Dental Traumatology 2008; **24**: 151–158; doi: 10.1111/j.1600-9657.2007.00532.x

Evaluation of success in the reattachment of coronal fractures

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Accepted 16 May, 2006

Abstract – The aim of this study was to evaluate clinically and radiographically the restored teeth using reattachment technique of fractured fragment to the remaining tooth. This study was conducted on 11 children (six girls and five boys; age range: 8–13 years). Before the treatment, the teeth were evaluated clinically and radiographically. The broken incisal part was directly reattached to the remaining tooth part with flowable resin composite. Thereafter, with the purpose of obtaining optimal esthetics and function, along the fracture line an external 'double chamfer' in the shape of a V was created and then covered with resin composite. During the follow-up (1–24 months) after the treatment, the teeth were evaluated clinically and/or radiographically with regard to periodontal, pulpal, coronal, color harmony of the fragments, and occlusion. In addition, the restored teeth were assessed in terms of parental–patient ratings of satisfaction. Both clinically and radiographically, no pathology was reported and all the restorations were successful. Moreover, the mean scores of parental–patient satisfaction were reported as 'satisfied, very-satisfied.'

It has been reported that the percentages of simple (enamel + dentin) and complex (enamel + dentin + pulp exposure) coronal fractures that occur in children's teeth by traumas are 28–44% and 11–15%, respectively (1, 2). The restoration of such kinds of fractures is esthetically and functionally very important, and such teeth have commonly been restored using resin composite. However, these materials have some disadvantages such as their being worn away more rapidly than tooth hard tissues and discoloration in time (3). Therefore, if a broken fragment is available, the restoration of a tooth with its own fragment has been suggested as an alternative treatment (4–7). The advantages of this alternative treatment method include (6–10):

- regaining color and size of the original tooth,
- being worn away in a similar proportion to adjacent tooth without trauma,
- giving an emotionally and socially positive response due to the protection of natural tooth structure,
- rapid and conservative nature of the treatment,
- economical aspect of a one-visit treatment.

Reattachment techniques, such as direct reattachment of the fragment, internal enamel groove, internal dentinal groove and external enamel groove in the shape of a V, have been used (7, 8, 11, 12). Reis et al. (12) and Demarco et al. (13) pointed out that when reattaching without making any extra preparation for the broken incisal part and for the remaining tooth in the mouth, lower values than an intact tooth fracture strength were obtained. Therefore, they stated the necessity of the application of the aforementioned extra-preparations on the tooth when reattaching the broken incisal part. Also, De Santis et al. (14) found that the external enamel groove in the shape of a V at the tooth's coronal surface gave better results when compared with the direct reattachment of the fragments.

In case reports in which broken fragments were reattached by both internal enamel groove and external enamel groove in the shape of a V, the restoration applications were successful (6–8). In this study, the reattached teeth were systematically evaluated with regard to periodontal, pulpal, coronal, color harmony and occlusion, and parental–patient satisfaction scores.

Clinical assessment, treatment, and follow-up of the cases

The study included 11 patients, whose age average was 10 years and 4 months, and who were admitted to the Department of Pedodontics at the faculty of Dentistry of Ataturk University in the years 2003–2004. The patients had coronal fractures in their maxillary incisor teeth (enamel + dentin or enamel + dentin + pulp exposure) and all had broken fragments. Informed consent was obtained from all parents. Time passed since the trauma occurred ranged from 30 min to 3 days (mean: 18 h). Of 13 broken teeth, six were in dry storage, two in tap water, and five in saline solution. The remnants on the incisal parts were removed using a fluoride-less paste and the fragments were stored in saline solution until their reattachment (approximately within 30 min). The gender, trauma type, and the treatment techniques are given in Table 1.

Just before the treatment, the patients were clinically and radiographically examined. Further assessments after the treatment were made at 1, 3, 6, 12, 18 and 24 months.

Table 1. Distribution of teeth in terms of gender, trauma type, and treatment technique

Gender		Trauma type		Treatment technique	
Girl	Boy	Enamel + dentin	Enamel + dentin + pulp	Reattachment of the fragment	Endodontic treatment + reattachment of the fragment
6	5	6	7	6	7

In the clinical assessment, children's general conditions, their hard tissue injuries and soft tissue lacerations, examination of oral regions and head and neck regions were performed in detail. Thereafter, clinical and radiographic assessments were made as regards the fractured tooth or teeth. These assessments included periodontal tissues, pulpal, coronal, color harmony, and occlusion before and after the treatment. Furthermore, after the reattachment of the broken incisal part, parental and patient satisfaction evaluations related to the appearance of teeth, color, shape, size and remaining period in the mouth were made as described by Kupietzky and Waggoner (15). Local anesthesia (Ultracaine DS; Aventis, Istanbul, Turkey) was applied to all patients before the treatment.

