

ETIOLOGIC FACTORS AND CLINICAL EVALUATION OF RESTORED FRACTURED ANTERIOR TEETH: AN OBSERVATIONAL STUDY

Kırık Anterior Dişlerin Etiyolojisi ve Restorasyonunun Klinik Değerlendirmesi: Gözlemsel Bir Çalışma

Uzay KOÇ VURAL, Arlin KİREMİTÇİ, Saadet GÖKALP

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ABSTRACT

Purpose: The aims of this study were to investigate the etiologic factors and to evaluate performance of composite resin on fractured crown in permanent anterior teeth at 6 and 12 months. **Subjects and Methods:** Records from 51 patients were retrieved from a Dental School Clinic, comprising 73 fractured anterior teeth directly restored with a submicron hybrid composite (Spectrum TPH) resin and respective adhesive system (Prime&Bond NT) were evaluated. The United States Public Health Service criteria were used to assess the clinical evaluation. Data were analyzed using the Wilcoxon Signed Rank, Kruskal–Wallis, Mann–Whitney U, and Siegel and Castellan tests. **Results:** Seventy-two maxillary incisors and one canine of 51 patients were evaluated. The patient's age at the time of therapy ranged from 14 to 64 years old (mean 25.47). Mostly observed crown fracture was seen in upper incisors (84.9%) and due to falls (58.8%). At the 6-month follow-up, one patient lost one restoration and at the 12-month, one patient lost one and one lost two restorations. A statistically significant difference was found in terms of marginal adaptation between 6 and 12 months. **Conclusion:** In this short-term observation period, remaining tooth structure was conserved and good patient compliance was achieved. Factors such as esthetic and/or cost should be considered to indicate the direct composite restorations.

Keywords: Dental trauma; direct composite resin; anterior restoration; incidence of trauma

ÖZ

Amaç: Bu çalışmanın amacı kırılmış daimi dişlerin etiolojisini araştırmak ve yapılan restorasyonların 6 ve 12. aylardaki performansını değerlendirmektir. **Bireyler ve Yöntem:** Diş hekimliği fakültesinin kayıtlarından faydalanarak 51 hastanın bir submikron hibrit kompozit (Spectrum TPH) ve kendi adezivi (Prime&Bond NT) kullanılarak tedavi edilmiş 73 kırık dişine ait kayıtlarına ulaşılmıştır. Veriler Wilcoxon Signed Rank, Kruskal–Wallis, Mann–Whitney U ve Siegel and Castellan testleri kullanılarak analiz edilmiştir. **Bulgular:** 51 hastada, 72 üst keser ve 1 kanin diş değerlendirilmiştir. Hastaların tedavi edildiği yaş aralığı 14-64 tür (ortalama 25.47). Kron kırığı en çok üst çenede (%84.9) ve düşme nedeniyle (%58,8) oluşmuştur. 6 ayda 1 hastada 1 restorasyon başarısızlığa uğramış, 12 ayda 1 hastada 1 ve başka bir hastada da 2 restorasyon başarısızlığa uğramıştır. 6 ve 12 ay arasında marjinal adaptasyon üzerinde istatistiksel olarak anlamlı bir sonuç bulunmuştur. **Sonuç:** Bu kısa gözlem süresi sonunda, kalan diş yapısının korunduğu ve iyi bir hasta memnuniyetine ulaşıldığı görülmüştür. Direk kompozit restorasyon yapımına karar verilirken estetik ve maliyet gibi faktörler göz önüne alınmalıdır.

