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Periodontal healing complications following extrusive and lateral luxation in the permanent dentition: a longitudinal cohort study

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Abstract – *Purpose*: To analyze the risk of tooth loss and complications in periodontal ligament (PDL) healing following *extrusive and lateral luxation* in the permanent dentition. *Materials and methods*: Eighty-two permanent teeth (78 patients) with extrusive luxation and 179 teeth (149 patients) with lateral luxation were included in the study. All teeth were examined according to a standardized protocol including clinical, photographic, and radiographic registration. Follow-up controls were performed at regular intervals (3, 6 weeks, 6 months, 1, 5, and 10 years). Statistics: The risk of repair-related resorption (surface resorption), infection-related resorption (inflammatory resorption), ankylosis-related resorption (replacement resorption), marginal bone loss, and tooth loss was analyzed with the Kaplan–Meier method. Differences among subgroups were analyzed with log-rank test and Cox regression. *Results*: The risk of periodontal healing complications was estimated after 3 years. *Extrusive luxation*: For immature root development, *infection-related resorption was* 2.4% (95% confidence interval (CI): 0–6.9%). For mature root development*, repair-related resorption* was 15.6% (95% CI: 4.4–26.7%), *infection-related resorption* was 5.1% (95% CI: 0–11.7%), and marginal bone loss was 17.5% (95% CI: 6.2–28.8%). No teeth showed *ankylosis-related resorption,* and no teeth were lost in the observation period. *Lateral luxation*: For immature root development*, repair-related resorption* was 2.1% (95% CI: 0–6.1%), *infection-related resorption* was 2.1% (95% CI: 0–6.1%). For mature root development*, repair-related resorption* was 29.5% (95% CI: 20.5–38.5%), *infection-related resorption* was 2.6% (95% CI: 0–6.4%), *ankylosis-related resorption* was 0.8% (95% CI: 0–2.3%), *marginal bone loss* was 6.9% (95% CI: 2.2–11.6%). *Conclusion*: The risk of severe periodontal healing complications in teeth with extrusive and lateral luxation injuries is generally low. Marginal bone loss and repair-related resorption occurred significantly more often in teeth with mature rather than immature root development. Marginal bone loss was associated with injuries involving multiple teeth.

Extrusive luxation is an injury to the tooth-supporting structures characterized by partial or total separation of the periodontal ligament (PDL) resulting in loosening and displacement of the tooth in an axial direction. The displacement will cause almost total disruption of the PDL attachment as well as severing or perhaps stretching of the apical neurovascular bundle. The injury will give rise to increased mobility of the tooth and disturbance of pulpal circulation or pulpal infarction (1–3).

Lateral luxation is an injury to the tooth-supporting structures characterized by partial or total separation of the PDL combined with a fracture of either labial or palatal/lingual bone where the tooth is displaced in a direction other than axial. Hence, the trauma involves damage to the PDL attachment as well as a high risk of severing the apical neurovascular bundle. Some areas of the root surface and the PDL will suffer separation injury where the damage mainly occurs in the intercellular structures. In other areas of the root surface, the tissue will be compressed, and both the cells and intercellular structures will be crushed (Fig. 1). Tissue compression will typically occur in the cervical part of the root and in the apical area where the apex of the tooth is displaced into the bone (1–3).

Healing following a luxation injury involves reorganization and reestablishment of the continuity of the PDL fibers as well as pulpal revascularization and re-innervation.

Teeth with minor luxation injuries such as concussion and subluxation have a very low risk of periodontal healing complications (4). However, exposure of the cervical root surface in teeth with extrusive luxation and compression zones on the root surfaces of teeth with lateral luxation may involve an increased risk of periodontal healing complications. Previous studies have mainly focused on pulpal healing. Accordingly, the risk of periodontal healing complications in teeth with extrusive and lateral luxation has not been fully documented in the literature (5–16).

The purpose of the present study was therefore to analyze the following parameters in teeth with extrusive and lateral luxation injuries:

1 What is the risk of periodontal healing complications such as repair-related resorption, infection-related resorption, ankylosis-related resorption, and marginal bone loss?
2 What is the long-term prognosis in regard to tooth survival?

Materials and methods

The material includes patients treated at the Department of Oral and Maxillo-Facial Surgery, Copenhagen University Hospital, Rigshospitalet, Denmark, in the period from 1972 to 1990.