Periodontal assessment

Before the treatment, the periodontal tissues around the affected teeth were examined with a periodontal probe in order to determine the coronal fracture line, and presence or absence of vertical root fracture. The clinically conducted periodontal assessment showed no vertical root fracture. The fracture line was at the supragingival level for all cases (Figs 1a,b and 2a,b). Moreover, the presence of the gingival tissue tear was evaluated in all cases, and in only one case a minor tear was seen (Fig. 3). Radiographically periodontal assessment was made on the occlusal radiographs. When taking their radiography, each patient wore a lead neck brace and a laboratory coat. The radiographs were recorded in a computer and evaluated in terms of alveolar bone fracture, lateral or extrusive luxation evidence, root fracture, pathologic root resorptions, and apical radiolucency using 100% enlargement (16).

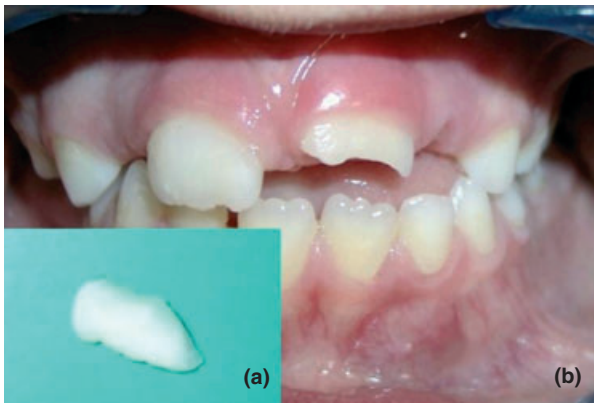

Fig. 1. Incisal (a) and coronal (b) parts of fractured maxillary left central incisor (enamel + dentin).

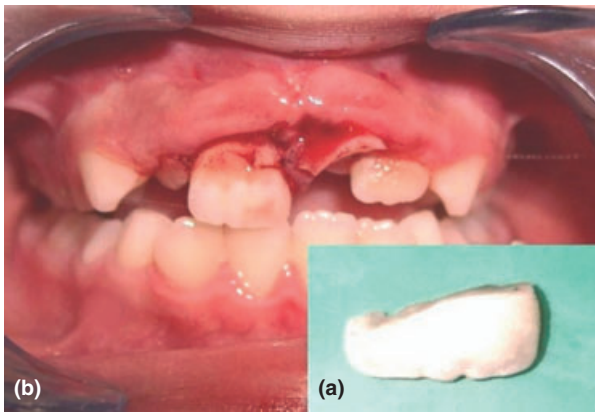

Fig. 2. Incisal (a) and coronal (b) parts of fractured maxillary left central incisor (enamel + dentin + pulp exposure).

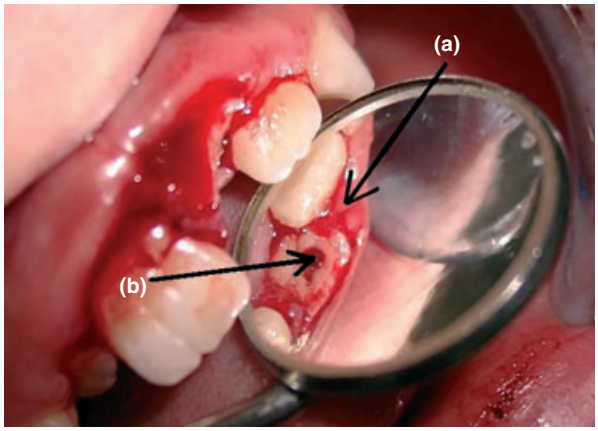

Fig. 3. Clinical appearance of fractured maxillary left central incisor (a: arrow for gingival tear; b: arrow for exposed pulp tissue).

The assessments showed that in only one case the tooth with lateral luxation changed its location from the socket to the lateral or apical part. This was the case with gingival tear clinically. The remaining cases ($n = 10$) did not display any of the above-mentioned pathologic diagnoses in the radiographic assessments.

Clinically, the gingival tear completely recovered after 10 days. In addition, in the periodontal assessment at all follow-up, swelling, abscess, draining sinus, color change, and loss of stippling on vestibular gingivae were evaluated. None of these symptoms and signs was observed. Radiographically, periodontal assessment at follow-up, an evaluation of the loss of lamina dura, presence of ankylosis, pathologic root resorptions,

alveolar bone margin resorption, and apical radiolucency checked but not found (16).

Pulpal assessment

All patients having trauma were evaluated clinically and radiographically in terms of pulp before and after the treatment. In the clinical assessment before the treatment, 7 of 13 teeth had pulp exposure. History of pulp sensitivity was taken from the patients and no change in pulp color was observed (Figs 3 and 4). Moreover, the remaining six teeth were found out to be sensitive to changes in pressure, dehydration and heat due to the exposed dentinal tubules (17). As the response of the tooth having trauma to the vitality test in the first visit was not significant due to it being in shock, the vitality test was carried out at the follow-up after treatment (18). Additionally, in the clinical assessment, discoloration of the coronal tooth part remaining in the mouth was also evaluated. No discoloration was observed in any of the cases.

