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Relationship between clinical–radiographic evaluation and outcome of teeth replantation

Adriana de Jesus Soares, Brenda Paula Figueiredo de Almeida Gomes, Alexandre Augusto Zaia, Caio Cezar Randi Ferraz, Francisco José de Souza-Filho

Endodontics, Piracicaba Dental School, State University of Campinas-UNICAMP, Piracicaba, SP, Brazil

Correspondence to: Prof. Dr Francisco José de Souza-Filho, Endodontia, Faculdade de Odontologia de Piracicaba, UNICAMP, Avenida Limeira, 901, Piracicaba, SP 13414-018, Brazil
Tel.: +5519 3412 5215
Fax: +5519 3412 5218
e-mail: franciscosouzafilho@yahoo.com.br

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Abstract – The aim of this retrospective study was to evaluate clinical and radiographic results related to avulsed and replanted teeth in patients who sought treatment at the Dental Trauma Center of the Dental School of Piracicaba, State University of Campinas, Piracicaba, SP, Brazil. One hundred replanted teeth were studied from 48 individuals (18 females and 30 males, with a mean age of 15 years and 9 months). Post-replantation factors (clinical and radiographic) were observed. The clinical aspects evaluated were crown discoloration, pulp necrosis, mobility changes, presence of fistulae and tooth infra-position. Radiographic examination aimed to identify replacement and inflammatory root resorptions, pulp canal obliteration and the presence of radiolucent areas. Depending on clinical and radiographic findings, results were classified as: complete success, acceptable success, uncertain success or failure. During anamnesis, other factors such as stage of root formation, period extra-alveolar, storage medium, type of splintation, and period after replantation time were recorded. The data obtained were statistically analyzed in order to determine the relationship between the post-replantation factors and outcome of teeth replantation. Linear logistic regression revealed that the majority of replanted teeth were associated with root resorptions and its occurrence duplicated proportionally as the time after replantation increased. Based on these findings, replantation procedures must be submitted to an accurate follow-up, as the success of replanted teeth, which already tends to be limited, may be even more jeopardized if cases are not controlled.

Teeth maintenance is one of the main goals of Dentistry. However, dental trauma is considered to be a serious threat to this objective. Studies performed worldwide reveal that dental trauma represents one of the most common reasons of search for emergency appointments (1).

In dental injuries, treatment of avulsion can be considered one of the most complicated. The attachment apparatus of the root (periodontal ligament and cement layer) is damaged. Dental hard tissues, alveolar bone, and gingiva might also be affected. The vessels and nerves of the pulp rupture at the apical foramen and the pulp tissues undergo necrosis. In these circumstances, the prognosis is largely dependent on the status of the periodontal ligament cells at the moment of replantation, which eventually may lead to failure (2).

The treatment outcome of replanted teeth can be influenced by several factors such as concomitant dentoalveolar injuries, stage of root formation, time elapsed between avulsion and replantation, the use of a suitable storage medium, and the type and duration of splintation (3, 4). Such factors may affect healing, leading to rapid osteogenesis in the socket and favoring ankylosis (fusion of bone and cementum) that, consequently, results in radicular resorptions (5). Replacement resorptions are characterized as the direct contact between the alveolar bone and root. This situation is normally linked to clinical findings such as lack of mobility (ankylosis) and presence of a high-pitched percussion sound (metallic sound) over the tested tooth, which clearly differs from adjacent non-injured teeth. Such lesions represent the most serious complication expected and is considered the main cause for the loss of replanted teeth (6, 7). Therefore, a positive prognosis of replanted teeth is not common in clinical situations because a combination of these, and many others factors, may be involved (8).

Replantation of avulsed permanent teeth is widely accepted as the correct therapeutic measure. However its long-term prognosis is still controversial, and many factors have been clained to affect their sucess rate (5).

The treatment of dental trauma requires a multidisciplinary attention (2). However, it represents one of the few situations where dentists are called upon to make unscheduled diagnostic and treatment decisions in an area that is outside their routine experience (3).

