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Direct Resin Composite Restorations in Vital Versus Root-filled Posterior Teeth: A Controlled Comparative Long-term Follow-up

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Clinical Relevance

In endodontically-treated posterior teeth, minimal direct composite restorations had a tendency to fail more often than their counterparts in vital teeth.

SUMMARY

This study compared direct composite restorations on vital versus endodontically-treated posterior teeth, six to eight years after placement. All clinical procedures were performed using standardized materials and protocols. The patients were identified with the aid of a computerized billing system followed by a chart search. With each patient, the prime investigator matched a randomly chosen endodontically-treated tooth (test tooth) with a vital counterpart (control tooth) with a direct composite restoration. Of the 84 patients who fulfilled the inclusion criteria, 44 were available for recall. Two calibrated observers, blinded to the tooth vitality status, evaluated the fillings by applying the modified USPHS criteria. The outcome was dichotomized to revision indicated/recommended vs revision not indicated. Odds Ratios (OR) and corresponding 95% Confidence Intervals (95% CI) were calculated. Residual confounding was corrected using a multivariable regression analysis with the remaining known confounders filling size, tooth type and age of the fillings in months as independent variables. The crude association between the presence/absence of root canal treatment and the need for revision (OR, 95% CI) was 2.12 (1.02-4.38; *p*=0.04). Correcting for all potential confounders in the multivariable analysis changed this association marginally to an OR of 1.98 (0.90-4.38; *p*=0.09).

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INTRODUCTION

Is there any scientific evidence to support the commonly believed myth that endodontically-treated teeth have a poorer long-term restorative prognosis compared to vital teeth? According to cohort studies on restoration materials, it would appear that endodontically-treated teeth are more prone to restoration loss and/or fracture than vital teeth.[1-2] However, contrasting results have also been published.[3] Pulpless teeth are loaded more heavily than their vital counterparts before a pain response is triggered,[4] which may predispose them to fracture. On the other hand, there appears to be little difference in moisture content or mechanical properties between vital and non-vital teeth.[5-6]

A major source of bias in follow-up studies comparing restorations in vital and endodontically-treated teeth is the lack of control. Differences in the success rates may simply be explained by the fact that endodontically-treated teeth have suffered from a more substantial hard tissue loss prior to restoration than their vital counterparts.[2] Furthermore, other factors, such as patient age and gender, the time the restorations were placed, bruxism, erosions, periodontal health, tooth type and oral hygiene may confound the results.[7-9]

Based on the reported good results with minimal direct resin composite restorations in posterior endodontically-treated teeth with relatively little substance loss,[1] the direct restoration approach was extended in the authors clinic from vital to root canal-treated teeth. Regardless of their vitality, premolars and molars with a maximal loss of one or two cusps, respectively, were restored using a directly placed bonded resin composite material according to a standard protocol. In the current study, an attempt was made to follow-up on all patients who had received direct composite restorations in both endodontically-treated and vital posterior teeth between 1997 and 1999 at the faculty practice of the department. The prime investigator randomly selected and matched root canal-treated test teeth with vital control teeth with a similar restoration size. Restorations in the test and control teeth were clinically evaluated by two calibrated observers who were blinded to tooth vitality. Potential confounding was corrected on three levels. First, the study was designed so that each patient acted as his or her own control, meaning that the endodontically-treated test tooth and the original vital control tooth were in the same oral cavity. Within each patient, the test tooth was matched with a control tooth that corresponded in filling size and date that the filling was placed. Finally, residual confounding was corrected using a multivariable regression analysis, where the remaining known confounders: filling size, tooth type and age of the fillings in months, were entered as independent variables.

METHODS AND MATERIALS

Cohort Identification

The protocol of this investigation was approved by the institutional ethics committee. Subjects included in this study received at least one root canal treatment and multiple interproximal direct composite restorations between January 1, 1997 and December 31, 1999 at the faculty practice of the Department of Preventive Dentistry, Periodontology, and Cariology, University of Zürich, School of Dental Medicine. All patients who fulfilled the above criteria were identified using the computerized billing system (Highdent Plus, CompuDENT, Koblenz, Germany). This system, however, did not distinguish between root canal treatments performed on front or posterior teeth, neither could the system evaluate where and on which teeth the composite restorations were placed. Consequently, a chart search was performed to identify all patients for recall. Patients who met the inclusion criteria were contacted in writing, with the aim and method of the free-of-charge recall examination explained. Additionally, a free dental hygiene procedure was offered. Patients who did not respond to the written invitation were invited personally by telephone. All patients who participated gave their informed consent.