In the radiographic assessment before the treatment, the level of root apex formation was noted. Four of thirteen teeth had open root apex (enamel + dentin = 2, Fig 5a; enamel + dentin + pulp exposure = 2, Fig. 6a). Further assessment was made to assess whether there was resorption and/or pulp canal obliteration (16). At the end of this assessment, these were not observed for all cases (Figs 5a and 6a).

Cervical pulpotomy was applied to the cases whose pulps were exposed. The teeth were isolated by rubber dam (Hygenic, Akron, OH, USA). Access to the coronal pulp was achieved using an aerator diamond bur (1015G; KG Sorensen, Braslleira, Brazil) and coronal pulp tissue up to the cervical constriction was removed with a sharp excavator. Hemorrhage from the exposed pulp was controlled by the application of a sterile cotton moistened using chlorhexidine for 3–5 min. A calcium hydroxide paste (Life Fast Set; Kerr, Salerno, Italy) was then applied to the exposed pulp (Fig. 7). Phosphoric acid (35%) (Vococid; Voco, Cuxhaven, Germany) was applied on hard tissues of the tooth. After 30 s, the acid was removed with an air-water spray and dried gently with polyurethane pellets (Pele Tim; Voco). Dentin bonding agent (Prime&Bond 2.1; Dentisply, Konstanz, Germany) was applied on the hardened

Fig. 4. The fractured maxillary right central incisor with a thin layer of hard dentin overlying a macroscopically unexposed pulp.

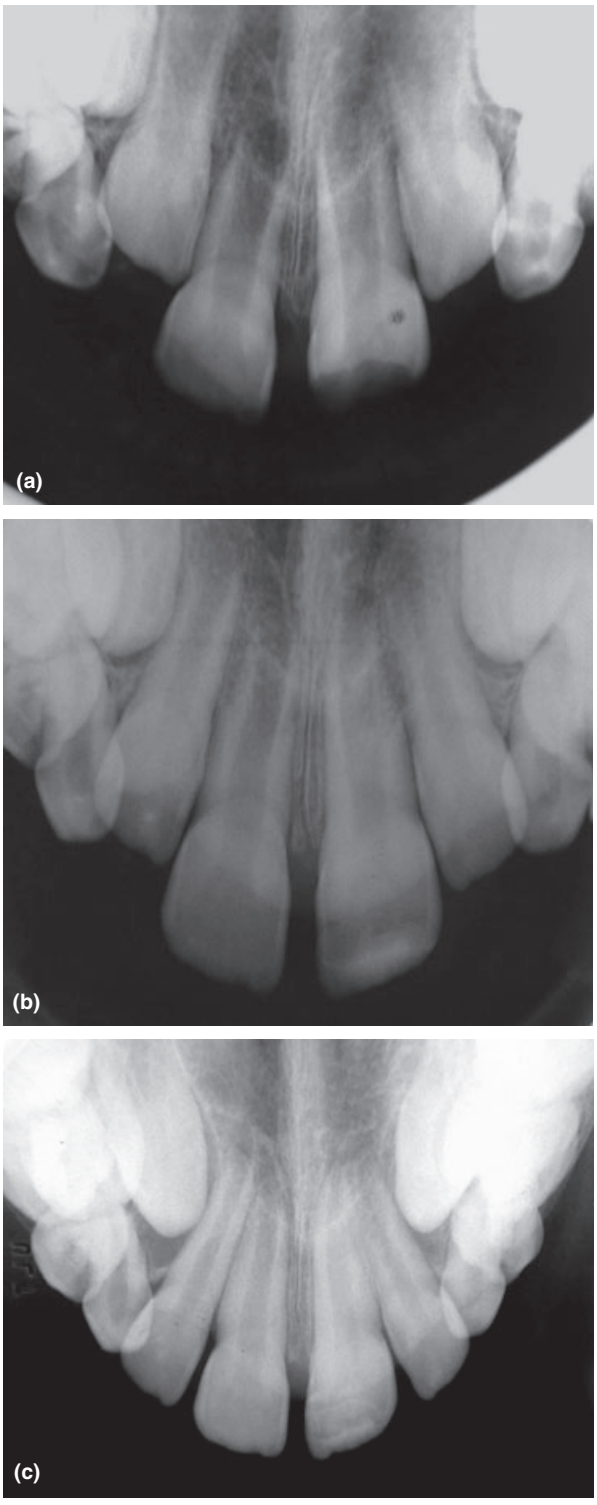

Fig. 5. Apical root development of the fractured immature maxillary left central incisor (a, before; b, 12 months after; c, 24 months after) (enamel + dentin).