The aim of this study was to evaluate clinical and radiographic results (post-replantation factors) of 100 replanted teeth and relate the data obtained with the success or failure of the replantation.

Materials and methods

A retrospective study was conducted with patients who sought treatment, after tooth replantation, at the Dental Trauma Center of the Endodontics Area, at the Dental

School of Piracicaba, State University of Campinas, Piracicaba, SP, Brazil, between May 2002 and June 2004. The study consisted of 48 patients with ages between 7 and 40 years, which had previously received emergency treatment in other institutions, including replantation of the avulsed tooth and splintation. Data such as the patient's age and gender, period after replantation, etiology of the trauma, tooth identification and amount of traumatized teeth were registered on a standardized form. Information such as extra-oral dry time, storage media, stage of root formation, type and duration of splintation, which are pre-replantation factors, were also recorded.

Clinical and radiographic evaluation of the post-replantation factors

During clinical examination, the aspects studied were: presence or not of pulp vitality, mobility changes, tooth discoloration, tooth infra-position, percussion sounds, pain on palpation, and presence of fistulae (Fig. 1a–c).

Tooth sensibility was tested using –50°C carbon dioxide (Endo-Frost; Roeko, Langenau, Germany). Pulp necrosis was determined when a negative response to this test was associated with radiographic evidences. Other factors that supported such diagnosis were the presence of a permanent gray discoloration of the tooth and the stop of root formation. A color scale (3M, Campinas, SP, Brazil) was used to detect chromatic changes. Differences between the replanted and the adjacent teeth were observed (Fig. 1a).

Ultraspeed periapical films (Kodak, São José dos Campos, SP, Brazil) were used for radiographic analysis at 55 kVp and 15 mA using the long-cone technique at right angles. The radiographs were analyzed by two of the authors, under optimal conditions, while using a white-light illuminator (Lumatron; Encor Indústria Fotográfica Ltd, Rio Claro, SP, Brazil) and a magnifying

Fig. 1. Images of clinical and radiographic aspects of replanted teeth. Within the clinical characteristics observed, it was possible to observe not only mobility changes but also chromatic alterations of the dental crown by darkening (a), dental infra-position resulting from the process of dental socket ankylosis (b) and presence of fistulae (c). As regards radiographic aspects, it was possible to observe processes of inflammatory resorption, characterized by irregular radiolucent areas distributed along the extension of the radicular surface (d, e); replacement resorptions, in which the image of the affected tooth passes to assume the radiographic image of the alveolar bone (f) and root canal obliteration (g).

glass large enough to allow binocular observation. The following aspects were identified: inflammatory or replacement root resorption, pulp obliteration, periapical radiolucency, and presence or absence of root-filled or intracanal medication (Fig. 1d–g).

If signs of inflammatory resorption were detected, the presence of bowl-shaped cavities involving both cementum and dentine would be radiographically identified. Clinical findings such as increased mobility and fistulae could also be associated with this pathological sign.

The radiographic characteristics of a tooth undergoing replacement resorption process (i.e. ankylosis) are loss of the periodontal space, which is replaced by bone, and an uneven root surface contour (3). In this study, when in doubt and when none of these indicators were found, this feature was not noted down.

The presence of apical pathology was recorded when radiographs revealed a definite loss of lamina dura and apex radiolucency. Similarly, pulp canal obliteration was determined when there was dentin deposition on the walls of the root canal, and consequent reduction of its lumen (9).

According to clinical and radiographic findings, the treatment success of replanted teeth was classified either as complete success, acceptable success, uncertain success, or failure. Complete success was recorded when the tooth was present and did not show any clinical signs of infection, radiographic signs of root resorption or periapical pathology (sensitivity test = positive). Acceptable success was recorded when the tooth was still present (with intracanal medication, root filled or pulp necrosis: sensitivity test = negative), without clinical or radiographic signs of infection. The treatment of replanted tooth was classified as uncertain if it was still undergoing root canal therapy and there was presence of radiolucent images. Failure of the treatment was recorded when the replanted tooth presented root resorption. The specific criteria are given in Table 1.