Clinical Procedures

All the clinical procedures were performed according to standard protocols by dentists trained in internal continuing education courses. There was a strict house rule as to how the restorations with resin composite and endodontic treatments had to be performed. Each dentist working at the University faculty practice had to take courses that introduced the techniques before being allowed to treat patients. These techniques were re-instructed twice per year. The head of the faculty practice supervised compliance with the clinical protocols. Root canal treatments and restorative procedures were carried out under rubber dam (Hygenic, Akron, OH, USA). As confirmed by the chart entries, no materials other than those described below were used.

Root canal treatments were performed during a minimum of one visit on vital teeth and as a part of at least two visits on non-vital teeth. The canals were instrumented using hand files (FlexoFiles, Maillefer, Ballaigues, Switzerland). During instrumentation, the root canals were rinsed with 1% NaOCl solution. A calcium hydroxide dressing was used for the interim. The roots were filled using gutta percha and an epoxy resin sealer (AH-plus, Dentsply DeTrey, Konstanz, Germany). Endodontically-treated posterior teeth that were restored using direct resin composite, that is, premolars with Class II cavities that had lost no more than one cusp and molars that had lost no more than two cusps, were reconstructed using a minimally invasive protocol without the aid of intracanal posts.

To reduce the negative effect of shrinkage stress on restored teeth, a selective bonding technique and an incremental restorative technique were used according to a standardized protocol. After gross preparation with 80 µm diamond burs (Intensiv, Grancia, Switzerland), the dentin was covered with light-cured glass ionomer cement (Vitrebond, 3M ESPE, Seefeld, Germany). Cavity finishing lines in enamel and possible proximal cervical finishing lines in dentin were subsequently fine-prepared using 25 µm diamond burs (Intensiv). The enamel was etched using 37% phosphoric acid (Ultraetch, Ultradent Products Inc, South Jordan, UT, USA). If proximal cervical finishing lines were located in dentin, a three-component adhesive system (Syntac Classic, Ivoclar Vivadent, Schaan, Liechtenstein) was applied. Subsequently, all finishing lines were covered with a bonding agent (Heliobond, Ivoclar Vivadent). The carefully air-thinned bond layer was light polymerized for 60 seconds (Optilux 500, standard light tip, Kerr Demetron, Danbury, CT, USA). Sectional transparent mylar matrices were placed and fixed with light conducting wedges (Luciwedge, Kerr Hawe, Bioggio, Switzerland). Resin composite fillings (Tetric Ceram, Ivoclar Vivadent) were placed in increments as described.[10-11] The first cervical increments were light polymerized through the light-conducting wedges; subsequently, the following two increments per proximal box and the two occlusal increments were polymerized through the dental hard tissues. Finally, the restoration was also polymerized from an occlusal direction. For each increment, 60 seconds of polymerization time were used. The restorations were occlusally adjusted, finished and polished with 8 µm finishing burs (Intensiv), finishing strips, finishing disks (Soflex, 3M ESPE, St Paul, MN, USA) and bristle brushes (Occlubrush, Kerr Hawe). A topical fluoride application (Elmex fluid, Gaba, Basel, Switzerland) completed the protocol.

Recall Visit

The prime investigator made a thorough dental checkup. Special attention was paid to the following clinical parameters: the presence of erosion, periodontal health, signs of bruxism and the occurrence of plaque. Periodontal health was dichotomized to healthy/nonhealthy; patients with probing depths more than 4 mm were assigned to the "periodontally non-healthy" group. Visible plaque was expressed as affected surfaces in percent.[12]

Subsequently, the prime investigator, by throwing a die, randomly selected a test tooth, that is, a posterior tooth that had received a root canal treatment and direct composite restoration six to eight years prior. In case there was only one such tooth, randomization was unnecessary. Subsequently, one of the vital teeth with a direct composite restoration placed during the same period was matched to the test tooth as the control tooth. The tooth with a restoration size that most closely resembled one of the test teeth was chosen. The tooth with a restoration that most closely resembled the test tooth was chosen.

The fillings were examined by two calibrated observers blinded to the vitality status of the test and control tooth. Composite restorations were evaluated by applying modified USPHS criteria (Table 1). In case

Table 1: *Criteria for the Clinical Evaluation of Direct Composite Restorations at Recall*

Category	Score	Revision*	Criteria
Marginal discoloration	0	no	No discoloration
	1	no	Slight staining
	2	recommended	Apparent discoloration
	3	yes	Recurrent caries
Marginal adaptation	0	no	No catching with the explorer, margin is completely continuous with tooth tissue
	1	no	Slight unevenness can be found with explorer
	2	recommended	Marginal gap
	3	yes	Recurrent caries
Restoration fracture	0	no	Completely intact restoration
	1	no	Slight cracks
	2	recommended	Subset fracture
	3	yes	Total fracture
Tooth fracture	0	no	Completely intact tooth
	1	no	Slight enamel cracks
	2	recommended	Crack extends into dentin
	3	yes	Total fracture

**The outcome (dependent) variable was dichotomized to "revision indicated/recommended" vs "revision not indicated;" extracted teeth were included in the logistic regression analysis as in need of revision.*

a disagreement between the two observers occurred, the prime investigator arbitrated the decision. Fractures of the filling and hard tissues were detected by the use of fiber optic illumination (Intralux 4000, Volpi, Schlieren, Switzerland), size and extension of the composite filling using ultraviolet light (Penviewer, Morita, Dietzenbach, Germany).