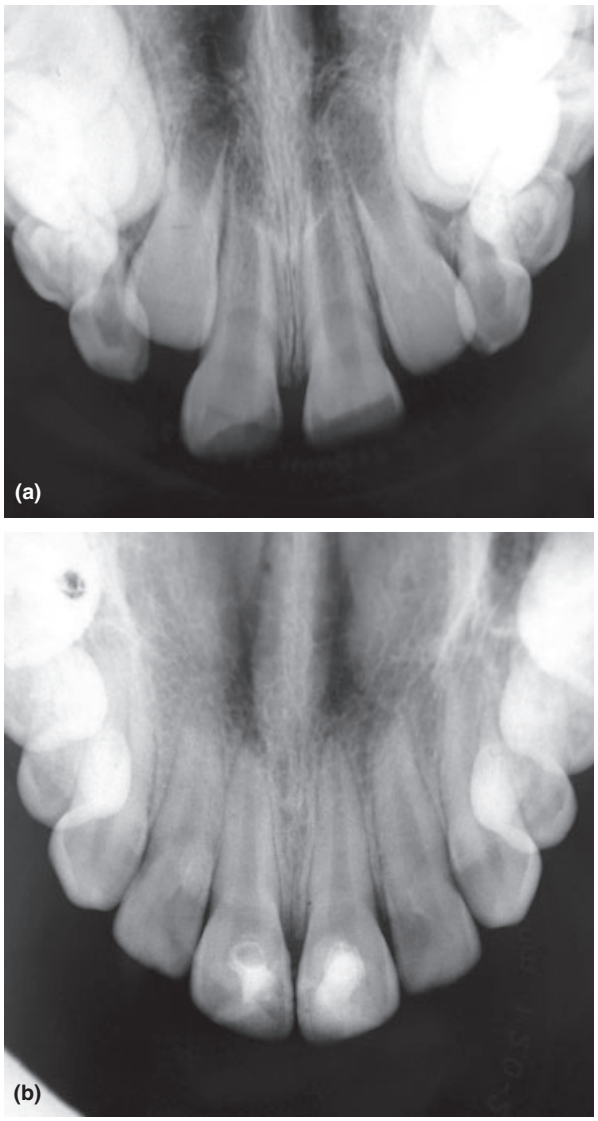

Fig. 6. Apical root development of the fractured immature maxillary central incisors (a, before; b, 24 months after) (enamel + dentin + pulp exposure).

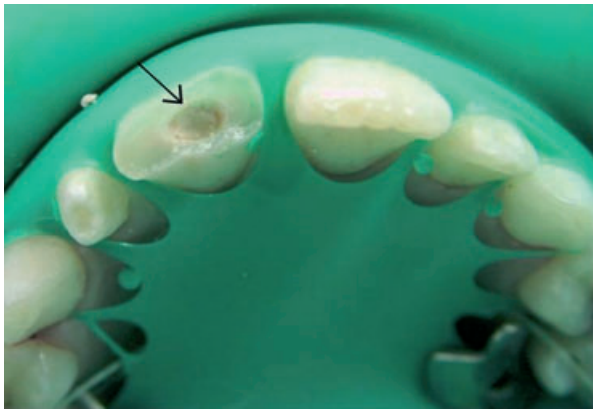

Fig. 7. Cervical pulpotomy application of the fractured maxillary right central incisor (enamel + dentin + pulp exposure).

Fig. 8. Hard tissue barrier formation apparent 24 months later (see arrow).

calcium hydroxide and tooth hard tissues, waited for 20 s, dried gently with water spray for 3 or 5 s and cured with visible light for 30 s.

In the clinical assessment at follow-up, the cases not undergoing cervical pulpotomy (enamel + dentin fragments) were evaluated in terms of discoloration (gray, blue, or red) of the coronal tooth part remaining in the mouth, discoloration as a result of pulp canal obliteration (yellowing), the results of the vitality tests of the teeth with both enamel + dentin and enamel + dentin + pulp exposure fragments, and tenderness to percussion (16, 18). These symptoms and signs were not observed.

In the radiographic assessment at follow-up, the level of apex formation of the teeth with root open apex, whether there was hard tissue barrier formation following cervical pulpotomy, pulp canal obliteration, apical radiolucency, and the radiographic evidence of pulp necrosis were evaluated. Apexogenesis in six teeth with open apex and hard tissue barrier in all teeth treated using cervical pulpotomy were noted (Figs 5a–c, 6a,b and 8).

Coronal assessment

In the coronal assessment before the treatment, the fracture line of the tooth fragment (enamel + dentin or enamel + dentin + pulp exposure) was evaluated. Moreover, any loss of additional tooth hard tissue in the broken incisal part was checked and a chipping was found in the fractured incisal part in 2 of 13 teeth (Fig. 9).