Statistical analysis

The data were collected and statistically analyzed using SPSS for Windows (SPSS Inc., Chicago, IL, USA). Cross-tabulations with chi-squared test or Fishers' exact test were performed to examine the relationship between clinical and radiographic findings, and treatment results. Based on this analysis, the linear logistic regression analysis was used to investigate these relationships further.

Table 2. Distribution of replanted teeth according to gender and age range

Age range	Gender		Total, *n* (%)
	Female	Male	
≤7	1	0	1 (2.1)
8–14	10	19	29 (60.4)
15–20	5	7	12 (25.0)
21–26	1	3	4 (8.3)
≥27	1	1	2 (4.2)
Total	18 (37.5)	30 (62.5)	48 (100.0)

$P = 0.728$; $P < 0.05$ (Fishers' exact test).

Results

The mean age of the patients was 15 years and 9 months. A predomination of the male gender was observed through all age groups. However, such information, however, was not statistically significant ($P < 0.05$). It was also observed that the number of replanted teeth varied according to gender, as shown in Table 2. Fifty-nine of the replanted teeth were central maxillary incisors, 16 lateral maxillary incisors, 9 lateral mandibular incisors, 12 central mandibular incisors, and 4 maxillary canines.

The sample of this study comprised cases with different periods after replantation. The most prevalent period after replantation time was 6 months (30 cases), followed by periods of 2 years (22 cases), 4 years (17 cases), 3 years (11 cases), < 1 year (10 cases), 1 year (10 cases), and 10 years (1 case), as shown in Table 3.

The pre-replantation factors considered, such as stage of root formation, type and period of storage, type and duration of splintation, and extra-alveolar periods did not show any statistically significant association with the outcome of teeth replantation (complete success, acceptable success, uncertain success and failure).

The linear logistic regression analysis indicated that when the period after replantation was considered, the increase of time after replantation duplicated the occurrence of root resorption. The data show that there was a significant association between period after replantation and treatment success ($P = 0.026$).

Clinical evaluation

The sensitivity test showed that 27% of the teeth presented with pulp necrosis, and only 5% with pulp

Table 1. Evaluation criteria of the results related to replantation procedure

Complete success	Acceptable successful	Uncertain success	Failure
Absence of clinical and radiographic signs	Absence of clinical and radiographic signs	Presence or absence of clinical signs and presence of radiographic signs	Presence or absence of clinical signs and presence of radiographic signs
Sensitivity test = positive	Sensitivity test = negative	Sensitivity test = negative + radiolucent areas	Sensitivity test = negative + root resorption
Tooth vitality	Tooth with root filled, intracanal medication or pulp necrosis	Tooth with root filled or intracanal medication or pulp necrosis	Tooth with root filled, intracanal medication or pulp necrosis
		Presence of radiolucent areas	Presence of radiolucent areas
			Presence of root resorption

Source: Modified from Ref. (7).

Table 3. Correlation between replantation teeth and success/failure

Period after replantation	Complete success	Acceptable success	Uncertain success	Failure	Total
<6 months	3	4	13	10	30
<1 year	0	2	0	8	10
1 year	1	0	1	7	9
2 years	0	3	4	15	22
3 years	0	2	0	9	11
4 years	0	2	2	13	17
8–10 years	0	0	0	1	1
Total	5	12	20	63	100

$P = 0.026$; $P < 0.05$ (Fishers' exact test).

