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The survival of indirect composite resin onlays for the restoration of root filled teeth: a retrospective medium-term study

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Abstract

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Aim To investigate the outcomes of root filled posterior teeth restored with indirect composite resin onlays using tooth and restoration survival as well as the quality of restoration as outcome measures.

Methodology All patients were treated by the same clinician with indirect composite onlays for the restoration of root filled posterior teeth between January 2008 and February 2010 in a single clinic setting. Primary root canal treatment was performed and onlays fabricated with the indirect method using indirect composite resin. Patients were seen every 4–6 months for maintenance visits according to standard clinic protocols and each patient's individualized maintenance schedule. Tooth and restoration survival were calculated, and the onlays were evaluated in accordance with the modified US Public Health Service (USPHS) criteria.

Results Thirty-one premolars and one hundred and fifty-eight molars (n = 189) of 153 patients were included. The observation period ranged from 24 to 52 months with a median follow-up time of 37 months. Tooth survival was found to be 100%, whilst the restoration survival was 96.8% and the functional restoration survival 98.9% at the end of the follow-up period. According to modified USPHS criteria, the A rating had a range of 83.1–100% for all evaluation criteria.

Conclusions Onlay restorations fabricated with indirect resin can be a viable option for the restoration of root filled teeth.

Keywords: composite resin onlays, endodontic therapy, endodontically treated teeth, onlay restoration, survival rate.

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Introduction

Following root canal treatment, qualitative and quantitative alterations occur at the remaining tooth structure (Dietschi *et al.* 2011). Irrigants such as sodium hypochlorite (NaOCl) and chelators such as ethylenediamine tetra-acetic acid (EDTA), commonly used in root canal treatment, have been found to interact with the organic and mineral dentine components (Patterson 1963, Oliveira *et al.* 2007, Aranda-Garcia *et al.* 2013). These qualitative changes are likely to lead to a reduction in tooth strength after root canal treatment.

With respect to quantitative changes, the percentage of loss in tooth structure seems to be a major

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consideration following root canal treatment especially when this involves the marginal ridges (Reeh *et al.* 1989b). Although a conservative access cavity preparation affects tooth rigidity by only 5% (Trope & Ray 1992), existing caries, large restorations or even cracks may further jeopardize tooth strength (Reeh *et al.* 1989b, Steele & Johnson 1999). An occlusal cavity restoration has been reported to reduce tooth stiffness by 20%, whilst a mesial–occlusal–distal (MOD) cavity preparation by 63% (Reeh *et al.* 1989b). An access cavity preparation in such cases will result in further loss of tooth structure and may render the tooth more prone to fracture, if it is not adequately restored (Nagasiri & Chitmongkolsuk 2005, Stavropoulou & Koidis 2007). Thus, the selection of the most appropriate restoration for each clinical case should be made after thorough consideration of these critical quantitative and qualitative changes.

It is well documented that the presence of a high-quality restoration following root canal treatment is crucial for a successful long-term outcome (Gillen *et al.* 2011). A definitive restoration should aim at effectively sealing the tooth, preventing reinfection of the root canal system and properly replacing the lost tooth structure to ensure clinically acceptable aesthetics and function (Dietschi *et al.* 2011). Traditionally, most clinicians prefer to use posts of various types followed by crown restorations for the treatment of root filled posterior teeth (Eckerbom & Magnusson 2001, Seow *et al.* 2003, Naumann *et al.* 2006). Composite restorations have also been evaluated for use in the restoration of root filled teeth (Mannocci *et al.* 2002). Fibre posts with direct composite restorations in root filled premolars with limited tooth structure loss have been shown to exhibit equivalent survival rates compared with premolars restored with crowns after 3 years (Mannocci *et al.* 2002). In longitudinal outcome studies based on a systematic review, root filled teeth restored with crowns had a 10-year survival of 81%, whilst teeth with direct restorations (amalgam, composite, cements) had a 10-year survival of 63% (Stavropoulou & Koidis 2007).