Following the assessment, the fragments were reattached. No internal groove was made in the fragments. Phosphoric acid (35%) was applied to the fracture surfaces with total-etch technique (Figs 10a,b and 11a,b). After 30 s, the acid was removed with an air-water spray and the surfaces were dried gently with polyurethane pellets. The dentin bonding agent (Prime&Bond 2.1) was applied to the prepared surfaces, waited for 20 s, spread over delicately with an air spray for 3–5 s and cured with visible light for 10 s. Utmost attention was paid to the dentin bonding agent so as not to cause any thickening on the surface.

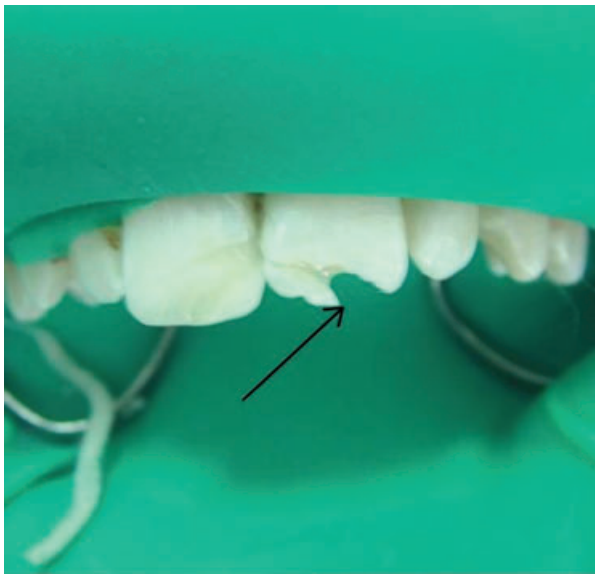

Fig. 9. Chipping in the broken incisal part of the fractured maxillary left central incisor.

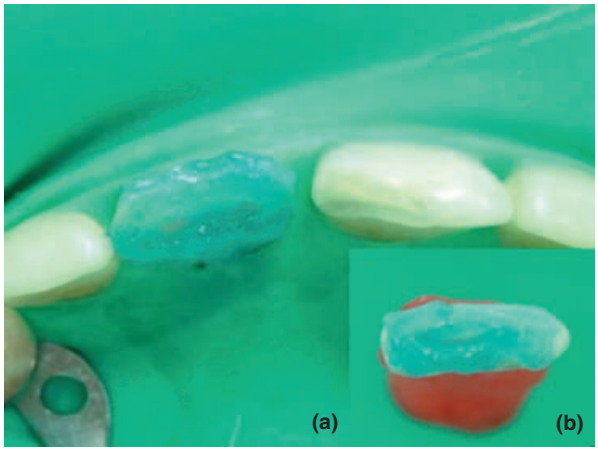

Fig. 10. Etching of the coronal (a) and incisal (b) parts of fractured maxillary right central incisor (enamel + dentin).

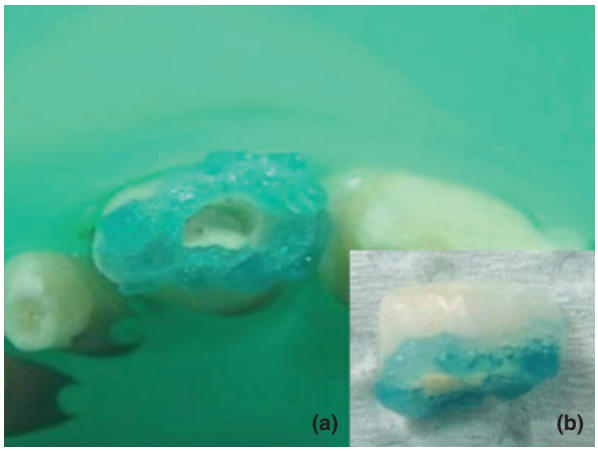

Fig. 11. Etching of the coronal (a) and incisal (b) parts of fractured maxillary right central incisor (enamel + dentin + pulp exposure).

The flowable resin composite (Tetric Flow; Ivoclar Vivadent, Schaan, Liechtenstein) was used to reattach the broken incisal part of the tooth in the mouth. The flowable resin composite was preferred because of its thixotropic quality, penetration, and its relative fluidity (19). Moreover, this material is used for restoration of a fractured tooth using the original tooth fragment (19, 20). The flowable resin composite was applied to the fracture surfaces of both parts, spread over the surface with a dental probe, and the fragments were reattached to their places (Fig. 12). The overflowing resin composite was removed and cured with visible light for 20 s from both the vestibular and lingual surfaces. A V-shaped external 'double chamfer' was created along the junction line using a diamond inverse cone bur (FG010012, HRC101; HORICO, Berlin, Germany) (Fig. 13). The 'double chamfer' was then etched with phosphoric acid for 30 s (Fig. 14), washed with an air-water spray and dried with polyurethane pellets. The application of dentin bonding agent was made as described above. A hybrid resin composite (Valux Plus; 3M, Seefeld, Germany) that is similar in color to that of the flowable resin composite was chosen, and composite bandage was made using the incremental technique to obtain optimal esthetics and function (5). Each layer was cured with visible light for 40 s.