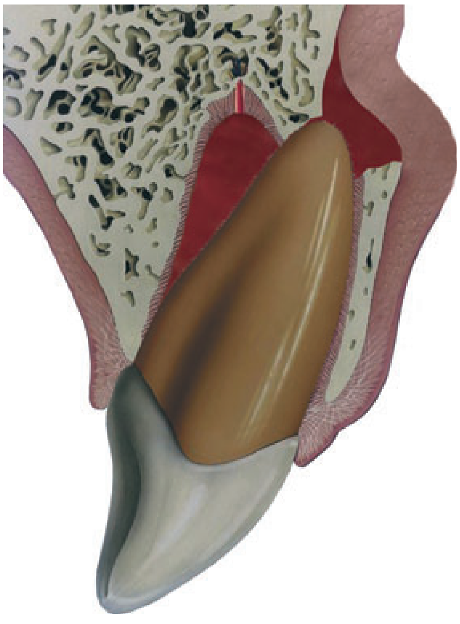

Fig. 1. Lateral luxation of a maxillary central incisor. Note displacement of the apex through the labial bone plate.

Patients were included in the study if they fulfilled the following criteria:

1 A permanent tooth that had suffered an *extrusive luxation* injury in which the tooth-supporting structures were characterized by partial or total separation of the PDL resulting in loosening and displacement of the tooth in an axial direction.
2 or a permanent tooth that had suffered a *lateral luxation* injury in which the tooth-supporting structures were characterized by partial or total separation of the PDL combined with a fracture of either labial or palatal/lingual bone and the tooth was displaced in a direction other than axial. Tooth-specific clinical information and radiographs obtained at the time of injury and at the subsequent controls according to a standardized protocol.
3 Clinical photographs from the time of injury.
4 A follow-up period of minimum 10 months.
5 The tooth had not previously suffered a trauma.
6 No major destruction of the crown because of dental caries or restorations.

The general follow-up program included controls after 3, 6 weeks, 6 months, 1, 5, and 10 years. The follow-up period ranged from 324 days (10.8 months) to 8.045 days (22.0 years) with a median of 458 days (1.3 years).

Clinical registration

At the time of the injury, the following parameters were registered on a special trauma chart: the patient's sex and age; cause, date, and time of injury; number of injured teeth; and the condition of the supporting tissue.

For each tooth, objective clinical information from the time of injury and the follow-up examinations was recorded using a standardized form where the following features were noted: tooth color (normal, yellow, red, gray, or crown restoration); dislocation (mm in vertical and horizontal direction); tooth mobility (scale 0–3); tenderness to percussion; and percussion tone (normal or high metallic sound indicating ankylosis) (17).

Furthermore, electrometric sensibility was registered on the incisal edge using a Sirotest II® pulp tester (scale 0–4). Injured and non-injured adjacent control teeth were tested at the time of the injury and at each follow up. At the follow-up examinations, the examinations included information on the presence or the absence of sinus tracts, gingivitis, gingival dehiscence, and periodontal pocket depths (i.e., >3 mm) (17).

Photographic registration

Horizontal and axial photographs were routinely taken at the time of injury (17).

Radiographic registrations

Three radiographs of the same area (ortho-, mesio-, and distoradial angulations) and a steep occlusal exposure were made at the initial examination and a periapical exposure at the follow-up controls. All radiographs were taken using film holders (17).

Root development

The stage of root development was determined by evaluation of radiographs from the initial examination. The teeth were divided into two groups that were analyzed separately: (i) Immature root development: the root development was incomplete, and/or the apex was not fully formed and (ii) Mature root development: the tooth had full root formation with a closed apex.

Treatment

The treatment consisted of manual reduction and splinting of the injured tooth to the adjacent teeth. Two methods were used for splinting: Rigid fixation with the use of cemented orthodontic bands united with acrylic or flexible fixation with a flexible temporization material (Protemp® 3M ESPE, Neuss, Germany) bonded to the labial crown surfaces (Table 1). The choice of splinting method was not randomized.

Antibiotics were generally not prescribed for extrusive luxation and lateral luxation injuries. However, in 18 patients (19 teeth), Penicillin 500 000 IU four times a day for 4 days was prescribed because of associated traumatic injuries such as avulsion with subsequent replantation or soft tissue lacerations.

Diagnosis of periodontal healing and complications

Abnormal periodontal healing was usually diagnosed within 2–3 months when root resorption became apparent.

In accordance with a previous clinical study by Andreasen and Andreasen (17), periodontal healing after luxation injuries was divided into the following four groups: (i) normal periodontal healing, (ii) repair-related resorption (surface resorption), (iii) infection-related resorption (inflammatory resorption, occurred only in teeth with pulp necrosis), and (iv) ankylosis-related resorption (replacement resorption).

The resorption diagnoses were based on radiographic analysis performed independently by two dentists. In case of disagreement, agreement was reached by consensus discussion.