Data Analysis

Observer agreement was calculated based on the four-score data scales (Table 1) recorded by the two observers prior to arbitration by the prime investigator applying kappa statistics.

The outcome variable was defined as "revision indicated/recommended" vs "revision not indicated" (Table 1). First, the crude association between presence/absence of root canal treatment and the need for revision was calculated. Then, a multivariable logistic regression model was fitted using the need for revision (yes/no) as the dependent variable and entering the potential confounders age of filling (interval scaled), restoration size (dichotomized to ≥ one cusp covered yes/no) and tooth type (molar/premolar) as independent variables. The cluster option was chosen to correct for the fact that the observations were independent across groups (clusters) but not within groups. Odds Ratios (OR) and corresponding 95% Confidence Intervals (95% CI) were calculated. Analyses were performed using the STATA 9.2 software package (StataCorp, College Station, TX, USA).

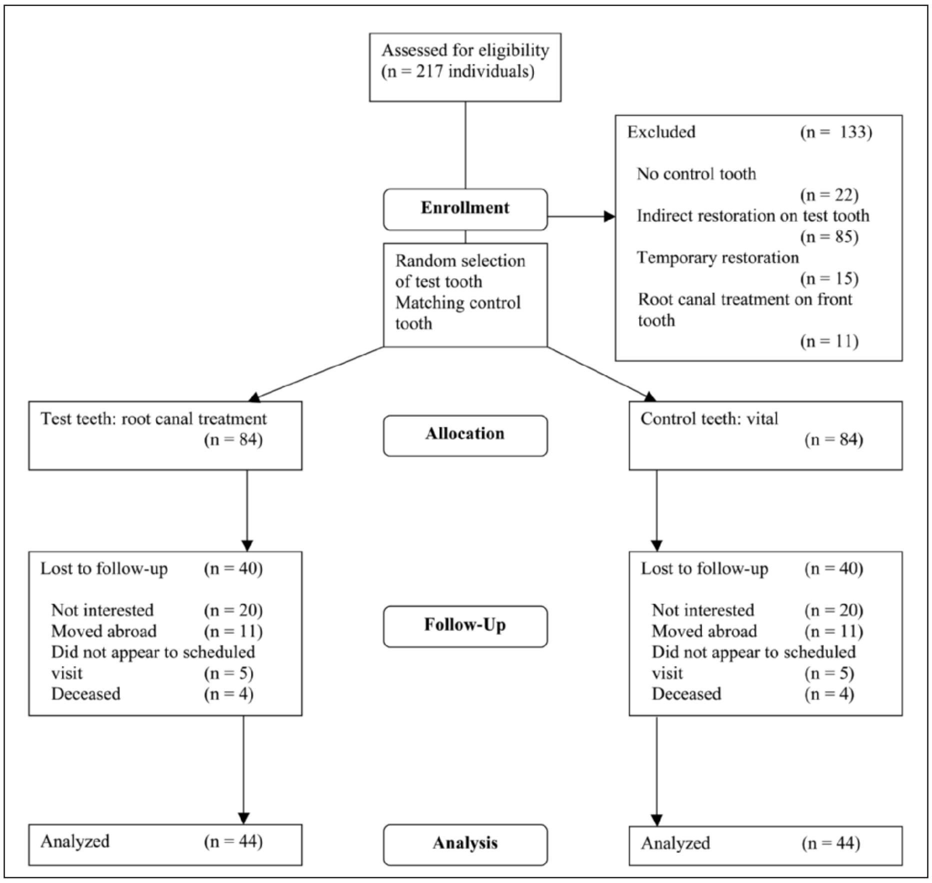

Figure 1. *Enrollment and follow-up of the patients in this study.*

Table 2: *Characteristics of the 44 Patients Available for Recall*

Characteristic	Root-filled Test Teeth	Original Vital Control Teeth
Patients' age	44.2 (±10.6)	
Male gender	21 (47.7%)	
Premolars	24 (54.6%)	25 (56.8%)
Maxillary teeth	22 (50.0%)	25 (56.8%)
Filling size: ≥ 1 cusp covered	15 (34.1%)	10 (22.7%)
Patients with dental erosions	7 (15.9%)	
Periodontally healthy patients	21 (47.7%)	
Patients with bruxism	11 (25.0%)	
Age of filling (months)	81.8 (± 10.4)	80.6 (± 12.8)
Plaque index at recall	50.2 (± 25.8)	

Figures are means (± SD) or numbers and percentages where indicated.