Treating the teeth, no post or pin was used to increase the reattachment strength of the fragments. The finishing and polishing were made with Sof-Lex discs (3M) (Figs 15a,b and 16a,b). Occlusion was checked. Oral hygiene training was given to the patients.

Color harmony

The reattachments were photographed to allow evaluation of their clinical color match (15). Color match assessment was determined similar to Kupietsky and Waggoner's (15) criteria rating system (Alpha, no

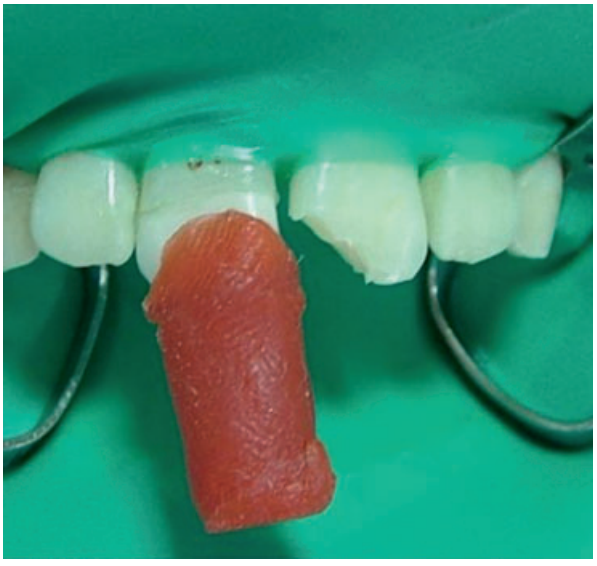

Fig. 12. Repositioning of the incisal part using flowable resin composite.

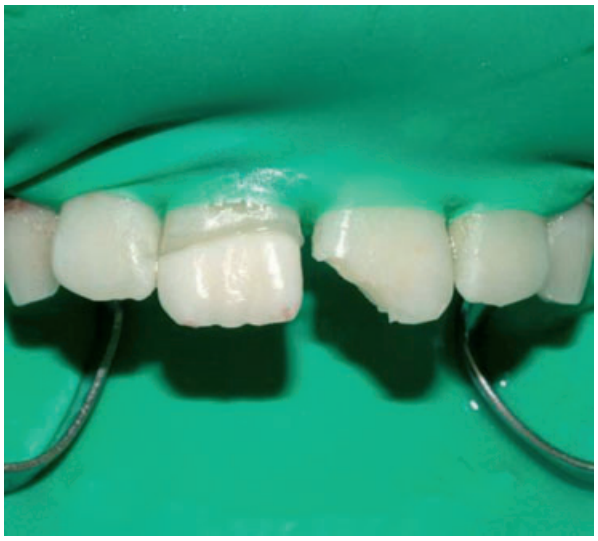

Fig. 13. External 'double chamfer' created on the fractured maxillary right central incisor.

Fig. 14. Etching of the double chamfer.

Fig. 15. Coronal fracture of maxillary left central incisor involving enamel and dentin before (a) and immediately after (b) the reattachment (score Alpha).

Fig. 16. Reattachment of fractured maxillary right central incisor with enamel + dentin + pulp exposure before (a) and immediately after (b) the treatment.

Table 2. Color match scores of reattached teeth

	Follow-up (months)							
Scores	Baseline	1	3	6	9	12	18	24
Alpha	2	3	4	7	10	13	13	13
Bravo	5	10	9	6	3	0	0	0
Charlie	6	0	0	0	0	0	0	0

noticeable difference from adjacent tooth; Bravo, slight shade mismatch; Charlie, obvious shade mismatch). The photograph assessments were made twice successively by an independent rater (a research assistant in pediatric dentistry). Kappa statistics was used to measure the reproducibility. The kappa score of the intraexaminer reproducibility was 0.83. Kappa values above 0.75 denote excellent agreement (21).

Color match scores immediately after reattachment and follow-up are shown in Table 2. Two of thirteen teeth had Alpha score at baseline (Fig. 15b). However, the alpha score increased with time, particularly after month 12 (Figs 17a,b and 18a,b).

Occlusal assessment

Occlusion was checked to prevent the stress from the patients' protrusive interference. At the follow-up, occlusion was checked clinically and no primary contact was detected. The widening of periodontal space, a sign of occlusal trauma, was also evaluated radiographically and no problem was detected (22) (Figs 5c, 6b and 8).