The extent of marginal bone loss was determined radiographically (by means of bisecting angle radiographs). The distance between the cementoenamel junction and the alveolar crest was measured mesially and

Table 1. The distribution of teeth in relation to gender, age, number of injured teeth in each patient, and the time elapsed from when the trauma occurred until treatment was performed (treatment delay)

Extrusive luxation (patients)		Immature root development No. patients (%)	Mature root development No. patients (%)	Total No. patients (%)
Gender	Female	12 (30.8)	9 (23.1)	21 (26.9)
	Male	27 (69.3)	30 (76.9)	57 (73.1)
Age	<20 years	39 (100.0)	32 (82.1)	71 (91.0)
	≥20 years	0 (0.0)	7 (17.9)	7 (9.0)
Number of injured teeth in each patient	One	6 (15.4)	5 (12.8)	11 (14.1)
	Three or more	16 (41.0)	22 (56.4)	38 (48.7)
Treatment delay[1]	<5 h	33 (89.2)	33 (91.7)	66 (90.4)
	5–24 h	3 (8.1)	3 (8.3)	6 (8.2)
	More than 24 h	1 (2.7)	0 (0.0)	1 (1.4)
Extrusive luxation (teeth)		No. Teeth (%)	No. Teeth (%)	No. Teeth (%)
Fixation	None	6 (14.3)	5 (12.5)	11 (13.4)
	Flexible	12 (28.6)	13 (32.5)	25 (30.5)
	Rigid	24 (57.1)	20 (50.0)	44 (53.7)
	Unknown	0 (0)	2 (5.0)	2 (2.4)
Lateral luxation (patients)		No. patients (%)	No. patients (%)	No. patients (%)
Gender	Female	18 (45.0)	44 (40.4)	62 (41.6)
	Male	22 (55.0)	65 (59.6)	87 (58.4)
Age	<20 years	40 (100.0)	73 (67.0)	113 (75.8)
	≥20 years	0 (0.0)	36 (33.0)	36 (24.2)
Number of injured teeth in each patient	One	11 (27.5)	14 (12.8)	25 (16.8)
	Two	19 (47.5)	42 (38.5)	61 (40.9)
	Three or more	10 (25.0)	53 (48.6)	63 (42.3)
Treatment delay[1]	<5 h	30 (90.9)	87 (80.6)	117 (83.0)
	5–24 h	3 (9.1)	18 (16.7)	21 (14.9)
	More than 24 h	0 (0.0)	3 (2.8)	3 (2.1)
Lateral luxation (teeth)		No. Teeth (%)	No. Teeth (%)	No. Teeth (%)
None		20 (41.7)	37 (28.2)	57 (31.8)
Flexible		9 (18.7)	34 (26.0)	43 (24.0)
Rigid		19 (39.6)	59 (45.0)	78 (43.6)
Unknown		0 (0.0)	1 (0.8)	1 (0.6)

[1]Information of treatment delay was available for 73 patients with extrusive luxation and 141 patients with lateral luxation.

distally with a sliding caliper on a bisecting angle radiograph. This distance measured at radiographs from the initial examination was compared with the same distance measured on radiographs taken at follow-up controls. If this distance was >2 mm, the condition was considered to be pathological and defined as marginal bone loss.

Statistical methods

Teeth with mature and immature development were analyzed separately because of the expected difference in healing potential in the two groups. The Kaplan–Meier method was used to analyze the risk of repair-related resorption, replacement resorption, infection-related resorption, marginal bone loss, and tooth loss. Robust confidence limits were obtained to account for the dependencies of teeth placed in the same patients (18–20). These methods can, however, not be applied if no events are recorded during the follow-up period. For healing complications with no events during the follow-up period, exact binomial confidence limits were computed based on the number of teeth still under observation after 3 years, which is the time point used for all point estimates. The comparison of the rates of healing complications after extrusive luxation and lateral luxation was calculated using log-rank test and Cox regression. All analyses were performed with the statistical software R (R Development Core Team, Vienna, Austria, 2010).

Results

Extrusive luxation

A total of 82 permanent teeth (78 patients, 57 males and 21 females) with an extrusive luxation injury were included in the study: 42 teeth with immature root development (eight of which had an additional crown fracture without pulp exposure) and 40 with mature root development (17 of which had an additional crown fracture without pulp exposure) (13). Table 1 gives the distribution of teeth in relation to gender, age, number of injured teeth in each patient, and the time elapsed from when the trauma occurred until the treatment was performed (treatment delay). The data set is further described in a previous article (13). Table 2 shows the results for the risk of periodontal healing complications in teeth with extrusive luxation injuries (mature as well as immature root development).