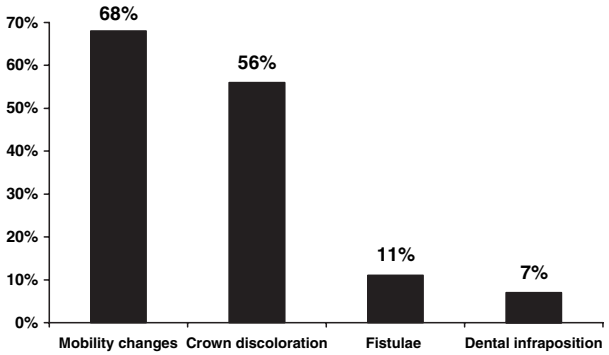

Fig. 2. Distribution of clinical aspects evaluated in relation to mobility changes, crown discoloration, fistulae and dental infraposition.

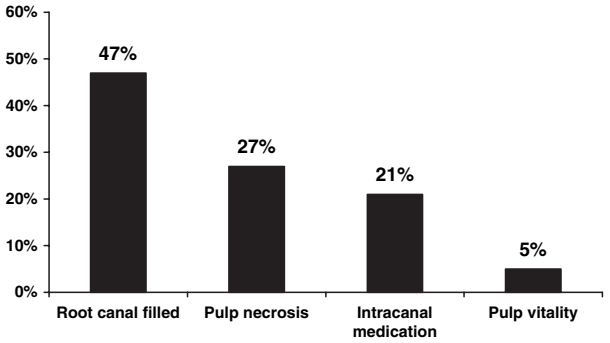

Fig. 3. Quantitave evaluation of root canal filled, pulp necrosis, intracanal medication and presence of pulp vitality.

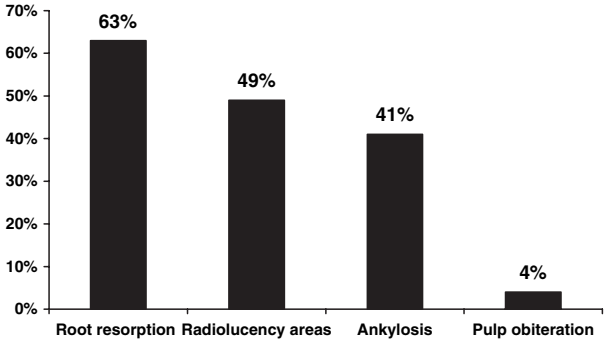

Fig. 4. Distribution of radiographic aspects evaluated in relation to presence of root resorption, radiolucency areas, ankylosis and pulp obliteration.

vitality. During clinical evaluation, 68 teeth revealed abnormal mobility (mobility changes). For instance, 27 presented decrease of mobility associated with any pathology (i.e. infection process and resorptions) and 41 presented absence of mobility (ankylosis). Fifty-six teeth had different types of crown discoloration, varying from yellow to gray. The presence of fistulae (11%) was sometimes associated with external inflammatory resorptions. Tooth infra-position was observed only in seven teeth (Fig. 2).

The results showed that there was a statistically significant relationship between the mobility changes ($P = 0.013$), necrosis ($P = 0.05$), and failure. No relationship was found in the case of presence or absence of fistula and infra-position ($P = 1.00$ and $P = 0.429$, respectively).

Radiographic evaluation

Among the teeth evaluated, 47 had been root-filled, while 21 were still undergoing treatment and presented with an intracanal medication (Fig. 3).

Radiographic evaluation revealed 49 teeth associated with radiolucent periapical areas, and 63 with images suggesting root resorptions. For instance, 41 teeth were classified as ankylosed and were associated with replacement resorption, while only 22 were identified with external inflammatory root resorptions according to clinical and radiographic aspects.

Only four teeth were seen to have root canal obliteration, two of them presenting associated radiolucent areas (Figs 1d–f and 4). Of the 100 replanted teeth, 89 had complete root formation while 11 were incompletely formed.

Chi-squared statistic analysis showed that the presence of radiolucent areas and resorptions associated with root surfaces were directly related to treatment failure ($P = 0.01$). The logistic linear regression analysis showed that only the presence of radiolucent areas and mobility were significant at a level of 5% and presented chance ratios of 6.122 and 0.302, respectively. After evaluation the clinical and radiographic aspects (post-replantation factors) were associated with success or failure related to the teeth replantation.