Anahtar kelimeler: Dental travma; direk kompozit rezin; anterior restorasyon; travma insidansı



Introduction

Oro-facial trauma, the second most common cause of tooth loss, has a significant negative effect on patient's appearance and mastication. It mainly affects the children and adolescents, especially their maxillary central incisors, which are the most visible. The most common risk factors are falls, automobile/bicycle accidents, collisions, gender and age, some behavioral characteristics, physical and sporting activity (1). The worldwide prevalence of traumatic dental injuries ranges between 6%-37% (2-4). Seasonal variations in the prevalence of trauma have also been reported (5-7). Dental trauma (DT) of the incisors and their supporting tissues, which is one of the most challenging dental emergency situations, requires immediate assessment and management due to psychological and physical reasons (4). This is especially important for young permanent teeth because of continuing development in order to minimize undesired complications. The treatment of dental trauma is sometimes neglected (8, 9) although it might lead to pain, difficulty in articulation and mastication as well as having considerable negative effects on patient's self-esteem (10, 11). However, aesthetics of the anterior teeth are very important aspects of human appearance and could be affected by many factors including the presence of fillings, tooth color, position, alignment, shape and number (12-16).

Cumulative epidemiological data on dental trauma are being reported from different countries. Published data on dental trauma relevant to the Turkish population is not sparse. Aren *et al.* (17) investigated type and cause of traumatic orofacial injuries in children up to 18 years of age and reported primary localization of the trauma was in the frontal region (41%) among the 1296 children in 12055 patients with orofacial trauma, who applied to Istanbul University, Medical Faculty, Department of Emergency. Tümen *et al.* (18) reported the prevalence of dental injuries as 8.0% in preschool children from 2 to 5 years old in South-Eastern Anatolia, Turkey. Toprak *et al.* (19) have reported that, of 154 patients aged 1-13 years, 337 traumatized teeth were observed over a two-year period in a public university. In this study, dental injuries were found to be most frequent in the 6-12 year age group. Zuhail *et al.* (20) have reported 317 children aged 6 -17 years with 514 permanent incisor teeth with trauma history, who applied for treatment in a 3-year period from the southern cities of Turkey. Kargul *et al.* (21) reported 120 girls and

180 boys (mean age: 7.87 ± 3.19) with trauma over a 2-year study period. In a previous study, Sari *et al.* (22) reported that the prevalence of traumatic dental injuries was 4.4% in all age groups in the data gathered from 5800 clinical patients from 2007 to 2011 in Samsun, Turkey. In this study, injuries were most commonly observed between 11-20 years. Although indirect (such as crowns) and direct treatment options do exist, monochromatic restorations are a common approach in the treatment of fractured anterior teeth since those are conservative, predictable, repairable, and inexpensive (23). To the best of our knowledge, clinical data on the long term follow up of fractured anterior teeth restored with direct composite resins is limited in the literature.

Therefore, the aims of this observational study were; to investigate the etiologic factors, effects of age and gender on DT and to examine the clinical behavior of direct composite resin performed with a submicron hybrid composite in vital and non-vital traumatized anterior teeth.

Subjects and Methods

Study population and evaluation protocols

The database of clinical records of the Restorative Dentistry Clinic at Hacettepe University, School of Dentistry was used in the present evaluation. All direct composite restorations that were placed by a postgraduate student during Restorative Dentistry courses (certificate program) between 2012 March to 2013 April, were selected for this analysis. This observational study were based on the analysis of patient records which were obtained at initial diagnosis and on the treatment methods of patients subjected to dental trauma. All restorations with minimum observation time of 12 months were selected from the clinical records. Restorations were placed either in vital or non-vital teeth, by using submicron hybrid composite resin (Spectrum TPH, Dentsply, Konstanz, Germany) and respective adhesive system (Prime&Bond® NT, Dentsply, Konstanz, Germany) (Table 1).

Patients were excluded if they had also received ceramic or composite veneers, severe parafunctional habits or poor oral hygiene. In total, 51 patients having 73 traumatized permanent incisors and one canine (four non-vital and 69 vital teeth) fulfilled the inclusion criteria.

Table 1. Brands, composition and manufacturer data of the restorative materials used in this study.