Repair-related resorption (surface resorption)

Repair-related resorption was found in seven teeth (Table 2, Fig. 2). The risk of *repair-related resorption* after 3 years was 15.6% (95% confidence interval (CI): 4.4–26.7%) in teeth with mature root development. No teeth with immature root development were diagnosed with repair-related resorption. Hence, there was a significantly higher risk of repair-related resorption in teeth with mature root development (P = 0.004). The resorption was located in the apical part of the root, and four of the teeth had pulp necrosis.

The majority of the teeth (two-thirds) were extruded <2 mm. There was no significant difference in the risk of repair-related resorption between teeth with more or <2-mm displacement (P = 0.53).

Infection-related resorption (inflammatory resorption)

Infection-related resorption was found in three teeth (Table 2, Fig. 3). Two of the three cases with infection-related resorption occurred in teeth with a closed apex, whereas one was found in a tooth with an open apical foramen. The risk of *infection-related resorption* after 3 years was 2.4% (95% CI: 0–6.9%) in teeth with immature root development and 5.1% (95% CI: 0–11.7%) in teeth with mature root development. The

Table 2. Extrusive luxation: the risk of periodontal healing complications and tooth loss estimated after 3 years in teeth with immature and mature root development

	Number of patients	Number of injured teeth	Teeth lost to follow-up	Number of teeth with healing complications at 3 years	Risk of healing complications	95% confidence interval
Immature						
Repair-related resorption	38	42	21	0	0	?
Infection-related resorption	38	42	21	1	2.4	[0–6.9]
Ankylosis-related resorption	38	42	21	0	0	[0–17.6]
Marginal bone loss	38	42	21	0	0	[0–17.6]
Tooth loss	38	42	21	0	0	[0–17.6]
Mature						
Repair-related resorption	39	40	25	6	15.6	[4.4 –26.7]
Infection-related resorption	39	40	25	2	5.1	[0–11.7]
Ankylosis-related resorption	39	40	25	0	0	[0–23.2]
Marginal bone loss	39	40	25	7	17.5	[6.2–28.8]
Tooth loss	39	40	25	0	0	[0–23.2]

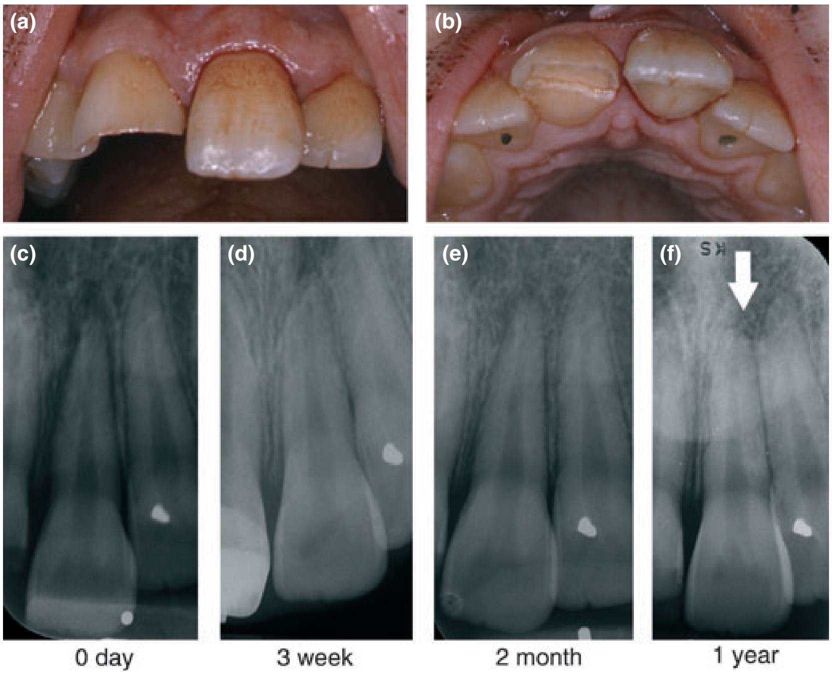

Fig. 2. Repair-related resorption affecting the apex of the left central incisor after an extrusive luxation injury in a 13-year-old boy. (a) Frontal view at the time of injury (day 0). (b) Axial view. (c–f) Radiographs from time of injury and at follow up. Note repair-related resorption affecting the apex after 1 year (arrow).