Figure 5 shows a total of 63 replanted teeth considered as failure (e.g. presence of the root resorption). Among the other cases, 20 teeth revealed uncertain success (radiolucent areas), while 12 teeth suggested acceptable success (root-filled, intracanal medication). These did not show signs of periapical infection and any root resorption was present. Only five teeth suggested complete success (tooth vitality).

Discussion

The outcome of tooth replantation shows wide variation. In some cases the teeth will remain functional for decades, while others are lost within weeks after replan-

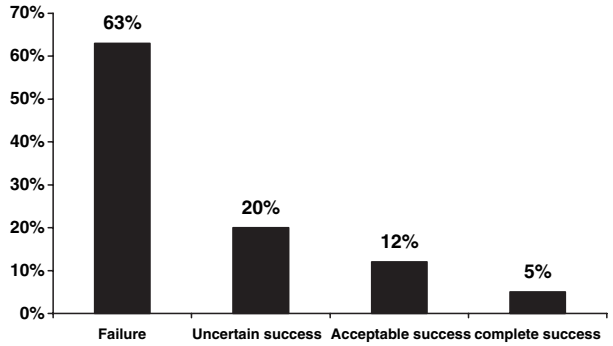

Fig. 5. Results of the treatment in the replanted teeth according to clincal and radiographic findings.

tation. Understanding the factors that govern the success or failure of replantation is important and has many implications.

Of the 100 replanted teeth, 89 had complete root formation while 11 were incompletely formed. According to Andreasen et al. (10), pulp revascularization may occur in replanted teeth with incomplete rizogenesis.

Around 70% of the replanted teeth analyzed in this study eventually received root canal treatment (intracanal medication and/or root canal filling). It was also observed that the frequency of teeth with intracanal medication (21%) was similar to that found in literature, as dressings are commonly indicated in cases of tooth replantation (11–14). A higher incidence of tooth loss was reported when the endodontic treatment was incomplete than when the endodontic treatment had already been concluded (3). Such results agree with earlier studies that suggest that teeth that have endodontic treatment present the best replantation results (15, 16). Nevertheless, the technical procedure of conventional root canal treatment in replanted teeth is difficult and highly demanding (17).

The percentage of pulp necrosis seen in this study (27%) is frequently encountered in literature (15, 16, 18), and is similar to the percentage reported by Andreasen (18), who found 24% of pulp necrosis in cases of tooth replantation. In general, around one-third of replanted teeth present pulp necrosis, which, consequently, is associated with the number of failures.

Clinical and radiographic evaluation results showed that 56% of the replanted teeth presented different types of crown discoloration, which varied from yellow to gray. This condition is frequently observed in traumatized teeth and is due to hemorrhage, pulp tissue decomposition, and the presence of bacteria inside the pulp chamber (19). Other authors (20, 21) have also mentioned such fact.

Mobility changes of teeth submitted to replantation were observed in 68% of the total number of cases in this study [27 – decrease of mobility and 41 – absence of mobility (ankylosis)], and are similarly reported by other authors (11, 12, 22). Eleven percent of all studied teeth were associated with fistulae. In a study involving 110 replanted teeth, the presence of fistulae was also mentioned that confirmed its occasional presence (11).

Among all evaluated teeth, 7% (four patients) presented infra-position. It should be observed that the age of these patients, at the time of avulsion, ranged between 9 and 18 years. Various studies relate the occurrence of this type of sequelae associated with teeth replanted in young patients (7, 23, 24).

The radiographic evaluation indicated radiolucent areas of different extensions in 49% of the teeth analyzed. According to Gonda et al. (8), the presence of radiolucent areas on the root apex and adjacent bone may be considered a pathognomonic sign of external inflammatory root resorption. Indeed, the results found in this study are in agreement with those of other authors (11, 12, 25).

