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Original article

Survival Rate Against Fracture of Endodontically Treated Premolars Restored with Crowns and Resin Composites: A Retrospective Study

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ABSTRACT

The purpose of this study was to assess the survival rate of endodontically treated premolars that were restored with resin composites or crowns. Additionally, possible risk factors were identified through the use of a retrospective cohort design. Based on inclusion and exclusion criteria, dental records of premolar ETT with crowns or composite restorations (recall period, 2018–2023) were gathered. Both the existence of the fracture and any potential prognostic variables were noted. Analysis using statistical methods was done at a significance level of P <0.05. The Chi square test was used for all comparisons, and frequency and percentages were used to depict the qualitative data. There was a significant difference in the survival rates against breakage between teeth replaced with crowns (95.1%) and resin composites (62.1%) (P<0.05). The results showed that there was a significant difference between them in terms of sex, age, opposing dentition, crestal bone level, and fracture incidence. Regarding premolars that have undergone endodontic treatment, crown restorations outperformed resin composites in terms of survival rate. Premolars receiving endodontic therapy and having crestal bone loss up to the middle third of the root were shown to be at an increased risk of fracture.

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INTRODUCTION

Restoring endodontically treated teeth is one of the most studied aspects in the dental field [1,2]. Since it is not uncommon for dentists to face difficulty managing a badly broken-down endodontically treated tooth, the extensive loss of tooth structure due to decay, failed restorations, or tooth fractures can be a daily challenge for most clinicians. To restore such teeth in a proper way and to put on a restoration that aids in restoring the function, biological integrity, as well as the natural look of the tooth without overlooking the mechanical considerations that should be considered while restoring such a challenging tooth. There are a wide variety of measures when it comes to restoring these debilitated teeth [3]. There's no single step-by-step guide that may help dentists restore every single debilitated tooth that is introduced into their offices. Every tooth presents a challenge and is unique in itself. This has led to the diversity in published literature about the opinions and the different treatment plans that may be used for restoring such teeth [1]. However, there are some measures and guidelines that are thought to increase the survival rate and the success of restoring these endodontically treated teeth.

The clinical success of endodontic treatment significantly improves when the tooth receives a coronal restoration that prevents coronal leakage and protects the remaining tooth structure from fracture [4,5]. Endodontically treated teeth (ETT) are weakened by the marked loss of tooth structure and are, therefore, prone to fracture [6]. An appropriate restorative plan should be carefully considered to protect ETT and improve their longevity [7].
The amount of remaining tooth structure affects the fracture resistance of ETT [8-10], tooth structure loss, quantified in terms of the number of sides, has been reported to be a significant factor associated with reduced tooth stiffness and an increased risk of fracture in posterior ETT [11]. Loss of marginal ridges decreases tooth stiffness, increases cuspal flexure, and, consequently, leads to a risk of tooth fracture [12].
Endodontically treated teeth (ETT) are considered at a higher risk of fracture compared to intact sound teeth as a consequence of lost tooth structure following pathological processes and endodontic treatment [9]. This biomechanical alteration has a negative impact on the long-term prognosis of the restoration of these teeth [1,13]. That's why, when considering the restoration of devitalized teeth, dental materials utilized should be able to replace lost tooth substance, ensuring mechanical, functional, and aesthetic performance in addition to a perfect coronal seal.
It remains unclear whether the type of coronal restoration, particularly crown and resin composite, affects the survival against fracture of endodontically treated teeth. Moreover, the prognostic factors affecting survival have not been previously reported. Bulk-fill resin composites have emerged as a new category of low- and high-viscosity composites that can be used in class I and class II restorations in increments of 4 or 5 mm [10-12]. The difference in the chemical monomeric resin formulations and filler characteristics, such as the type, volume fraction, density, and particle size and distribution, can affect the depth of cure and mechanical properties [14], justifying further investigations for the indication of bulk-fill resin composites in MOD cavities.
Ceramic restoration is another option for restoring ETPs. Ceramics have many advantages, such as translucency, fluorescence, chemical stability, biocompatibility, high compressive strength, and a thermal expansion coefficient similar to tooth structure [15]. Despite their desirable characteristics, ceramics are fragile under tensile and occlusal forces, making them susceptible to fracture [16]. Therefore, the aim of this retrospective cohort study was to compare the survival rates against fracture of endodontically treated premolars that were restored with either a crown or resin composite. In addition, the significant prognostic factors for fracture were identified.

