Dental Traumatology

Dental Traumatology 2012; **28**: 200–204; doi: 10.1111/j.1600-9657.2011.01073.x

Transient discoloration of the coronal fragment in intra-alveolar root fractures

Barbro Malmgren[1,2], Sofie Hübel[1]

[1]Department of Paediatric Dentistry, Eastman-institutet; [2]Department of Clinical Science, Intervention and Technology (CLINTEC), Division of Paediatrics, Karolinska University Hospital, Huddinge, Stockholm, Sweden

Correspondence to: Barbro Malmgren, Department of Paediatric Dentistry, Eastmaninstitutet, Dalagatan 11, S-113 24 Stockholm, Sweden
Tel.: +46 7 398 517 88
e-mail: barbro.malmgren@telia.com

Accepted 18 September, 2011

Abstract – *Background*: Root fractures are a relatively rare type of injury with frequencies of 0.5–7% of traumatized permanent teeth. It is well known that teeth with intra-alveolar root fractures have a good prognosis. The pulp remains vital in about 80% of these teeth. If pulp necrosis develops, this normally only occurs in the coronal fragment. Although several studies on intra-alveolar root fractures have been published during the last decades, none have mentioned that transient discoloration can occur. The aim of our study was to study the frequency and prognosis for intra-alveolar root fractures with discoloration. *Material and methods*: The material consisted of 42 permanent incisors from 21 boys and 18 girls aged 7–19 years (mean = 12.7, median 12.0). In two girls and one boy, two incisors exhibited concurrent intra-alveolar root fractured. The follow-up period ranged from 1 to 9 years. The colour changes were determined at each control by transillumination of the clinical crown from the facial and palatal surfaces. Electrometric sensibility was evaluated and compared to the values of adjacent teeth using an electric pulp tester. At the final clinical and radiographic control, the type of healing was registered. *Results*: Discoloration was found in nine teeth. The root development was completed in all these teeth. The discoloration disappeared within 4 weeks to 6 months in eight teeth. The sensibility, which was lost at the injury, followed the changes in discoloration, and all teeth had regained normal sensibility when the discoloration had disappeared. Only one tooth, which showed a greyish hue, developed pulp necrosis. *Conclusion*: Transient discoloration in intra-alveolar fractures is relatively common and is indicative of a good prognosis for healing.

Intra-alveolar root fractures are a relatively rare type of injury with a frequency of only 0.5–7% of traumatized permanent teeth (1–3). It is well known that teeth with intra-alveolar root fractures have a good long-term prognosis. The pulp remains vital in about 80% of the teeth (4–7). If pulp necrosis develops, this normally only occurs in the coronal fragment (8–11). The first radiographic sign usually presents within 3 months after injury and is often seen as a progressive widening of the space between the two fragments, followed later by radiolucences at the fracture sites indicative of pathologic changes in the adjacent periradicular bone (8, 10). Occasionally, a sinus tract at a level on the buccal mucosa corresponding to the fracture line can be found (11).

Discoloration of the crown following trauma might occur. A pink discoloration that occurs shortly after injury, i.e. within 2–3 days, can be reversible (12–14). If the crown of the tooth turns progressively grey, pulp necrosis should be suspected. This may be accompanied by a periapical radiolucency, which can be observed as early as 2–3 weeks after injury. Pulp necrosis after luxation of permanent teeth has been reported to occur in 8% of immature teeth and in 38% of mature teeth (9). In many cases, however, no radiographic sign of periodontal involvement can be observed. In these cases, sterile pulp necrosis can be suspected (15).

Loss of electrometric sensibility can be temporary, later returning to normal as occurs in other luxation injuries (9, 16). Lack of pulpal sensibility alone or coronal discoloration alone (13, 17) is not sufficient evidence to confirm a diagnosis of pulp necrosis. The presence of periapical radiolucency is a more predictable sign of the presence of pulp necrosis (13). However, pulpal repair has been reported to occur after all three of the aforementioned signs being observed (14).

Partial or complete obliteration of the pulp canal is a common finding after root fractures (14, 18). In clinical studies of root-fractured permanent incisors, pulp canal obliteration was found in 69–73% (5, 6, 10). Pulpal sensibility testing is normal in most cases, but a negative response can be registered in teeth with totally obliterated pulp cavities. Secondary pulp necrosis is a rare finding in these cases (5). A yellowish shade is seen in teeth with coronal pulp canal obliteration.

Transient colour changes have also been described in connection with transient apical breakdown (TAB) after luxation injuries in permanent teeth (19, 20). It appeared that discoloration and loss of electrometric sensibility returned to normal when there was radiographic evidence of resolution of the TAB.