Root resorptions were found in 63% of the evaluated teeth. The most frequent sequelae found was root replacement resorption (ankylosis), totaling 41% of all resorption cases. Various studies relate the association of root replacement resorption (ankylosis) with replanted teeth (11, 12, 25, 26). External and internal inflammatory resorptions were present in 22 and 2%, respectively, of all cases of teeth with root resorption.

Radiographic findings also revealed that pulp obliterations occurred in 4% of all replanted teeth. This type of sequelae is a result of the excessive and irregular formation of hard tissue that consequently reduces the pulp lumen (9, 27), and is frequently associated with history of tooth traumatism (27).

The logistic regression analysis showed a statistically significant relationship between the presence of radiolucent areas and mobility changes ($P < 0.05$). The analysis revealed that the occurrence of root resorptions would be 16 times more likely when ankylosis (absence of mobility) was present. Therefore, replacement resorption (ankylosis) in this study affected practically half of the evaluated teeth.

The period after replantation might be relevant for the prognosis of replanted teeth as the data show a significant association between period after replantation and success of the treatment. This finding is supported by Mackie & Worthington (7) who affirmed that the frequency of failed therapies varied directly proportional to the period after replantation.

Sequelae originated from replacement resorptions (ankylosis) generally affect children under development, promoting serious esthetics and functional deficiency caused by dental infra-position (24). Based on these data the doubtful prognosis of tooth replantation motivates a discussion about the indication or not of this therapeutic protocol.

Recently, other authors have questioned the real value of tooth replantation (24, 28, 29). However, great resistance is shown to this position, as tooth replantation has been adopted since ancient years and is considered to be widely performed and accepted. The present study confirms that replantation success is minimal and a revision of such protocol is paramount.

In dental trauma, few clinical studies investigated the negative influence of the survival expectation of replanted teeth (30). Despite the obviously dramatic impact of healing on tooth loss/tooth removal, only one

clinical study investigated and documented the negative influence of endodontic infections on the survival expectation of replanted teeth (31). Besides, the patients and/or their guardians should be informed about the limitations of replantation, as well as about possible future interventions. Furthermore, clinical studies must be undertaken aiming to offer new protocols beyond descriptive data.

Conclusion

In this study, it was possible to conclude that the prognosis and complications associated with replanted teeth must be taken into account. Moreover, a special attention should be given to resorptions, ankylosis, periapical radiolucent areas, and presence of signs of infections, as such factors may lead to failure of the tooth replantation.