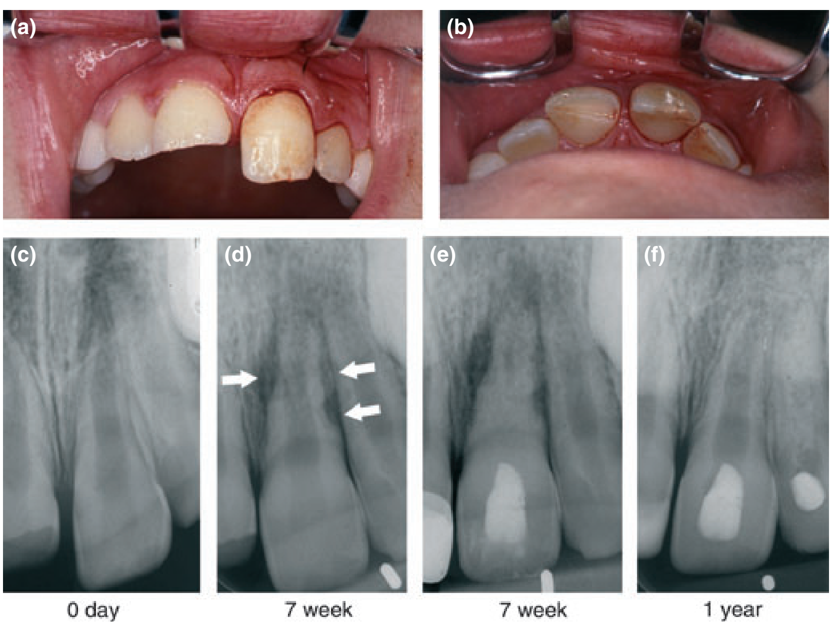

Fig. 3. Infection-related resorption affecting left central incisor after an extrusive luxation injury in a 9-year-old boy. (a) Frontal view. (b) Axial view. (c–f) Radiographs from the time of injury and at follow up. (d) Seven weeks after injury, note infection-related resorption is affecting the root (arrow). (e) Seven weeks after injury and after placement of calcium hydroxide. (f) One year after injury.

resorption cavities were located on the roots both apically, mid-root, and cervically.

Ankylosis-related resorption (replacement resorption)

Ankylosis-related resorption was not observed in the observation period (Table 2).

Marginal bone loss

Marginal bone loss was observed in seven of the 82 teeth with an extrusive luxation injury (Table 2). The risk of marginal bone loss after 3 years was 17.5% (95% CI: 6.2–28.8%) for teeth with mature root development. No bone loss was found in teeth with immature root development. Hence, the risk of marginal bone loss was significantly higher in teeth with mature root development ($P = 0.004$). All affected teeth were part of a multi-trauma (more than one tooth involved), and three of them had an additional crown fracture. The risk of marginal bone loss was significantly higher for patients with multi-trauma than in patients with only one traumatized tooth ($P = 0.004$).

Long-term tooth survival

All teeth included in the present study survived throughout the observation period.

Lateral luxation
A total of 179 permanent teeth (149 patients, 87 males and 62 females) with lateral luxation were included in the study: 48 teeth with immature root development (five of which had an additional crown fracture) and 131 with mature root development (28 of which had an additional crown fracture). Table 1 gives the distribution of teeth in relation to gender, age, number of injured teeth in each patient, and treatment delay. The data set is further described in a previous article (13). Table 3 summarizes the results for the risk of periodontal healing complications in teeth with lateral luxation injuries (mature as well as immature root development). All healing complications were diagnosed within the first 3 years.

Repair-related resorption (surface resorption)

Repair-related resorption was found in 38 cases (Table 3). The majority (37 teeth) had mature root development. The risk of repair-related resorption after 3 years was 2.1% (95% CI: 0–6.1%) in teeth with

Table 3. Lateral luxation: the risk of periodontal healing complications and tooth loss estimated after 3 years in teeth with immature and mature root development

	Number of patients	Number of injured teeth	Teeth lost to follow up	Number of teeth with healing complications at 3 years	Risk of healing complications	95% confidence interval
Immature						
Repair-related resorption	39	48	22	1	2.1	[0–6.1]
Infection-related resorption	39	48	22	1	2.1	[0–6.1]
Ankylosis-related resorption	39	48	22	0	0	[0–13.7]
Marginal bone loss	39	48	22	0	0	[0–13.7]
Tooth loss	39	48	22	0	0	[0–13.7]
Mature						
Repair-related resorption	109	131	86	37	29.5	[20.5–38.5]
Infection-related resorption	109	131	86	2	2.6	[0–6.4]
Ankylosis-related resorption	109	131	86	1	0.8	[0–2.3]
Marginal bone loss	109	131	86	9	6.9	[2.2–11.6]
Tooth loss	109	131	86	0	0	[0–8]