Although several studies on intra-alveolar root fractures have been published during the last decades, none

have mentioned that transient discoloration that is unrelated to the development of pulp necrosis can occur. It is our clinical experience that there is a common misconception that a discoloration *per se* necessarily indicates pulp necrosis. Thus, we found it important to report our experience of transient discoloration in root fracture teeth. The aims of our study were therefore to study the frequency and prognosis for teeth with intra-alveolar root fractures with discoloration and to test whether pulp necrosis is more common among discoloured root-fractured teeth than among those without discoloration.

Material and methods

Records from all patients who suffered intra-alveolar root fractures in permanent incisors referred to the Department of Paediatric Dentistry at the Eastman Institute in Stockholm, Sweden, from 2000 to 2009 were collected and assessed (n = 71). Twenty-nine were excluded for the following reasons: seven with marginal root fractures were extracted in connection with the injury, 12 in which the pulp in the coronal fragment was extirpated when referred, five in which the coronal fragment was avulsed and replanted, one tooth that was both intruded and fractured and four where the records were incomplete. The selection left included 42 permanent incisors from 21 boys and 18 girls aged 7–19 years (mean = 12.7, median 12.0). In two girls and one boy, two incisors exhibited concurrently intra-alveolar root fractured.

The stage of root development was estimated from the length of the root and width of the apical foramen, and the teeth were allotted to five groups according to Cvek et al. 2001 (4). Electrometric sensibility was evaluated and compared to the values of adjacent teeth using an electric pulp tester (Vitality Scanner; Analytic Technologies, Redmond, WA, USA) scaled 0–80. A value between 20 and 40 was estimated as normal. The controls followed established guidelines (21). The location of the root fracture, type and amount of dislocation of the coronal fragment were registered. At the final clinical and radiographic control, the type of healing was registered as healing with hard tissue, connective tissue, connective tissue and bone and no healing according to Andreasen & Hjorting-Hansen (11). The follow-up period ranged from 1 to 9 years.

The colour changes were determined clinically at each control by transillumination of the clinical crown from the facial and palatal surfaces and on intra-oral colour photographs. The colour was classified as grey, rosy, grey/rosy, grey/red or brown/rosy, and as a shade guide a set-up with these hues was used (Fig. 1). All the photographs were used for classification, made by the two authors separately and later co-ordinated. The photographs were also used for double determinations. When the second determination was made in the same way after 3 months, the classifications were equal in all cases. The first documented discoloration was used to decide whether the colour got lighter or darker.

Statistical analysis

Chi-square test was used to test whether pulp necrosis is more common among discoloured root-fractured teeth than among those without discoloration. The significance level of $P < 0.05$ was used. The data were analysed using STATISTICA v. 10 (STATSOFT; Scandinavia AB, Uppsala, Sweden).

Results

The outcome of the analyses of the material (n = 42) is presented in Table 1. In the material as a whole, healing with hard tissue formation was seen in 16 teeth (38.1%), healing with connective tissue in 17 teeth (40.5%) and healing with interposition of bone and periodontal ligament (PDL) in three teeth (7.1%). No healing was

Table 1. Frequency of teeth with different dislocation of coronal fragment, fracture location and types of healing in relation to discoloration

Registrations	Total number of teeth	Colour No discoloration	Discoloration
Fracture location			
Apical third	13	9	4
Middle third	24	20	4
Cervical	5	4	1
Dislocation of coronal fragment			
No dislocation	16	14	2
Extrusion	16	11	5
Retroclination	8	7	1
No information	2	1	1
Type of healing			
Hard tissue	16	15	1
Connective tissue	17	12	5
Bone and connective tissue	3	1	2
No healing	6	5	1
Total	42	33	9

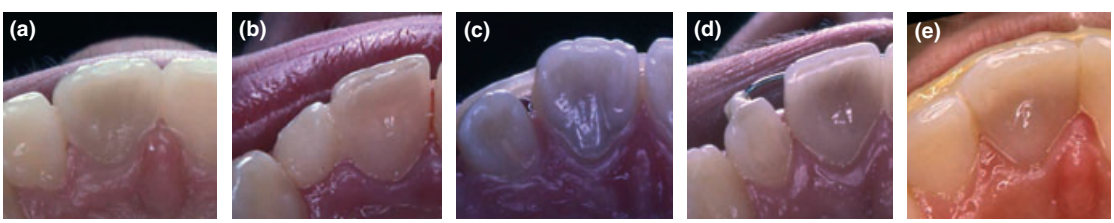

Fig. 1. Scale used for the evaluation of discoloration.

found in six teeth (14.3%). Full root formation with closed apex was present in 34 teeth (80.9%), full root formation with half-closed apex in six teeth (14.3%) and full root formation with an open apex in two teeth (4.8%). No dislocation of the coronal fragment as well as extrusion was found in 16 teeth (38.1%) and retroclination in eight teeth (19%). No information on dislocation was available in two cases (5%). The fracture position was in the apical part of the root in 13 teeth (31%), in the middle in 24 teeth (57%) and in the cervical part in five teeth (12%) of the cases.