METHODS

Study design and data collection

The retrospective cohort study protocol was conducted in a Tripoli private dentistry clinic. The premolars getting endodontic treatment at the dental clinic were the subjects of data collection from radiographs and dental records, and the patients were recalled between January 2018 and March 2023. Post-endodontic coronal restorations, consisting of resin composites or full-coverage crowns, were supplied by restorative, postgraduate, or undergraduate dentists. The following criteria were used to recruit the subjects:

Selection standards and information gathering

The following criteria had to be met in order to be considered for inclusion: (1) full root formation; (2) restoration using full-coverage crowns or direct resin composites; (3) occluding with natural teeth or fixed dental prostheses; (4) sufficient clinical and radiographic records.
The teeth with the following conditions were excluded: (1) endodontic or restorative procedural error(s) that damaged the tooth's structural integrity; (2) endodontic access via an existing crown; (3) preoperative fractures or cracks; (4) a post removed during root canal retreatment; and (5) concurrent orthodontic treatment. The following information was noted: age, sex, location of the tooth, kind of coronal restoration, prosthesis abutment function, opposing tooth, posterior tooth support, proximal contact(s), degree of bone support, and parafunctional habits. Furthermore, the presence of a fracture was identified, and data regarding its location and restorability were documented.

Endodontic and restorative procedures

Under rubber dam isolation, root canal treatments were carried out by postgraduates, undergraduates, or endodontists. Using the crown-down procedure, root canal cleaning and shaping were carried out using 0.02 taper hand stainless steel or 0.04/0.06 taper rotary Ni-Ti files with irrigants consisting of 17% EDTA and 2.5% sodium hypochlorite. Following the intracanal administration of calcium hydroxide medication, the prepared root canals were obturated using either the cold hydraulic (sealer-based) technique, vertical compaction, lateral compaction, or gutta-percha cones and root canal sealer (zinc oxide, epoxy resin, or calcium silicate-based sealer). Prosthodontics, postgraduates, and undergraduates all

completed crown restorations. As a final repair, full-coverage crown restorations with core build-up or post-placement were frequently scheduled.

When there was uncertainty about the outcome of the patient's endodontics or periodontics or when the patient was waiting for crown restorations, direct resin composite restorations were used as a long-term, temporary solution. When a patient could not afford a crown or when there was only occlusal surface tooth structure loss in an ETT, resin composites were occasionally utilized as a permanent replacement. A post was only recommended in cases where the retention of the residual tooth structure for core build-up was insufficient in cases that were repaired with crown restorations. The prepared root canals were filled with prefabricated fiber posts (D.T. Light-Posts, BISCO Inc., Schaumburg, IL, USA), which were cemented using adhesive resin-based.

When resin composite restorations were used to restore ETT, no posts were needed during the placement process. Cavit (CAVITON, GC Corp., Tokyo, Japan) or glass-ionomer cement liner (Vitrebond, 3M ESPE, St. Paul, MN, USA; or GC Fuji VII, GC Corp.) applied at a thickness of 1-2 mm were used to construct the access cavity. The resin composite (Z250 or Z350, 3M ESPE) was applied and adhered to using either self-etch (Clearfil SE Bond, Kuraray Noritake Dental Inc.) or etch-and-rinse (Adper Single Bond 2, 3M ESPE) adhesive.

Outcome assessment

The occurrence of a tooth fracture was recorded. The primary outcomes were fractured or survived without fracture. Next, the fracture location was identified as a coronal, coronal-root, or root fracture. The fractures were finally categorized as restorable (repaired or replaced with a new restoration) or nonrestorable (required tooth extraction).

Statistical analysis

Statistical analysis was performed with SPSS 20®1, Graph Pad Prism®1, and Microsoft Excel 2016. All qualitative data were presented as frequencies and percentages, and all comparisons were performed using the Chi square test.