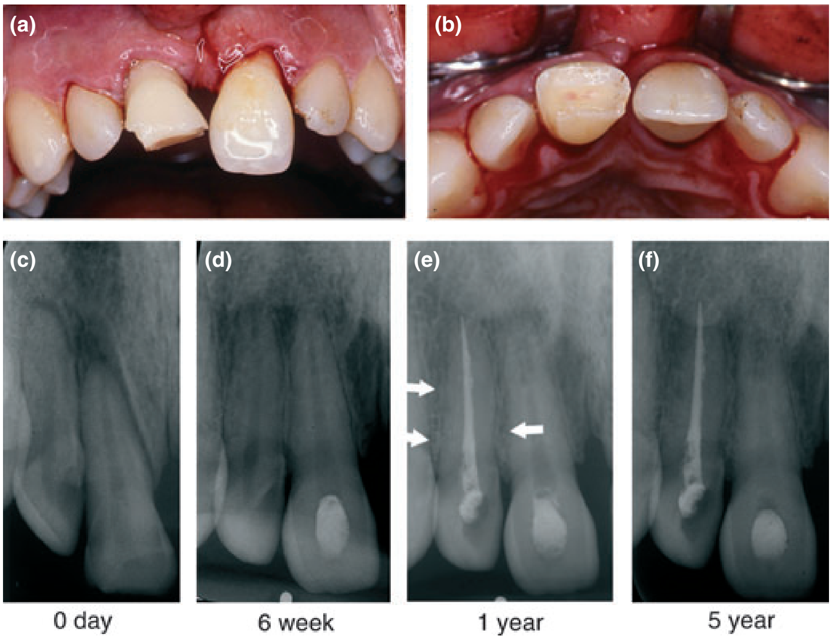

Fig. 4. Ankylosis-related resorption affecting a right maxillary lateral incisor suffering from a lateral luxation injury in a 21-year-old man. The two central incisors were avulsed and replanted. (a) Frontal view at time of injury (day 0). (b) Axial view. (c–f) Radiographs from time of injury and at follow up. At the 6-week control, there were clinical signs of ankylosis-related resorption (high percussion tone). At the 1- and 5-year controls, there were radiographic signs of ankylosis-related resorption.

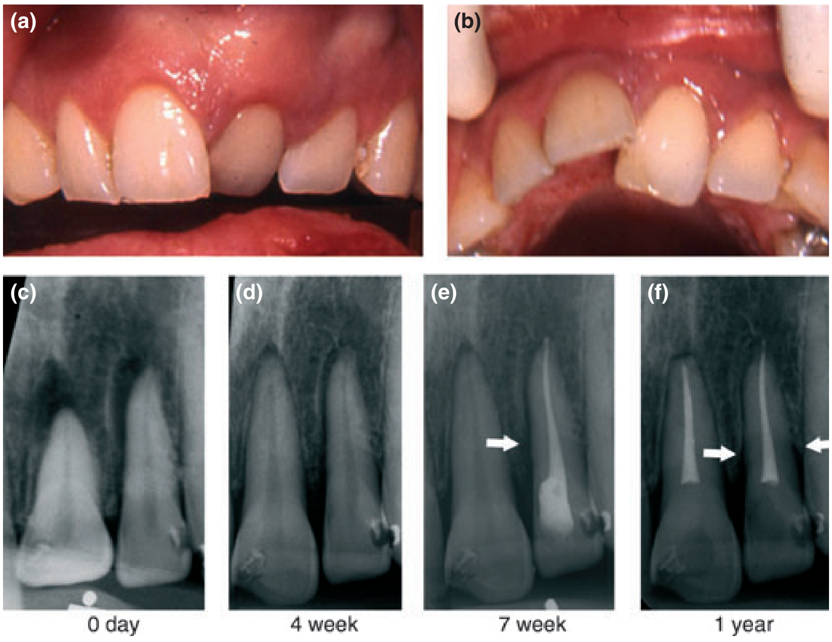

Fig. 5. Marginal bone loss affecting left maxillary lateral incisor suffering lateral luxation injury in a 30-year-old woman. Also the left maxillary central incisor was laterally luxated. (a) Frontal view at the time of injury (day 0). (B) Axial view. (c–f) Radiographs from time of injury and at follow up after 7 weeks and 1 year; mesial and distal marginal bone loss is apparent (arrows).

immature root development and 29.5% (95% CI: 20.5–38.5%) in teeth with mature root development. Hence, there was a significantly higher risk of repair-related resorption in teeth with mature root development ($P < 0.001$). Repair-related resorption occurred mainly in multi-trauma cases. All cases of repair-related resorption were located in the apical part of the root and manifested as a slight rounding of the apex. In 25 teeth, pulp necrosis was also diagnosed.

Infection-related resorption (inflammatory resorption)

Infection-related resorption was found in only three cases (Table 3). One of these cases occurred in a tooth with immature root development. The risk of infection-related resorption estimated after 3 years was 2.1% (95% CI: 0–6.1%) in teeth with immature root development and 2.6% (95% CI: 0–6.4%) in teeth with mature root development. Resorption was located mid-root or cervically, or in one case throughout the root's entire surface.