Material	Composition	Manufacturer
Spectrum TPH	<ul style="list-style-type: none"> • Bis-GMA-adduct {adduct of 2,2- Bis[4-(2-hydroxy-3-methacryloyloxypropoxy)-phenyl] propane with hexamethylene diisocyanate} • Bis-EMA {2,2-Bis[4-(2-methacryloyloxyethoxy)-phenyl]propane} • TEGDMA (3,6-dioxaoctamethylene dimethacrylate) • Photo initiators • Stabilizers • Bariumaluminiumborosilicate (mean particle size < 1.5 µm) • Highly dispersed silicon dioxide (particle size 0.04 µm) 	Dentsply, Konstanz, Germany
Prime&Bond NT	<ul style="list-style-type: none"> • Di-and trimethacrylate resins • Functionalised amorphous silica • PENTA (dipentaerythritol penta acrylate monophosphate) • Photoinitiators • Stabilizers • Cetylamine hydrofluoride • Acetone 	Dentsply, Konstanz, Germany

Evaluation of restorations was conducted as a part of routine clinical controls by two experienced clinicians at 6th and 12th months following the procedure. The data on the type of the material used, tooth vitality (vital or non-vital) date of placement, age, gender, time and cause of the injury, time interval between trauma and treatment, number of tooth affected, tooth sensitivity and related information were gathered from patients files. The type of trauma was described according to the Ellis' classification; Class I included only enamel fracture; class II included enamel and dentin fracture; and class III included enamel and dentin fracture with pulp tissue exposure which required root-canal treatment. All restorations were placed in a routine treatment protocol which is described below. In case of Ellis III crown fracture, the tooth was first endodontically treated by conventional methods and in case of Ellis I and II crown fracture, an extended bevel was performed by means of sterile diamond burs at high speed under water cooling on both the facial and palatal surface, to allow for a gradual increase in the resin composite thickness. No additional mechanical retention was performed. Incisal edges and corners were rounded. The enamel was etched with 37% phosphoric acid for 30 s and with dentin for 15 s and rinsed thoroughly with water. Excess water was removed with an air syringe. Isolation was performed using a saliva ejector and cotton rolls. The adhesive was applied using a micro brush and gently dried with an air syringe for 5 s. After leaving a shiny surface, it was LED light-cured for 20 s (Led Max 5; Hilux, Benlioglu Dental, Ankara, Turkey) set to 500–700 mW/cm² intensity. The composite resin was placed using the incremental technique in 2 mm layers and light polymerized

for 20 s. All restorations were finished with extra/ ultra-fine composite finishing burs (Diatech Dental AC, Heerbrugg, Switzerland) and polished with discs (SwissFlex; Diatech Dental AC, Heerbrugg, Switzerland). The Enhance PoGo Complete Kit (Dentsply, Addlestone, York, PA, USA) was used to polish the palatal surface. Interproximal areas were examined using dental floss. Occlusion was evaluated by the help of lateral and protrusive movements of the mandible. Any necessary adjustment was done with a finishing bur, and the final polishing procedure was repeated. At recalls, wet gauze pads were used to clean tooth surfaces before the clinical examination, and clinically evaluated by two experienced and examiners using dental explorer and mirror, in accordance to following United States Public Health Service (USPHS) criteria for the clinical evaluation of *dental restorative* materials and findings were recorded on the standardized trauma forms. Evaluated criteria were; percussion sensitivity, sensitivity to cold air, color match, marginal adaptation, anatomic form, surface roughness, marginal discoloration and secondary caries. Two investigators analyzed the restorations. In case of disagreement, a senior researcher other than the study investigators analyzed the restorations and a final consensus was reached.

Statistical analysis

Statistical Package for Social Sciences (SPSS) for Windows software, version 21.0 (IBM SPSS Statistics for Windows, Version 21.0, Armonk, NY, USA) was used for data analysis. Descriptive statistics were used to report the frequency distribution of the evaluated criteria. The Fisher's exact or Pearson's

Chi-square tests were used to analyze differences between two variables and confidence interval was set to 95%. Intra-group comparisons of baseline, 6, and 12 months values were also performed. Differences in the evaluated variables of the clinical status of the restorations over time were analyzed using the Cochran test.