Recently, onlays and overlays have been proposed for restoring root filled teeth with promising *in vitro* results (Jiang *et al.* 2010). The fabrication of indirect ceramic or resin composite overlays or onlays aims at the coverage of missing tooth structure with limited further tooth preparation. These types of restorations permit greater control over occlusal and proximal contacts and reduce the negative effect of polymerization shrinkage when compared to direct restorations. In addition, 360-degree tooth preparation used in crown construction is avoided. More conservative preparation results in enhanced capability of the clinician to evaluate the restoration *in situ* and to limit the consequent irritation to the periodontium (Blank 2000).

The rationale behind this treatment modality is that the preparation pattern embraces the tooth structure and provides cuspal coverage, similar to crown restorations. In addition, onlays are less time-consuming, less costly for the patient and easier to repair especially when fabricated with resin composite (Blank 2000).

The aim of this retrospective study was to investigate the outcomes of root filled posterior teeth restored with indirect composite resin onlays using tooth and restoration survival as well as the quality of restoration as outcome measures. The quality of restoration was assessed using modified US Public Health Service (USPHS) criteria (Bayne & Schmalz 2005).

Materials and methods

The study was carried out in accordance with the ethical principles of the World Medical Association Declaration of Helsinki and received approval from the Ethics Committee of the Technical University of Dresden.

All patients were treated by the same experienced clinician with indirect composite onlays for the restoration of root filled posterior teeth between January 2008 and February 2010 in a single clinic setting. To be included in the retrospective analysis, patients had to present with at least one posterior tooth having a composite onlay restoration placed following initial root canal treatment.

Exclusion criteria were the following:

- Root filled teeth with significant loss of tooth structure that were restored with full-coverage crown restorations.
- Teeth with pre-existing onlay or crown restorations
- Teeth that had undergone previous root canal treatment
- Patients with history of bruxism
- Less than 2 years of follow-up following restoration

All patients entered an individualized maintenance programme following restoration placement and were followed up for routine dental maintenance.

Treatment

All root canal treatments were performed by a dentist with advanced education in endodontics and more than 15 years of practice limited to endodontics and restorative dentistry. The routine clinical protocol included root canal treatment under rubber dam isolation using the ProFile System (Dentsply Maillefer, Ballaigues, Switzerland) and irrigation with 5.25% NaOCl (SultanHealthcare, Hackensack, NJ, USA) and 17% EDTA solution (Vista Dental Products, Racine, WI, USA). After 1 week of dressing with $Ca(OH)_2$ (Ultracal XS paste, Ultradent Products Inc., South Jordan, UT, USA), the canals were filled with gutta-percha and sealer using the lateral compaction technique. A light-cured glass–ionomer material (Vitrebond, 3M, St. Paul, MN, USA) was used as an orifice barrier, and the access preparation was temporarily restored with Cavit G (3M, ESPE, Seefeld, Germany).

Seven days following the root canal treatment, onlay preparations were performed on the treated teeth in the same setting by a clinician who had more than 20 years of experience in restorative dentistry. In all cases, the functional cusp(s) were occlusally reduced, by 1.5 mm, allowing the proper clearance for adequate bulk of restorative material.

The remaining cusp(s) were included in the preparation only if they had been previously restored or fractured. In the same appointment, the final impression was taken, and tooth colour was chosen with the aid of the Vita colour guide (Vita Zahnfabrik, Bad Säckingen, Germany). Following impression, the prepared tooth was restored temporarily with a mouldable interim restorative material (TelioOnlay, Ivoclar-Vivadent, Schaan, Liechtenstein), and the patient was scheduled for the final appointment. All onlays were fabricated with the indirect method using an indirect composite resin material (Gradia, GC, Tokyo, Japan). At the final appointment, the interim restorative material was removed with the aid of a dentine explorer. The prepared tooth area was cleaned with alcohol to remove any additional remnants of the temporary restoration, and to disinfect the cementation area. The restoration was tried on the preparation for accuracy of fit. The restoration was considered acceptable if following its seating, a dental explorer running through the restorative margin circumferentially of the tooth did not meet any gap or resistance. If the seating of the restoration was inadequate, or if there was a void between the margin of the restoration and the tooth at any point, a new impression was taken, interim restorative material was placed and the patient was asked to return for another appointment. Following verification of adequate fit, the restoration was cemented using a self-etching, dual-cured and resin cement (TotalCem; Itena Clinical, Paris, France).

According to standard clinical protocols, patients were asked to immediately contact the restorative dentist in case they had any problems with their restoration or with the restored tooth.