Discoloration was present in nine teeth and transient discoloration in eight of these teeth. Root development was completed in all these discoloured teeth. A detailed description of the outcome of the teeth with discoloration is seen in Table 2. The discoloration varied between a grey, rosy, grey/rosy, and brown/rosy (Figs 1 and 2) hue and disappeared within 4 weeks to 6 months (mean 8.4, median 6.5 weeks). No sensibility was registered at the first visit, but the sensibility was regained successively as the discoloration disappeared. One root-fractured tooth healed with hard tissue formation (11%), five with connective tissue (56%) and two with interposition of bone and PDL (22%). Only one, which showed a greyish hue, developed pulp necrosis (11%).

There was no significant difference in the prognosis between teeth with and without discoloration ($P = 0.76$).

Discussion

Root fractures are a relatively rare type of injury, and also discolorations are rare among root-fractured teeth. In the present study, the fracture position was in the middle in 57% of teeth, in the apical part in 31% and in the cervical part in 12%. This is in agreement with results in earlier studies, where the reported fracture position has been 64%, 30% and 6%, respectively (4, 7). The outcome in the present study with healing with hard tissue in 40.5%, connective tissue in 38.1%, connective tissue and bone in slightly more than 7% and with no healing observed in 14.3% is better compared with outcomes in earlier studies (18, 22) where the corresponding figures were 30%, 43%, 5% and 20%, respectively. Although the numbers are small, the material in this study might therefore be considered representative for the outcome of root fractures with discoloration.

The diagnosis of necrosis in root-fractured teeth is difficult. Pulp necrosis following root fractures is normally asymptomatic, and the diagnosis must be based on colour changes, lack of pulpal sensibility and radiographic findings (15). This study confirms that transient discoloration can occur in root-fractured teeth. Indeed, we found discoloration in nine of 47 teeth (19%) in our material registered during a 10-year period. The discoloration persisted in only one tooth. Compared with the material as a whole, the outcome for the teeth with discoloration differed. Only one developed pulp necrosis (11%) compared with the whole material where pulp necrosis was found in nine teeth (14.3%).

Loss of electrometric sensibility can be temporary, later returning to normal like in other luxation injuries (9, 16). This study showed that lost sensibility in teeth with discoloration also was regained when the discoloration disappeared. Partial or complete obliteration of the pulp canal is a common finding after root fractures (14, 18). In the permanent dentition pulp, root canal obliteration is relatively common after luxation injuries. These teeth have a good prognosis. During observation periods of up to 20 years, periapical radiolucency has been reported to occur only in 13–16% (23). Root-fractured teeth with obliteration have even a better prognosis, and secondary pulp necrosis is a rare finding in these cases. Pulpal sensibility testing is normal in most cases but the response will become weaker as calcification continues making sensibility testing not reliable (5).

A safer diagnostic tool is the radiograph. However, during the initial stages of the healing process in root fracture, root resorption either at the periphery of the fracture line adjacent to the PDL, external surface resorption, or centrally at the border of the root canal, internal surface resorption, has been reported to occur in 60% of a clinical material of root-fractured permanent incisors (24). Also an internal tunnelling resorption might occur. This is shown in Fig. 2f. These resorptions are signs of healing processes. Signs of pulp necrosis after root fractures are radiographically shown as progressive widening of the space between fragment and appearance of radiolucency in the adjacent alveolar bone (8, 10). If the tooth is not splinted, the coronal fragment is loose, slightly extruded and sensitive to percussion (11). In some cases, a sinus tract is found at the level on the buccal mucosa corresponding to the fracture line (11).