RESULTS

Of the 84 patients who met the inclusion criteria for this study, for various reasons, 40 were not available for the six- to eight-year recall (Figure 1). Details of the 44 patients available for recall showed that test and control teeth were similar with respect to possible confounding factors (Table 2).

Cohen's Kappa value for observer agreement prior to arbitration was 0.8. The crude association between presence/absence of root canal treatment and the need for revision (OR, 95% CI) was 2.12 (1.02-4.38; p=0.04). Correcting for all potential confounders in the multivariable analysis changed this association marginally to an OR of 1.98 (0.90-4.38; p=0.09).

At recall, 21 of the root-filled test teeth were found to be in need of revision compared to 13 of the original vital control teeth. The major reason for the need for revision between the root canal-treated teeth and their vital counterparts was hard tissue fractures (coronal or vertical root fractures) that occurred 10 times more often in the root canal-treated versus the originally

Table 3: *Reasons for Needed Revision*

Reason*		Root-filled Test Teeth	Original Vital Control Teeth
Marginal discoloration:	score > 2	10	4
Marginal adaptation:	score > 2	10	6
Restoration fracture:	score > 2	4	4
Tooth fracture:	score > 2	8	1
Tooth crowned alio loco:	reason unknown	2	1
Extraction:	recurrent caries	0	1
	periodontitis	1	0
	vertical root fracture	2	0
	endodontic failure	1	0

*One tooth could have more than one reason for an "in need of revision" outcome.

vital teeth (Table 3). Among 21 of the root-filled teeth in need of revision, four were already extracted at recall (Table 3), while two more needed extraction because of recurrent caries and endodontic problems. Among 13 of the originally vital control teeth in need of revision, one was extracted at recall and two needed extraction because of rampant caries and endodontic involvement. All the other teeth could be maintained by replacement or reparation of the composite filling. Consequently, the survival rate was 38/44 (86%) with the test and 41/44 (93%) with the control teeth.

DISCUSSION

The current study revealed that root canal-treated teeth restored with direct composite restorations have a tendency to require revision more frequently than their vital counterparts restored in the same manner. This tendency, however, was only marginally significant.

The recall rate of 52% after six to eight years in the current study is typical for a cosmopolitan city, such as Zürich.[13] Many patients could not be motivated to return to the university faculty practice, while others had moved abroad. It cannot be excluded that the patients in the cohort who returned for recall differed from those who did not appear with respect to certain confounding factors. However, the introduction of bias based on that possibility should be minimal, because the test and control teeth were in the oral cavity of the same individuals. The matching procedure used in this study design reduced confounding to the extent that the association of root canal treatment and the need for restoration revision was not significantly altered after tooth-related confounding factors (which could differ within patients) were entered into the statistical model. Two methodological approaches to counteract confounding were applied in this study: matching (of controls) and statistical adjustment for residual confounding. The crude odds ratio in the matched comparison was a fair description of the true association. Further adjustments for other (non-matched) confounders did not change the extent of association substantially. It would appear that previous research on the longevity of restorations on vital versus endodontically-treated teeth did not deal fully with the problem of confounding; restorative methods were either not standardized or the follow-up was based on chart or insurance file entries.

The success rate of the direct composite fillings reported here is in line with published reports.[9] The reasons for the relatively high incidence of hard tissue fractures in the endodontically-treated teeth that were under investigation may only be speculated upon. Pulpless teeth may be loaded more heavily than their vital counterparts.[4] Furthermore, loss of the pulp chamber roof during endodontic access preparation hampers flexural cusp strength.[14] The current observation that failure of the tooth-restoration interface was more likely than failure of the composite material is in line with published finite element simulations.[15] Crown fractures are the most common cause of endodontic failures.[16] These failures appear to occur less frequently in crowned teeth than in their counterparts with direct restorations.[16] Crowns appear to lengthen the tooth longevity of endodontically-treated teeth compared to fillings but do not completely prevent vertical root fractures.[17] The current data allows for no direct extrapolation as to whether the success rate would have been higher for endodontically-treated teeth had they been crowned. With two cases in 42 endodontically-treated teeth, the incidence of vertical root fractures was relatively low in the current study material. Furthermore, it should be realized that, in the majority of instances, the revision that was required in the teeth under investigation was a simple replacement or reparation of the filling.

Future research should aim at comparing the long-term cost/benefit ratios of the different coronal restoration options in vital and endodontically-treated teeth.

CONCLUSIONS

Minimal direct composite restorations showed a propensity for failure more frequently in endodontically-treated teeth compared to their vital counterparts. This tendency, however, was statistically only significant marginally.

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