Ankylosis-related resorption (replacement resorption)

Only a single case with ankylosis-related resorption was observed (Table 3, Fig. 4). The tooth was part of a multi-trauma; its apex was fully closed. The tooth was treated by manual reduction; however, repositioning was incomplete. The estimated risk of ankylosis-related resorption after 3 years was 0.8% (95% CI: 0–2.3%) in teeth with mature root development. The resorption was located in the cervical part of the root. Acid-etch technique and applied resin were used for splinting.

Marginal bone loss

Marginal bone loss was observed in nine teeth with mature root development and lateral luxation (Table 3, Fig. 5). The estimated risk of marginal bone loss after

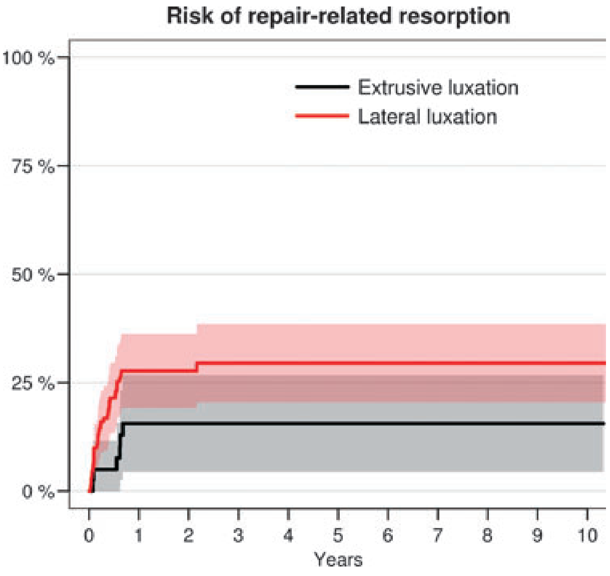

Fig. 6. The survival graph for the risk of repair-related resorption in mature teeth with extrusive and lateral luxation ($P = 0.1$, Cox regression analysis).

3 years was 6.9% (95% CI: 2.2–11.6%). No marginal bone loss was found in teeth with immature root development. Hence, there was a significantly higher risk of marginal bone loss in teeth with mature root development ($P = 0.03$). All of the affected teeth were part of a multi-trauma (more than one tooth involved). The risk of marginal bone loss was significantly higher for patients with multi-trauma than in patients with only one traumatized tooth ($P = 0.03$).

Long-term tooth survival

All teeth in the study survived the entire observation period.

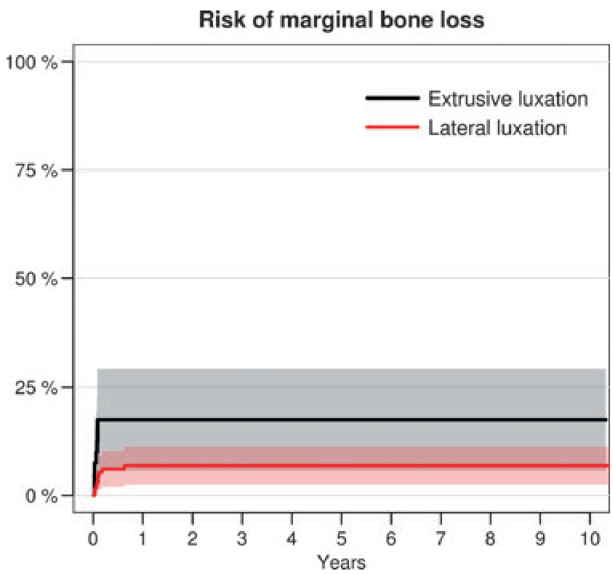

Fig. 7. The survival graph for the risk of marginal bone loss in mature teeth with extrusive and lateral luxation ($P = 0.04$, Cox regression analysis).

Comparison of differences in risk of healing complications after extrusive and lateral luxation

There was no statistically significant difference (Cox regression analysis) in the risk of repair-related resorption, infection-related resorption, replacement-related resorption, and tooth loss between teeth with extrusive and lateral luxation. However, the risk of marginal bone loss after 3 years was higher in mature teeth with extrusive luxation than in mature teeth with lateral luxation (hazard ratio: 3.3 (95% CI: 1.1–7.7), $P = 0.04$) (Table 2 and Table 3).

Figures 6 and 7 show the risk of repair-related resorption and marginal bone loss in mature teeth with extrusive and lateral luxation.