Table 2. Outcome of root-fractured teeth with discoloration of the crown

Patient no	Age at injury	Fracture location	Dislocation of coronal fragment	Discoloration	Discoloration duration	Type of healing
1	15	Apical	None	Brown/rosy	7 weeks	Hard tissue
2	15	Apical	Extruded	Grey/red	7 weeks	Connective tissue
3	12	Apical	Extruded	Rosy	8 weeks	Connective tissue
4	13	Apical	Retroclination	Grey	6 weeks	Bone and connective tissue
5	13	Middle	None	Brown/rosy	6 months	Connective tissue
6	12	Middle	No information	Grey	Persisted	No healing
7	13	Middle	None	Grey/rosy	4 weeks	Connective tissue
8	17	Middle	Extruded	Rosy	4 weeks	Connective tissue
9	15	Cervical	Extruded	Grey/rosy	6 weeks	Bone and connective tissue

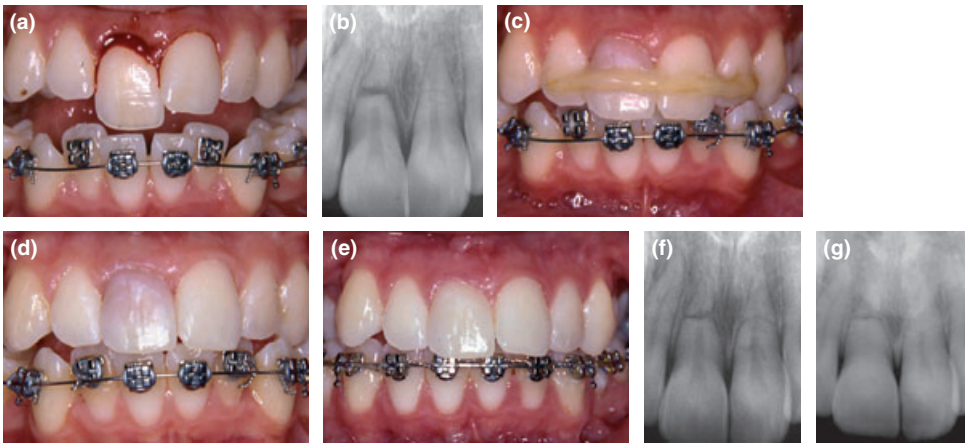

Fig. 2. A 15-year-old girl, who 3 days before received a blow against her mouth. The right upper incisor had had an intra-alveolar root fracture before which had healed with connective tissue. (a, b) Clinical photograph and radiograph 3 days after injury showing extrusion of the coronal fragment in 11 and an intra-alveolar without dislocation in 21. (c) Discoloration in 11 2.5 weeks after injury. (d) 2 months after injury, the discoloration is still obvious. (e, f) 1 year and 6 months after injury, 11 have regained its normal colour. Both incisors have a negligible increased mobility and normal sensibility and have healed with connective tissue. Internal tunnelling resorption can be seen in 21. (g) Control 9 years after injury. Obliteration is seen in 11. The resorption process is arrested in 21, and obliteration in the coronal pulp canal can be seen. Courtesy Dr Maria Andersson.

Discoloration of a root-fractured tooth might be a sign of pulp necrosis, pulp canal calcification or an internal bleeding with hyperaemia of the pulp capillaries. One of the sequelae of trauma from severe injuries is complete interruption of the blood supply (25). An increased blood pressure may lead to the rupture of capillaries and release of red blood cells into the pulp chamber. The haemolysis leads to the diffusion of haemoglobin into the dentinal tubules (12, 25). The shift from pink to greyish-blue takes approximately 2 weeks. A certain fading of the grey-blue tint can occur, or an opaque grey hue can persist. If the pulp survives, the stain can disappear. Transient discoloration after other types of traumatic injuries to the teeth is a well-known phenomenon. This is particularly common in primary teeth. Bijella et al. (26) reported discoloration in more than half of luxated teeth during follow up. Discoloration became evident within one to 3 weeks as a pink colour shining through the crown (27). It has been suggested that the blood supply will gradually re-establish its normal function and the pink colour will disappear (25). Revascularization in replanted immature teeth might occur (28, 29), and an intra-alveolar root-fractured tooth could be considered as a young immature tooth or a tooth showing TAB as the wide communication at the fracture surface gives possibility to revascularization and outflow of oedema.

The results of this study clearly show that it is important to consider that a discoloration and/or loss of sensibility *per se* do not indicate pulp necrosis. Other signs and symptoms, such as changes in crown colour, the development of a sinus tract, pulp calcification and bony radiographic changes, must be taken into consideration for correct diagnosis. Of these, the radiographic image is most important.

Although the numbers in this study are too small to draw any statistically significant conclusions, our study confirms our clinical experience over four decades from the Eastman Institute in Stockholm that transient discoloration in intra-alveolar root-fractured teeth is relatively common and is indicative of a good prognosis for healing.