RESULTS

Data distribution of the endodontically treated premolars

The endodontically treated teeth comprised 127 premolars in (32%) males and (95%) females, with (54.3%) less than 40 years, (45.7%) more than 40 years, (66.1%) located in the maxilla, and (33.9%) located in the mandible. Regarding opposing dentition: (53.3%) opposed by natural teeth, while (46.5%) opposed by fixed restoration. In tooth type, the highest percentage was in the second max (48.8%), while the lowest percentage was in the second mandibular (8.7%). In proximal contact, 2 sides (85%) were higher than no sides—1 side (15%). Regarding crestal bone level, the coronal (86.6%) was higher than the middle (13.4%). In fracture, only 22 percent demonstrated fracture, as presented in table 1.

Comparison between endo-treated teeth that were restored with crowns or resin composites

Comparison between them was performed using the Chi square test, which revealed significant differences between them regarding sex (P=0.007), age (P=0.01), opposing dentition (P = 0.0001), crestal bone level (P=0.03), and fracture incidence (P = 0.0001), as presented in table 1.

Three crowns and 25 composites were fractured; they had crown root fracture, and the fracture was unrestorable. The association between fracture and all other parameters was evaluated and revealed significant differences regarding all parameters, which means that the material used, sex, age, tooth location, opposing tooth, tooth type, proximal contact, and crestal bone level were considered as potential prognostic factors, as presented in table 2.

Linear regression analysis

The results of a linear regression analysis where fracture incidence is the dependent variable and various independent variables include material used, sex, age, tooth location, opposing teeth, tooth type, proximal contact, and crestal bone loss are presented in Table 3. The results indicate that age, opposing tooth, and crestal bone level have statistically significant associations with fracture incidence since their p-values are < 0.05.

Table 1. Data distribution of the endodontically treated premolars that were restored with crowns or resin composites.

Variables		Total		Crown		Composite		P value
		N	%	N	%	N	%	
Sex	Male	32	25.2%	22	36.1%	10	15.2%	0.007*
	female	95	74.8%	39	63.9%	56	84.8%	
Age	less than 40 years	69	54.3%	26	42.6%	43	65.2%	0.01*
	more than 40 years	58	45.7%	35	57.4%	23	34.8%	
Tooth location	Maxilla	84	66.1%	39	63.9%	45	68.2%	0.61
	Mandible	43	33.9%	22	36.1%	21	31.8%	
Opposing tooth	Natural tooth	68	53.5%	48	78.7%	20	30.3%	0.0001*
	Fixed restoration	59	46.5%	13	21.3%	46	69.7%	
Tooth type	First max. premolar	39	30.7%	18	29.5%	21	31.8%	0.96
	Second max premolar	62	48.8%	30	49.2%	32	48.5%	
	First Mand premolar	15	11.8%	8	13.1%	7	10.6%	
	Sec Mand premolar	11	8.7%	5	8.2%	6	9.1%	
Proximal contact	2 sides	108	85.0%	55	90.2%	53	80.3%	0.12
	0-1 side	19	15.0%	6	9.8%	13	19.7%	
Crestal bone level	coronal	110	86.6%	57	93.4%	53	80.3%	0.03*
	middle	17	13.4%	4	6.6%	13	19.7%	
FRACTURE	no	99	78.0%	58	95.1%	41	62.1%	0.0001*
	yes	28	22.0%	3	4.9%	25	37.9%	

Table 2. Association between fractures in endodontically treated premolars and other factors.

Variables		FRACTURE				P value
		No		Yes		
		N	%	N	%	
Group	Crown	58	95.1%	3	4.9%	0.0001*
	Composite	41	62.1%	25	37.9%	
Sex	Male	0	0.0%	32	100.0%	0.001*
	Female	67	70.5%	28	29.5%	
Age	Less than 40 years	67	97.1%	2	2.9%	0.0001*
	More than 40 years	32	55.2%	26	44.8%	
Tooth location	Maxilla	80	95.2%	4	4.8%	0.0001*
	Mandible	19	44.2%	24	55.8%	
Opposing tooth	Natural tooth	68	100.0%	0	0.0%	0.0001*
	Fixed restoration	31	52.5%	28	47.5%	
Tooth type	First max. premolar	39	100.0%	0	0.0%	0.0001*
	Second max premolar	50	80.6%	12	19.4%	
	First Mand premolar	8	53.3%	7	46.7%	
	Sec Mand premolar	2	18.2%	9	81.8%	
Proximal contact	2 sides	96	88.9%	12	11.1%	0.0001*
	0-1 side	3	15.8%	16	84.2%	
Crestal bone level	Coronal	98	89.1%	12	10.9%	0.0001*
	Middle	1	5.9%	16	94.1%	

Table 3. Linear regression analysis model, fracture incidence as the dependent variable, while material used, sex, age, location, opposing teeth, tooth type, proximal contact, and crestal bone loss were the independent variables.