Discussion

Extrusive and lateral luxation represents a severe injury to the PDL and pulp. The present study shows that the risk of serious complications such as infection-related resorption, ankylosis-related resorption, and tooth loss are low for these types of injuries. However, repair-related resorption occurred quite frequently in teeth with mature root development. This observation implies that PDL attachment has a great potential for the regeneration in teeth with extrusive or lateral luxation injuries.

In a *lateral luxation*, the apex of the root is typically forced through the labial bone plate (1–3). The apical PDL and the blood vessels entering the pulp will therefore be severely traumatized. This explains the typical location of the *repair-related resorption* at the root tip. Pulp necrosis occurred frequently in mature teeth with extrusive luxation or lateral luxation and was often associated with periapical radiolucencies. Periapical inflammation elicited by infected pulp necrosis is known to be related to osteoclastic activity at the apex of the tooth in the area of the inflammation (20). A dual etiology of *repair-related resorption* may therefore exist, which in these cases makes repair-related resorption in the apical area a hybrid between repair- and infection-related resorption. Because of the non-progressive nature of these two resorptive events, these cases should, however, be grouped as repair-related resorption. Furthermore, the repair-related resorption may be a result of transient apical breakdown. This phenomenon has been described following extrusive and lateral luxation injuries in teeth with complete root formation (7, 11). The resorption is reversible and represents osteoclastic activity at the apical foramen and in the apical part of the root canal, facilitating the ingrowth of new vascular tissue into the pulp canal.

The risk of *repair-related resorption* was higher in teeth with lateral luxation than in teeth with extrusive luxation (mature root development). This difference could be related to an increased occurrence of compression zones on the root surface of lateral luxated teeth as well as a higher occurrence of pulp necrosis. However, this difference was not statistically significant (Hazard ratio: 2.0 (95% CI: 0.87–4.79), $P = 0.10$), see Fig. 6.

There was no statistical difference in the estimated risk of *infection-related resorption, ankylosis-related resorption,* and *tooth loss* between teeth with extrusive and lateral luxation ($P > 0.05$). However, there was a significantly higher risk of *marginal bone loss* in teeth with extrusive luxation than in teeth with lateral luxation (mature root development, $P = 0.04$), (see Fig. 7). This result was unexpected because a lateral luxation compared with an extrusive luxation is associated with more extensive damage to the supporting structures. However, all cases of marginal bone loss occurred in patients where more than one tooth was traumatized. Marginal bone loss may therefore primarily be associated with a situation where multiple teeth have been injured rather than to the diagnosis of an individual tooth.

The mechanical properties of bone in children are different from those of adults. Children's bone is less mineralized and more resilient (21, 22). The higher resilience of the involved tissues in children has a shock-absorbing effect and thus reduces the amount of damage to the tissue. In the present study, this resulted in a more frequent finding of *repair-related resorption* and *marginal bone loss* in teeth with mature root development than in teeth with immature root development.

In the present study, only one tooth was diagnosed with ankylosis-related resorption. This type of resorption will eventually lead to tooth loss. However, that did not occur within the observation period. Sometimes ankylosis-related resorption is diagnosed years after the trauma has occurred. It is therefore possible that further cases could be identified over a longer observation period.

The very low frequency of infection-related resorption, ankylosis–related resorption, and tooth loss found in this study appears to be similar to the result from previous clinical studies (14–16). However, Oikarinen et al. (10) reported a somewhat higher frequency of marginal bone loss, infection-related resorption, and ankylosis-related resorption. This variation may to some extent be explained by different treatment modalities, for example the type of fixation. In the study by Oikarinen, rigid splinting with metal bars and steel wires, sometimes covered with acrylic, may have adversely affected the conditions for periodontal healing. Stålhane and Hedegaard (5) made no distinction between extrusive luxation, lateral luxation, and intrusion injuries. The healing scenarios are quite different for these three trauma entities, and a comparison with the results of this study therefore cannot be made.

The choice of splinting type and the effect of antibiotic have been widely debated in relation to more serious dental injury types such as avulsion and intrusion. This study unfortunately cannot add to this discussion. The material has very few serious healing complications such as infection-related and ankylosis-related resorption. Furthermore, the study was not originally designed to evaluate the effect of systemic antibiotics and the choice of fixation type. No randomization protocol was applied for these factors, and the criteria for application were not rigidly defined from the onset. It was therefore not possible to include these factors in the analysis.

In conclusion, the risk of severe periodontal healing complications in cases of extrusive luxation or lateral luxation of teeth is generally low, even if the pulpal neurovascular supply and the PDL suffer significant damage. The findings of the present study support the observation that the pulp and the PDL appear to have extraordinary healing capacities after trauma. Marginal bone loss and repair-related resorption occurred significantly more often in teeth with mature than immature root development, and marginal bone loss was associated with traumatic injuries involving more than one tooth.

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