References

1. 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.
2. Ravn JJ. Dental injuries in Copenhagen schoolchildren, school years 1967–1972. Community Dent Oral Epidemiol 1974;2:231–45.
3. Stalhane I, Hedegard B. Traumatized permanent teeth in children aged 7–15 years. Sven Tandlak Tidskr 1975;68:157–69.
4. Cvek M, Andreasen JO, Borum MK. Healing of 208 intra-alveolar root fractures in patients aged 7–17 years. Dent Traumatol 2001;17:53–62.
5. Jacobsen I, Zachrisson BU. Repair characteristics of root fractures in permanent anterior teeth. Scand J Dent Res 1975;83:355–64.
6. Zachrisson BU, Jacobsen I. Long-term prognosis of 66 permanent anterior teeth with root fracture. Scand J Dent Res 1975;83:345–54.
7. Cvek M, Tsilingaridis G, Andreasen JO. Survival of 534 incisors after intra-alveolar root fracture in patients aged 7–17 years. Dent Traumatol 2008;24:379–87.
8. Jacobsen I, Kerekes K. Diagnosis and treatment of pulp necrosis in permanent anterior teeth with root fracture. Scand J Dent Res 1980;88:370–6.
9. Andreasen FM, Pedersen BV. Prognosis of luxated permanent teeth – the development of pulp necrosis. Endod Dent Traumatol 1985;1:207–20.
10. Andreasen FM, Andreasen JO, Bayer T. Prognosis of root-fractured permanent incisors – prediction of healing modalities. Endod Dent Traumatol 1989;5:11–22.
11. Andreasen JO, Hjorting-Hansen E. Intraalveolar root fractures: radiographic and histologic study of 50 cases. J Oral Surg 1967;25:414–26.

12. Arwill T, Henschen B, Sundwall-Hagland I. The pulpal reaction in traumatized permanent incisors in children aged 9–18. Odontol Tidskr 1967;75:130–47.
13. Jacobsen I. Criteria for diagnosis of pulp necrosis in traumatized permanent incisors. Scand J Dent Res 1980;88:306–12.
14. Andreasen FM. Pulpal healing after luxation injuries and root fracture in the permanent dentition. Endod Dent Traumatol 1989;5:111–31.
15. Andreasen JO, Andreasen FM, Andersson L. Textbook and color atlas of traumatic injuries to the teeth, 4th edn. Oxford: Blackwell Munksgaard; 2007. 378 pp.
16. Skieller V. The prognosis for young teeth loosened after mechanical injuries. Acta Odontol Scand 1960;18:171–81.
17. Magnusson B, Holm AK. Traumatised permanent teeth in children – a follow-up. I. Pulpal complications and root resorption. Sven Tandlak Tidskr 1969;62:61–70.
18. Andreasen JO, Andreasen FM, Mejare I, Cvek M. Healing of 400 intra-alveolar root fractures. 1. Effect of pre-injury and injury factors such as sex, age, stage of root development, fracture type, location of fracture and severity of dislocation. Dent Traumatol 2004;20:192–202.
19. Andreasen FM. Transient apical breakdown and its relation to color and sensibility changes after luxation injuries to teeth. Endod Dent Traumatol 1986;2:9–19.
20. Cohenca N, Karni S, Rotstein I. Transient apical breakdown following tooth luxation. Dent Traumatol 2003;19:289–91.
21. Flores MT, Malmgren B, Andersson L, Andreasen JO, Bakland LK, Barnett F et al. Guidelines for the management of traumatic dental injuries. III. Primary teeth. Dent Traumatol 2007;23:196–202.
22. Cvek M, Mejare I, Andreasen JO. Healing and prognosis of teeth with intra-alveolar fractures involving the cervical part of the root. Dent Traumatol 2002;18:57–65.
23. Jacobsen I, Kerekes K. Long-term prognosis of traumatized permanent anterior teeth showing calcifying processes in the pulp cavity. Scand J Dent Res 1977;85:588–98.
24. Andreasen FM, Andreasen JO. Resorption and mineralization processes following root fracture of permanent incisors. Endod Dent Traumatol 1988;4:202–14.
25. Auslander WP. Discoloration, a traumatic sequela. N Y State Dent J 1967;33:534–8.
26. Bijella MF, Yared FN, Bijella VT, Lopes ES. Occurrence of primary incisor traumatism in Brazilian children: a house-by-house survey. ASDC J Dent Child 1990;57:424–7.
27. Aguilo L, Gandia JL. Transient red discoloration: report of case. ASDC J Dent Child 1998;65:346–8, 356.
28. Kling M, Cvek M, Mejare I. Rate and predictability of pulp revascularization in therapeutically reimplanted permanent incisors. Endod Dent Traumatol 1986;2:83–9.
29. Ohman A. Healing and sensitivity to pain in young replanted human teeth. An experimental, clinical and histological study. Odontol Tidskr 1965;73:166–227.