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References

1. Côrtes MIS, Marcenes W, Sheiham A. Prevalence and correlates of traumatic injuries to the permanent teeth of school children aged 9–14 in Belo Horizonte. Endod Dent Traumatol 2001;17:22–6.
2. Trope M. Clinical management of the avulsed tooth. Dent Clin North Am 1998;39:93–113.
3. Barrett EJ, Kenny DJ. Avulsed permanent teeth: a review of the literature and treatment guidelines. Endod Dent Traumatol 1997;13:153–63.
4. Andreasen JO, Andreasen FM Text book and color atlas of traumatic injuries to teeth, 3rd edn. Copenhagen: Munksgaard; 1994. p. 771.
5. Andreasen JO, Kristerson L. The effect of extra-alveolar root filling with calcium hydroxide upon periodontal healing after replantation of mature permanent incisors in monkeys. J Endod 1981;17:349–54.
6. Ogunyinka A. Replantation of avulsed teeth: considerations and complications. Afr J Med Sci 1998;27:129–31.
7. Mackie IC, Worthington HV. An investigation of replantation of traumatically avulsed permanent incisor teeth. Br Dent J 1992;172:17–20.
8. Gonda F, Nagase M, Chen RB, Yakata H, Nakajima T. Replantation: an analysis of 29 teeth. Oral Surg Oral Med Oral Pathol 1990;70:650–5.
9. Jacobsen I, Kerebs K. Long-term prognosis of traumatized permanent anterior teeth showing calcifying processes in the pulp cavity. Scand J Dent Res 1077;85:588–98.
10. Andreasen JO, Borum MK, Jacobsen HI, Andreasen FM. Replantation of 400 avulsed permanent incisors: 2. Factors related to pulpal healing. Endod Dent Traumatol 1995;11:59–68.
11. Knight MK, Gans BJ, Calandra JC. The effect of root canal therapy on replanted teeth of dogs: a gross, roentgenographic and histologic study. Oral Surg Oral Med Oral Pathol 1964;18:227–42.
12. Andreasen JO. Periodontal healing after replantation and autotransplantation of incisors in monkeys. Int J Oral Surg 1981;10:54–61.
13. Heindahl A, Von Konow L, Lundqvist G. Replantation of avulsed teeth after long extra-alveolar periods. Int J Oral Surg 1983;12:413–7.
14. Cvek M, Cleaton-Jones P, Austin J, Lownie J, Kling GM, Fatti P. Effect of topical application of doxycycline on pulp revascularization and periodontal healing in replantated monkey incisors. Endod Dent Traumatol 1990;6:170–6.
15. Andreasen JO, Hjørting-Hansen E. Replantation of teeth: I. Radiographic and clinical study of 110 human teeth replanted after accidental loss. Acta Odont Scand 1966;24:263–86.
16. Andreasen JO, Hjørting-Hansen E. Replantation of teeth: II. Histological study of 22 replanted anterior teeth in humans. Acta Odontol Scand 1966;24:287–306.
17. Pohl Y, Filippi A, Kirschner H. Results after replantation of avulsed permanent teeth. I. Endodontic considerations. Dent Traumatol 2005;21:80–91.
18. Andreasen JO. Effect of pulp necrosis upon periodontal healing after surgical injury in rats. Int J oral Surg 1973;2:62–8.
19. Nutting EB, Poe GS. A new combination for bleaching teeth. J South Calif Dent Assoc 1963;31:289–91.
20. Cvek M. Endodontic management of traumatized teeth. In: Andreasen JO, Andreasen FM, editors. Textbook and color atlas of traumatic injuries to teeth, 3rd edn. Copenhagen: Munksgaard; 1994. p. 517–86.
21. Andreasen FM, Vestergaard Pedersen B. Prognosis of luxated permanent teeth – the development of pulp necrosis. Endod Dent Traumatol 1985;1:207–20.
22. Lenstrup K, Skieller V. A follow-up study of teeth replantation after accidental loss. Acta Odont Scand 1959;17:503–9.
23. Malmgrem B, Malmgrem O. Rate of infraposition of reimplanted ankylosed incisors related to age and growth in children and adolescents. Dent Traumatol 2002;18:28–36.
24. Kinirons MJ, Gregg TA, Welbury RR, Cole BOI. Variations in the presenting and treatment features in reimplanted permanent incisors in children and their effect on the prevalence of root resorption. Br Dent J 2000;189:263–75.
25. Trope M. Root resorption of dental and traumatic origin: classification based on etiology. Pract Periodont Aesthet Dent 1998;19:515–22.
26. Tronstat L. Root resorption: etiology, terminology and clinical manifestations. Endod Dent Traumatol 1988;4:241–52.
27. Andreasen JO. External root resorption: its implication in dental traumatology, paedodotics, periodontics, orthodontics and endodontics. Int Endod J 1985;18:109–18.
28. Trope M. Clinical management of the avulsed tooth: present strategies and future directions. Dent Traumatol 2002;18:1–11.
29. Flores MT, Andreasen JO, Bakland LK, Feiglin B, Gutman JL, Oikarinen K et al. Guidelines for evaluation and management of traumatic dental injuries. Dent Traumatol 2001;5:193–8.
30. Pohl Y, Wahl G, Filippi A, Kirschner H. Results after replantation of avulsed permanent teeth. III. Tooth loss and survival analysis. Dent Traumatol 2005;21:102–10.
31. Pohl Y, Filippi A, Tckin Y, Kirschner H. Periodontal healing after intentional auto-alloplastic reimplantation of injured immature upper front teeth. J Clin Periodontol 2000;27:198–204.