Assessment of parental–patient satisfaction

Kupietzky and Waggoner's (15) assessment questionnaire was used to find out the satisfaction level of parents and patients (Table 3). The questionnaire was given to the parents and patients 12 and 24 months after the treatment, and their satisfaction level was evaluated in terms of appearance, color, shape, and size and remaining in the mouth. The scoring system in the evaluation scale was from 1 to 5 (from very unsatisfied at very

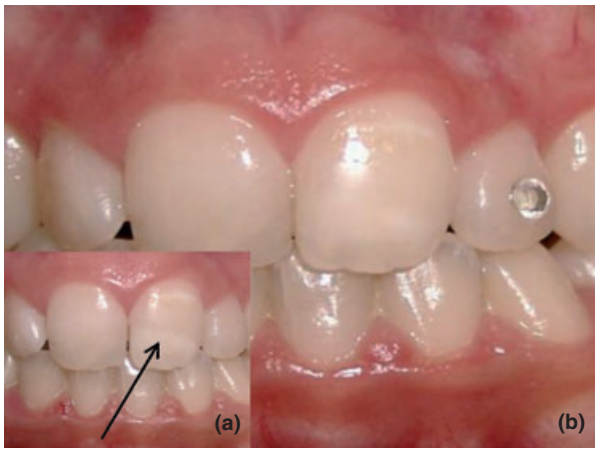

Fig. 17. (a) The color difference between the coronal and incisal parts at baseline (score Charlie). (b) Clinical view. 12 months after reattachment (score Alpha) (enamel + dentin).

Fig. 18. (a) Clinical appearance of reattachment of the discolored incisal part to fractured maxillary left central incisor (score Charlie). (b) The maxillary left central incisor regaining original color after 12 months (score Alpha) (enamel + dentin + pulp exposure).

Table 3. Scale of parental–patient satisfaction

	Average for satisfaction			
	Parental		Patient	
Assessment criteria	12 months	24 months	12 months	24 months
Appearance	4.4	4.7	4.4	4.8
Color	4.2	4.8	4.5	4.8
Shape	4.7	4.9	4.9	5.0
Size	4.7	5.0	5.0	5.0
Period in the mouth	5.0	5.0	5.0	5.0
Average	4.6	4.9	4.8	4.9

1: very unsatisfied; 2: unsatisfied; 3: uncertain; 4: satisfied; 5: very satisfied.

satisfied). The mean scores for parental and patient satisfaction are given in Table 3. The rating scores from parental and patient satisfaction for each evaluation criterion ranged from 4 to 5 (satisfied or very satisfied).

Discussion

When the fractured incisal part is still available, reattaching it to the remaining tooth in the mouth is an alternative treatment. In this study, reattached teeth were evaluated with respect to the periodontal, pulpal, coronal, color harmony, occlusion, and parental–patient satisfaction level. In the clinical examination of the patients' periodontal tissues at follow-up, swelling and discoloration in the vestibular gingivae, abscess, sinus, and loss of stippling were evaluated and none of these symptoms were observed in the patients. These results are in agreement with previous reports (6–8, 11, 23). After the treatment, periodontal tissues were evaluated radiographically with regard to pathologic resorption which may occur on all parts of the root (18). These kinds of resorption were not observed in any of the cases, not even in the case with lateral luxation. The endodontic treatment to be applied to the injured tooth is related to the fracture line. Seven of thirteen fractured teeth with complicated coronal fractures (enamel + dentin + pulp exposure) were cervically amputated (21). The remaining were treated without making any endodontic treatment. It has been mentioned that when cervical pulpotomy is carried out using calcium hydroxide, there will be a systematic recovery and also a calcific barrier formation at 2–3 months (16). Therefore, calcium hydroxide pulpotomy technique was preferred in the endodontic treatment. For this study, in the clinical and radiographic endodontic assessment at follow-up after the treatment, the discoloration of the tooth remaining in the mouth, the loss of vitality, tenderness to percussion, the failure of the formation of physiologic apex, apical radiolucency, and pulp canal obliteration were not seen. All cases had 100% success.

At the follow-up, fragment detachment was not observed in any case. The use of flowable resin composite in the reattachment of the fractured incisal part to the tooth hard tissue and creating a V-shaped external 'double chamfer' along the fracture line and covering it with resin composite might have contributed to this end. Cengiz et al. (20) reattached the tooth fragment using a flowable resin composite and reported successful results after 2.5 years. In other studies, it was stated that the fracture strength obtained by the direct reattachment of the fragments was lower than an intact tooth fracture strength, and additional preparations were recommended (13, 14).

Alpha scores for color match ranged from 15% (baseline) to 100% (especially after 12 months). This result is in agreement with the results of Simonsen (7) and Toshihiro and Rintaro (24) who explained that the incisal fragment may regain some original color because of water absorption in mouth.

Kupietzky and Waggoner's (15) assessment scale was used to determine the level of parental and patient

satisfaction. At the 12th and 24th month follow-up, the satisfaction mean scores were 4.6 and 4.9 for the parents and 4.8 and 4.9 for the patients, respectively. Both parent and patient satisfaction was affected because of appearance and color of the reattached teeth, but just a little. Their overall satisfaction was approximately very satisfied.