Results

There were 73 restorations in 51 patients. 27 men and 24 women with anterior dental trauma who were examined on a 12 month study period were included in the study. All invited participants attended to recalls which took place at 6th and 12th months. Mean age of participants was 25.47 ± 14.05 years (Table 2).

Table 2. Demographic information of the study participants.

Demographic Information		
Age* (n = 51)	n	%
14–16	16	31.4
17–24	18	35.3
25–64	17	33.3
Sex (n=51)		
Female	24	47.1
Male	27	52.9

* $X \pm SS = 25.47 \pm 14.058$

Table 4. Etiology of dental trauma by age.

Age	Falls		Collision with people		Bicycle accident		Sports accident		Car accident		Struck by an object		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
14-16	11	21.5	1	2.0	1	2.0	2	4.0	-	-	1	2.0	16	31.4
17-24	9	17.7	4	7.8	1	2.0	1	2.0	1	2.0	2	3.9	18	35.2
25-64	10	19.6	1	2.0	-	-	-	-	1	2.0	5	9.8	17	33.3
Total	30	58.8	6	11.8	2	3.9	3	5.9	2	3.9	8	15.7	51	100

Thirty-one patients had one (60.8%), 18 patients had two (35.3%) and two patients had three (3.9%) fractured teeth by the trauma. Mostly observed fracture type was Ellis II crown fracture, which was statistically significant ($p < 0.001$) (Table 5). According to USPHS criteria, retention rate was 98.6% at six months, 91.78% at 12 months. One patient had lost one restoration; three patients had lost five restorations at the end of 6, and 12 months, respectively (Table 5). The reasons for the loss of restorations were biting

The male/female ratio was 1.125/1 and frequency of dental trauma was higher in men than women, which was not statistically significant ($p = 0.674$). In all age groups different kinds of falls were the main cause of the dental trauma (58.8%), ($p < 0.0001$). The relationship between cause of trauma and sex was not statistically significant ($p = 0.559$) (Table 2). The etiology of dental trauma stratified by age is presented in Table 3.

Table 3. Etiology of traumatic dental injuries stratified by gender.

Etiology of traumatic dental injuries	Sex				Total		p
	female		male		n	%	
	n	%	n	%			
Falls	14	27.5	16	31.4	30	58.8	0.559
Collision with people	2	3.9	4	7.8	6	11.8	
Bicycle accident	0	0.0	2	3.9	2	3.9	
Sports accident	1	2.0	2	3.9	3	5.9	
Traffic accident	1	2.0	1	2.0	2	3.9	
Struck by an object	6	11.8	2	3.9	8	15.7	
Total	24	47.1	27	52.9	51	100.0	

Time interval between trauma and dental treatment request was found to be different. It ranged between the first days to fifty-eight years. Mostly observed crown fracture was seen in upper jaw and distributed equally between right and left side (Table 4).

shelled nuts or hard food and being struck by an object. Changes in marginal adaptation rates with time were found to be significant ($p = 0.046$). Loss of retention was mostly observed in Ellis II group.

Sensitivity to cold air, percussion sensitivity, surface roughness, secondary caries and loss of vitality were not observed at the end of 12 months (Table 6). Changes in marginal discoloration and color-match variables over time were not significant ($p = 0.083$, $p = 0.157$, respectively).

Table 5. Distribution of traumatic dental injuries according to the Ellis classification and their locations in the dental arch.