Variables	Unstandardized Coefficients		95.0% Confidence Interval for B		P value
	B	Std. Error	Lower Bound	Upper Bound	
Group	**0.222**	0.068	0.088	0.356	0.001*
Sex	**-0.183**	0.073	-0.327	-0.039	0.013*
Age	**0.460**	0.081	0.299	0.620	0.0001*
Tooth location	**0.042**	0.079	-0.114	0.198	0.594
Opposing tooth	**0.331**	0.082	0.169	0.494	0.0001*
Tooth type	**-0.170**	0.070	-0.308	-0.031	0.017*
Proximal contact	**-0.179**	0.176	-0.527	0.169	0.312
Crestal bone level	**0.786**	0.177	0.437	1.136	0.0001*

β regression coefficient, SE standard error, CI confidence interval.

DISCUSSION

Different materials and concepts are used in the restoration of teeth that have undergone endodontic treatment. Amalgam or composite restorations are the options available to conservative preparers for endodontic access preparation. Cuspal protection is necessary for some posteriors whose larger amount of structure was lost in order to direct stresses to the root's long axis and prevent longitudinal fractures. Because internal tooth structure is removed during endodontic therapy, teeth that have had this procedure are generally thought to be more prone to fracture than teeth that have not had this procedure.

The goal of the current study was to identify the predictive indicators for fracture and evaluate the survival rates against fracture of endodontically treated premolars repaired with resin composites or crowns. When compared to teeth repaired with resin composites (62.1%), teeth restored with crowns (95.1%) had higher survival rates against fracture over the 5-year observation period. This is in line with another research [7,11,17] that showed a good survival rate for ETT repaired with crowns. These findings have prompted dentists to typically schedule and perform full-coverage restorations following endodontic therapy for ETT premolars. Comprehensive research [18] has shown that the long-term survival rate of root canal-treated teeth (RCT) covered with crowns is greater (81%after 10 years) than that of RCT without crown coverage (63%after 10 years). These findings go counter to study suggesting that endodontically treated premolars could be conservatively restored with resin composite as a permanent restoration and that full-coverage crown insertion is not required [19].

Prior researches [20, 21] frequently showed that, when compared to healthy teeth, maxillary premolars treated with composite resin showed statistically comparable fracture resistance. This discovery could be explained by the resinous materials' capacity to experience elastic deformation akin to that of teeth [22]. On the other hand, premolars reconstructed with composite resin showed statistically lower fracture resistance than intact teeth, according to other investigations [23, 24]. Therefore, restoring cuspal coverage is regarded as a suitable intervention to extend the life of ETT.

Compared to ETT with 1 or 0 neighboring teeth (15.8%), individuals with 2 adjacent teeth had a greater survival rate (88.9%). In this study, two neighboring teeth were present in the majority of the instances, which was favorable for the teeth under evaluation to survive breakage, by spreading occlusal stresses and lowering functional loading on the teeth, the proximal contacts of neighboring teeth increase the survival rate against ETT fracture [25]. The advantages of preexisting proximal contacts or neighboring teeth on ETT were documented in numerous clinical investigations [26].

This is consistent with additional investigation showing that premolar ETT are receiving both vertical and lateral occlusal stresses had a higher survival rate when there was 2-side proximal contact [27]. Although this impact was not seen in molar ETT, which mostly received vertical stresses, it is theoretically possible that the presence of neighboring teeth could aid in the distribution of occlusal forces and lower the risk of tooth fracture.

The kind and presence of opposing teeth directly affect the amount of the occlusal force. A higher occlusal force on ETT is produced by an opposing natural tooth or fixed-abutment prosthesis than by a removable prosthesis or in the absence of an opposing dentition. Nonetheless, in this investigation, the survival rate of endo-treated premolars was influenced by the opposing dentition. More female patients than male patients attended the follow-up, with the majority of the study's patients being female. The two sexes in this study did, show a notable difference in terms of survival

without fractures. Occlusal force in females is often lower than in males, which could introduce bias into the results for this population under study [16].