Conclusions

- Reattachment was periodontally found to be a successful treatment method.
- Through follow-up, the clinical discoloration, radiographic apical radiolucency, pathologic root resorptions and pulp canal obliterations in the teeth were not observed. The hard tissue barrier formation and physiologic apex formation were seen in the teeth. Therefore, the treatments were successful in terms of pulpal.
- The combination of the flowable resin composite and hybrid resin composite used to reattach the tooth's fractured incisal part was successful.
- The opaque appearance in the fractured incisal part decreased with time.
- The use of original fragments of fractured teeth was reported as 'satisfied', 'very satisfied' in terms of parental and patient satisfaction.

References

1. Kirzioglu Z, Ozay Erturk MS, Karayilmaz H. Traumatic injuries of the permanent incisors in children in southern Turkey: a retrospective study. Dent Traumatol 2005;21:20–5.
2. Kargul B, Caglar E, Tanboga I. Dental trauma in Turkish children, Istanbul. Dent Traumatol 2003;19:72–5.
3. Powers JM. Cements. In: Craig RG, Powers JM, editors. Restorative dental materials, 11th edn. St. Louis, MO: Mosby; 2002. p. 618–22.
4. Curzon MEJ, editor. Special tests: radiographs and sensibility (vitality) testing. In: Handbook of dental trauma: a practical guide to the treatment of trauma to the teeth. Cornwall: MPG Books Ltd; 1999. p. 18–27.
5. Andreasen JO, Andreasen FM, editors. Crown fractures. In: Essentials of traumatic injuries to the teeth. Copenhagen: Munksgaard; 1992. p. 29–46.
6. Kirzioglu Z. Restoration of a fractured incisor by using original tooth fragment: a case report. Ataturk Univ Dis Hek Fak Derg 1994;4:120–4 (English Abstract).
7. Simonsen RJ. Restoration of a fractured central incisor using original tooth fragment. J Am Dent Assoc 1982;105:646–8.
8. Diangelis AJ, Jungbluth M. Reattaching fractured tooth segments: an esthetic alternative. J Am Dent Assoc 1992; 123:58–63.
9. Worthington RB, Murchison DF, Vandewalle KS. Incisal edge reattachment: the effect of preparation utilization and design. Quintessence Int 1999;30:637–43.
10. Dean JA, Avery DR, Swartz ML. Attachment of anterior tooth fragments. Pediatr Dent 1986;8:139–43.
11. Rappelli G, Massaccesi C, Putignano A. Clinical procedures for the immediate reattachment of a tooth fragment. Dent Traumatol 2002;18:281–4.
12. Reis A, Loguercio AD, Kraul A, Matson E. Reattachment of fractured teeth: a review of literature regarding techniques and materials. Oper Dent 2004;29:226–33.
13. Demarco FF, Fay R-M, Pinzon LM, Powers JM. Fracture resistance of re-attached coronal fragments-influence of different adhesive materials and bevel preparation. Dent Traumatol 2004;20:157–63.
14. De Santis R, Prisco D, Nazhat SN, Riccitiello F, Ambrosio L, Rengo S et al. Mechanical strength of tooth fragment reattachment. J Biomed Mater Res 2001;55:629–36.
15. Kupietzky A, Waggoner WF. Parental satisfaction with bonded resin composite strip crowns for primary incisors. Pediatr Dent 2004;26:337–40.
16. Andreasen JO, Andreasen FM, Bakland LK, Flores MT. Traumatic dental injuries, 2nd edn. Copenhagen: Blackwell Munksgaard; 2003.
17. Olsburgh S, Jacoby T, Krejci I. Crown fractures in the permanent dentition: pulpal and restorative considerations. Dent Traumatol 2002;18:103–15.
18. Roberts G, Longhurst P. Oral and dental trauma in children and adolescents. New York: Oxford; 1996.
19. Bayne SC, Thompson JY, Swift EJ, Stamatiades P, Wilkerson M. A characterization of first-generation flowable composites. J Am Dent Assoc 1998;129:567–77.
20. Cengiz SB, Kocadereli I, Gungor HC, Altay N. Adhesive fragment reattachment after orthodontic extrusion: a case report. Dent Traumatol 2005;21:60–4.
21. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–74.
22. Ash MM, Ramfjord S, editors. Occlusion in operative and restorative dentistry. In: Occlusion, 4th edn. Philadelphia, PA: W.B. Saunders; 1995. p. 390–444.
23. Chu FCS, Yim TM, Wei SHY. Clinical considerations for reattachment of tooth fragments. Quintessence Int 2000;31: 385–91.
24. Toshihiro K, Rintaro T. Rehydration of crown fragment 1 year after reattachment: a case report. Dent Traumatol 2005;21: 297–300.