	Tooth number	Ellis I		Ellis II		Ellis III		Total		
		n	%	n	%	n	%	n	%	
Upper (n=70)	Right (n=35)	11	4	5.5	24	32.9	2	2.7	30	41.1
		12	-	-	3	4.1	1	1.4	4	5.5
		13	-	-	1	1.4	-	-	1	1.4
	Left (n=35)	21	9	12.3	22	30.1	1	1.4	32	43.8
		22	2	2.7	1	1.4	-	-	3	4.1
Lower (n=3)	Left	31	2	2.7	-	-	-	-	2	2.7
	Right	42	-	-	-	-	1	1.4	1	1.4
Total		17	23.3	51	69.9	5	6.8	73	100	

According to USPHS criteria, retention rate was 98.6% at six months, 91.78% at 12 months. One patient had lost one restoration; three patients had lost five restorations at the end of 6, and 12 months, respectively (Table 5).

The reasons for the loss of restorations were biting shelled nuts or hard food and being struck by an object. Changes in marginal adaptation rates with

time were found to be significant ($p=0.046$). Loss of retention was mostly observed in Ellis II group. Sensitivity to cold air, percussion sensitivity, surface roughness, secondary caries and loss of vitality were not observed at the end of 12 months (Table 6). Changes in marginal discoloration and color-match variables over time were not significant ($p=0.083$, $p=0.157$, respectively).

Table 6. Scores of evaluated criteria at 6 and 12 months.

	6 months			12 months		
	Alpha*	Bravo**	Charlie***	Alpha*	Bravo**	Charlie***
	n	n	n	n	n	n
Percussion	72	-	-	-	-	-
Sensitivity	72	-	-	-	-	-
Color match	70	2	-	65	2	-
Marginal adaptation	69	3	1	65	2	5
Anatomic form	71	1	-	66	1	-
Surface roughness	72	-	-	67	-	-
Marginal discoloration	69	3	-	64	3	-
Secondary caries	72	-	-	-	-	-

* Restoration is continuous with existing anatomic form; explorer does not catch

** Explorer catches; no crevice is visible into which explorer will penetrate

*** Restoration mobile, fractured, or missing

Discussion

This observational study was conducted to examine the etiologic factors, effects of age and gender on the trauma and to evaluate the performance of composite resin on restoring fractured crown in permanent anterior teeth. Most of the reported studies of dental trauma have focused on specific subpopulations (such as children from public or private schools), localized geographical regions

or limited age groups. Furthermore, most of the available data on dental trauma have been collected retrospectively from cross-sectional studies or from longitudinal studies of patient records (3, 24, 25). The distribution of dental trauma (DT) in this study was consistent with those reported in other Turkish (20, 26) and international studies (27, 28) regarding age, gender, location and causes of trauma. The general agreement in the literature is that the prevalence of trauma is higher in males than females (3, 25, 29,

30). Although no significant difference was found, the number of males was higher than females in the present study, which is consistent with the current literature. Major reasons for the injuries were falls (58.8%) for both gender and in all age groups. Corroborative results are present in the literature (22, 31). Present study also documented that falls were the common cause in the 14-16 age groups. On the other hand, enamel and dentin fractures without pulp exposure (Ellis II) were the most common type of dental injuries observed in maxillary central incisors, which is in agreement with the findings reported by Ivancic Jokic *et al.* (32). Very few studies are available on the prevalence of DT among adult age groups in Turkey. In the present study, DT was most frequently observed in the age group of 17-24 years but the frequency of trauma was not statistically significant between different age groups. This result was in accordance with a study which was carried out by Zengin *et al.* (33) and a Brazilian study (34). This finding may be attributed to the tendency of young people to engage in all sorts of activities.