The critical element for survival against fracture was the level of crestal bone. A higher risk of tooth fracture was associated with endodontically treated premolars whose bone support had been lowered to the middle third of the root, as opposed to the usual crestal bone level at the cervical third. The long-term survival of teeth has been shown to be negatively impacted by the loss of bone support in prior clinical trials [28, 29]. The amount of support provided by the bone influences the fracture resistance of ETT, and the risk of fracture in vitro is increased by horizontal bone loss [30]. The crestal bone level was found to be a major predictive factor for the survival of premolar fractures, which is in line with our clinical findings [28].

Young age was a positive predictive factor for anticipated tooth survival, with 97.1% of restored endodontically treated teeth under 40 years old having no fractures compared to 55.2% of teeth over 40 years old. A plausible rationale could be that, due to fewer restorative procedures in the past, teeth that have had treatment tend to have more tooth material left in them. As a result, teeth that are younger may be more resistant to masticatory forces [31]. This is in line with findings from other studies [32, 33] that showed an increase in the occurrence of vertical root fractures in teeth treated with endodontia as patients age. It has been suggested that the underlying issues are mostly caused by endodontic teeth drying out over time and by modifications to the collagen cross-linking in those teeth. Pulpless teeth are more prone to fractures than teeth with vital pulp.

In this study, a post was very seldom placed in the cases restored with resin composite; however, the crowned teeth were restored with a post. All posts utilized in this study were prefabricated fiber posts that may offer a lower risk of fracture in contrast with using a rigid cast post. The glass fiber post, in a meaningful way, absorbed interface stress from the coronal to apical areas of the post and dentine interface. The fiber posts with an elastic modulus (11.50 GPa) similar to that of dentin make something like a monobloc configuration. This similarity in elastic modulus can evenly distribute stress within root dentin. Consequently, increasing the fracture survival rates [34]. Within the limitations of this retrospective cohort study, the fracture survival rates of premolar ETT with full-coverage crowns were higher than those with direct resin composites.

CONCLUSION

The overall fracture survival rate of endodontically treated premolars restored with full-coverage crowns was higher than that restored with resin composite restorations. Sex, age, tooth location, opposing tooth, tooth type, proximal contact, and crestal bone level were considered significant prognostic factors.

Conflicts of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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معدل مقاومة الكسر للضواحك المعالجة لبيا والمرممة بواسطة التيجان والحشوات الراتنجية: دراسة بأثر رجعي

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المستخلص

هذه الدراسة عبارة عن تقييم مقاومة الكسر للضواحك المعالجة لبياً والتي تم ترميمها باستخدام حشوات الراتنج أو التيجان. بالإضافة إلى ذلك، تم تحديد عوامل الخطر المحتملة بأثر رجعي. الطرق: بناءً على معايير الاشتمال والاستبعاد، تم جمع سجلات لأسنان الضواحك المعالجة لبيا بعد ان ثم تركيب التيجان أو الترميم بإستخدام حشوات الراتنج (فترة الاستدعاء، 2018-2023). ولوحظ وجود الكسر وأي متغيرات محتملة. تم إجراء التحليل باستخدام الأساليب الإحصائية عند مستوى دلالة P <0.05. تم استخدام اختبار مربع كاي لجميع المقارنات، وتم استخدام التكرار والنسب المئوية لتصوير البيانات النوعية. النتائج: كان هناك اختلاف كبير في معدلات مقاومة الكسر بين الأسنان المغلفة بالتيجان (95.1%) على الأسنان المعالجة بواسطة الحشوات الراتنجية (62.1%) (P<0.05). أظهرت النتائج وجود اختلاف كبير بينهما من حيث الجنس والعمر والأسنان المقابلة ومستوى العظم وحدوث الكسور. الاستنتاجات: فيما يتعلق بالضواحك التي خضعت للعلاج اللبّيّ، فقد تفوقت ترميمات التاج على المركبات الراتنجية من حيث معدل البقاء. تبين أن الضواحك التي تتلقى علاجًا لبيًا وتعاني من فقدان ثلث العظم تكون أكثر عرضة لخطر الكسر.

الكلمات الدالة. التيجان، معدل البقاء، حشوات الراتنج، الأسنان المعالجة لبيا، كسر الأسنان.