pressure [42]. In contrast, bacterial penetration is more rapid where impending hydrostatic pressure from an outward pulpal fluid flow is minimal or nonexistent, as after concomitant luxation injuries [15].

In the present study crown fractures with a compromised blood supply due to subluxation lead to a

Table 6. Multivariate regression model of general factors affecting pulp survival after crown fractures

Factors	Coef.	Std. Error	t	p> ItI
Sex	0.09	0.08	1.1	0.264
Age	0.001	0.01	1.9	0.059
Fracture depth (near the pulp)	0.4	0.07	6.3	0.001

The prognostic factors that have been shown to have a significant p<0.005 effect.

Table 7. Multivariate regression model of injury factors affecting pulp survival after crown fractures

Factors	Coef.	Std. Error	t	p> ItI
Stage of root development	0.03	0.01	2.92	0.01
Fracture depth (near the pulp)	0.34	0.06	5	0.001
Contaminant subluxation	0.38	0.07	5	0.01

The prognostic factors that have been shown to have a significant (p<0.005) effect.

Table 8. Linear regression analysis of factors of affecting pulp vitality after complicated crown fractures

Factors	Coef.	Std. Error	t	p> ItI
Sex	0.15	0.16	0.9	0.37
Age	0.06	0.02	2.4	0.02
Emergency treatment received	0.01	0.06	2.3	0.05
Time before referal	0.19	0.07	2.61	0.01
Stage of root development	0.23	0.06	3.7	0.001
Fracture depth	0.2	0.13	1.5	0.129
Contaminant subluxation	0.24	0.15	2.5	0.016

From this analysis that have been shown differently from uncomplicated crown fractures if the fracture line involves pulp there are two more factors affecting pulp survival – emergency treatment received and time interval between injury and provided treatment

Table 9. Multivariate regression model of injury factors affecting pulp survival after complicated crown fractures

Factors	Coef.	Std. Error	t	p> ItI
Time before referal	0.2	0.08	2.6	0.014
Age	0.06	0.02	2.52	0.017
Stage of root development	0.23	0.06	3.71	0.001

The regression model explains importance of investigated factors if they interact together.

higher frequency of on vital teeth. This frequency arised from 4.88% (crown fractures without subluxation) to 41.18% in fractures teeth with subluxation. Andreasen reported prevalence of pulp necrosis in fractured and subluxated teeth increased to 25%–50% [23]. In present study we have similar findings.

More presence of non vital we can see in group with complicated crown fractures and this findings is not in agreement with other studies [8, 11] that might be explained with treatment protocol used in clinic, that all teeth with complicated apical development and pulp involvement due to the dentoalveolar trauma were treated with pulpectomy and endodontic therapy after. In older patients, where the success rate for conservative pulp therapy on mature traumatized teeth is less predictable and tooth formation is complete, routine endodontic therapy is more likely the treatment of choice [17, 28, 42].

Nevertheless, since it has been shown that partial pulpotomy procedures can still be successful in older patients, the decision whether or not to retain the pulp is more often governed by the amount of remaining root dentine and the requirements for crown retention rather than whether the pulp is exposed or not [36]. Although the outcome may not be as predictable in the long term, partial pulpotomy procedures can provide an expedient and much cheaper treatment option for some patients, particularly if there is sufficient tooth structure remaining for the crown to be restored with a composite resin material or by re-cementation of the fractured segment [11, 15, 16, 40].

Completely different finding were described in the study by Jackson et al. and concluded that more conservative treatment of closed apex teeth sustaining complicated crown fractures, utilizing vital pulp therapy, techniques would appear to be appropriate [8].

In contrast, other results assessing pulp vitality after trauma were seen in teeth with complicated crown fractures and no complicated root development which have been treated with partial or cervical pulpotomy. The successes rate of presence vital teeth raised up to 98%. This finding is according with previous investigations [17].

There are several authors who suggested that this procedure is therefore regarded as a temporary treatment to be followed by pulpectomy once root formation is complete [24, 30].

Furthermore, the treatment may cause a loss of tooth substance in the cervical area to such an extent that a full crown restoration with anchorage in the root canal is often required to prevent a root fracture .

Analysis of factors affecting pulp vitality

In particular study general factors age, sex, emergency treatment received, have no significant influence on pulp survival, after uncomplicated crown fractures the same findings were observed in other studies [3, 39].

The effect of time interval between injury and dentin coverage and subsequent risk of pulp necrosis is still a question due to the small number of clinical trials.

In the present study there was no statistical difference between the various time intervals. This might be explained with a fact that the biggest part of injured teeth had delayed treatment.

In this study using univariate analysis of local injury factors that have been found to have a significant effect on pulp survival for non complicated crown fractures were fracture depth ($p<0.001$), present subluxation ($p<0.001$), stage of root development ($p<0.05$), This finding is also supported by other authors [3, 9] and literature review done by P. F. Day and M. S. Duggal [14], about prognostic factors after dento-alveolar trauma,– a review of existing evidence.

In this regard we have found that for teeth with complete apical maturity [stage 5] according to Cveks classification and crown fractures with subluxation non vital teeth were observed in 64.29% (n=9) and evaluated that the less mature the root was the less non vital teeth were observed stage 4 (wide open apical opening and root length nearly complete) – 28.5% (n=4) and stage 3 wide open apex only 1 case (7.1%).

The same finding, the more immature the root formation is the greater is the chance to maintain vitality after contaminant luxation injury have been reported in other studies [3, 9].

Multivariate regression model of general factors affecting pulp survival after crown fractures have shown that age ($p<0.05$), in association with fracture depth ($p<0.001$), in dentin have a significant effect of losing pulp vitality. This finding could be explained with a fact that pulp takes a greater part of tooth crown and pulp horns are more extent.

Linear regression analysis of factors affecting pulp vitality after complicated crown fractures, there were evaluated two more factors – emergency treatment received and time interval between injury and provided treatment and this is in agreement with very many other studies and trauma textbooks [14, 17, 35, 37, 38].

CONCLUSIONS

- The frequency was nearly twice as high for boys 69.5% as for girls 30.5%.
- Crown fractures without subluxation showed pulp survival in 95.12% and pulp necrosis in 4.88%.
- Crown fractures with present subluxation showed pulp necrosis in 41.18%
- The primary factors related to pulp healing events after crown fractures appears to be compro-

mised pulp circulation due to concomitant subluxation as well as the stage of root development and fracture depth.

• For complicated crown fractures there were two more factors affecting pulp survival emergency treatment received, time before referral.

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