In this study, time gap between trauma and dental assessments varied from one day to fifty-eight years and treatment negligence was the common attitude. In an Australian rural center study, (31) only one-third of the patients has been reported to apply for dental treatment within the day of the injury, while the rest of the study population were found to have delayed the treatment up to 1 year. It is therefore necessary to improve patient education concerning the causes, prevention and emergency management of dental trauma in order to decrease the high frequency of delayed treatment. Different techniques are available for the treatment of fractured anterior teeth such as orthodontic bands, pin-retained resins, porcelain veneers, jacket crown, reattachment of coronal fragment or composite resin restoration with acid etch adhesive technique. Porcelain restoration has the main disadvantages of being an operator sensitive technique that requires laboratory work and high cost and it is contraindicated in young children (35-37). Accordingly, restoration of the missed coronal fragment with composite resin is a viable alternative. As a minimal invasive procedure with relatively lower treatment costs and by being a less time-consuming treatment option which can produce *aesthetically pleasing results*, modern resin composites may become the material of choice for direct anterior restorations. It was also reported that using total-etch adhesive systems and resin composite with bevel preparation might significantly improve the fracture resistance (38). This procedure allows

a greater thickness of resin layer and masks the line between the material and tooth structure which, in turn, improves the aesthetic results. Dental trauma affects self-esteem. Fractured anterior teeth have negative impact on the perception of facial attractiveness. Present study demonstrated that maxillary incisors as the most commonly affected teeth which were in agreement with several studies (22, 28).

In this study, the absence of tooth sensitivity, surface roughness, secondary caries and vitality loss in the baseline, at 6th and 12th months indicated that the full covering of composite material have provided sufficient protection of the dentin/pulp complex. The results of the present study suggested that direct composite restorations bonded to fractured teeth to have an approximate survival rate of 92% at the 12 months follow-up. The considerably high performance of the restorations for marginal adaptation after 12 months can be attributed to the use of total etching, the application of adhesive system and the composite resin with the incremental technique. One of the major strengths of the present study is to include the teeth having not only Ellis II fracture but also Ellis I fracture. Two main approaches have been described in the literature for the restoration of the fractures restricted to enamel tissue. In a study conducted by Traebert *et al.* (39), traumatized teeth having small enamel fractures were restored although Schuch *et al.* (40) did not restore such fractures. In addition to using adhesive materials, retention of restoration can be achieved to a larger extent by preparing the cavity. It was reported that, since the surface of adhesion increases, enlarging the limits of the preparation might be beneficial (41). For fractures restricted to enamel, size of the cavity is strict which jeopardizes the longevity of the restoration. Considering the most frequent retention loss was seen in Ellis II in the present study, our results do not support previous claims such as increasing the size of the cavity may be beneficial. Composite resin restorations analyzed in this study showed minor and negligible variations in the anatomical form. At end of 12 months, only 2 teeth received Bravo score for anatomic form, probably because of the sufficient conversion of monomer to polymer which resulted in adequate resistance to wear. In this study, it was observed that there were six restorations registered throughout the study period as Bravo category for marginal discoloration. A possible explanation may be the use of submicron hybrid composite resins, which have low coefficient of thermal expansion, more inorganic filler content as well as finishing and polishing procedure. In the

anterior region, the location of the restoration allows direct and easy access. However, to the best of our knowledge, there are no multi-dimensional clinical studies except for some case reports. From this point of view, this study is the first to present the etiologic factors and clinical aspects of restored fractured teeth simultaneously.

The limitations of this study are largely due to its observational design and relatively short follow-up period. Selection bias is an intrinsic to all observational studies; to minimize this, during the recruitment period, all patients presenting with fractured anterior tooth were included in this study.

Conclusion

Within the limitations of this study, falls are main cause of dental trauma and mostly observed fracture type was Ellis II. With respect to the treatment protocol, direct restoration technique using composite resin can be considered as clinically acceptable at 24 months.

Source of funding

None declared

Conflict of interest

None declared

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- Corresponding Author:**
Uzay Koç Vural
 Department of Restorative Dentistry
 Faculty of Dentistry Hacettepe University
 Sıhhiye/Ankara
 Phone: +90 507 212 26 26
 e-mail:uzay.koc@hacettepe.edu.tr