Outcome evaluation

All patients were seen every 4–6 months for maintenance visits according to standard clinic protocols and each patient's individualized maintenance schedule. Evaluation of the teeth and their restorations according to modified USPHS criteria was performed once in one of their maintenance visits during the study period.

Baseline radiographic and clinical records were collected for included teeth. At the recall appointment, one of the authors who did not provide the root canal treatment or restoration on these patients evaluated the following parameters:

1. The structural integrity of the tooth as determined by presence or absence of crown and/or root fracture,
2. The outcome of the primary root canal treatment based on clinical and radiographic measures. The periapical tissues were classified as 'healed' (absence of apical periodontitis, signs and symptoms), or as having 'disease' (presence of apical periodontitis, signs or symptoms).
3. Evaluation of the restorations in terms of retention, colour match, marginal adaptation, marginal discoloration, anatomical structure, presence of caries and presence of fracture using modified USPHS criteria (Bayne & Schmalz 2005) (Table 1). The evaluation was based on clinical examination and radiographic evaluation of periapical radiographs.

Descriptive analysis was performed for the evaluation of tooth and restoration outcomes (proportions of teeth or restorations survived, respectively) as well as for the quality evaluation of the onlays. Tooth survival was defined as the tooth remaining *in situ* at the follow-up examination without report of a biological event (caries, tooth fracture, periodontal reason) or

Table 1 Modified USPHS criteria

Retention
A – Full retention is present
B – Part of the restoration is fractured and the retention is partially lost
C – Retention is absent
Colour match
A – Restoration matches adjacent tooth structure in shade and/or translucency
B – Mismatch in shade and/or translucency is within normal range of tooth shade
C – Mismatch in shade and/or translucency is outside normal range of tooth shade
Occlusal marginal adaptation
A – Explorer does not catch crevice when drawn across the restoration/tooth interface. No crevice an explorer can be drawn is visible on the restoration margin
B – Explorer catches and crevice is visible but no exposure of dentine
C – Explorer penetrates crevice defect with exposure of dentine but restoration is not mobile in the cavity
Interproximal marginal adaptation
A – Explorer does not catch crevice when drawn across the restoration/tooth interface. No crevice an explorer can be drawn is visible on the restoration margin
B – Explorer catches and crevice is visible but no exposure of dentine
C – Explorer penetrates crevice defect with exposure of dentine but restoration not mobile in the cavity
Occlusal marginal discoloration
A – No discoloration is visible along restoration/tooth interface
B – Partial discoloration is visible along restoration/tooth interface but has not penetrated in pulpal direction
C – Marginal discoloration has penetrated in pulpal direction
Interproximal marginal discoloration
A – No discoloration is visible along restoration/tooth interface
B – Partial discoloration is visible along restoration/tooth interface but has not penetrated in pulpal direction
C – Marginal discoloration has penetrated in pulpal direction
Interproximal anatomical structure
A – Restoration is visually continuous with existing anatomical form. Restoration is not under contoured compared with the surrounding teeth
B – Restoration is under contoured compared with the surrounding teeth with no exposure of dentine (partial anatomical form is lost)
C – Restoration is sufficiently lost to expose dentine
Occlusal anatomical structure
A – Restoration is visually continuous with existing anatomical form. Restoration is not under contoured compared with the surrounding teeth
B – Restoration is under contoured compared with the surrounding teeth with no exposure of dentine (partial anatomical form is lost)
C – Restoration is sufficiently lost to expose dentine
Secondary caries at the occlusal surface
A – Secondary caries is absent
B – Secondary caries is present
Secondary caries at the interproximal surfaces
A – Secondary caries is absent
B – Secondary caries is present
Marginal fracture
A – Marginal fracture is absent
B – Marginal fracture is present
Body fracture
A – Body fracture is absent
B – Body fracture is present

tooth extraction. The outcome for each restoration was defined as (i) restoration survival, (ii) functional restoration survival and (iii) absolute restoration failure. Restoration survival was defined as the restoration remaining *in situ* at the follow-up examination without presenting an absolute failure, or having experienced loss of retention. Functional restoration survival was defined as the restoration remaining *in situ* at the follow-up examination without presenting an absolute failure. Restorations that lost their retention and were recemented without the need for any laboratory modifications were included in the functional survival category. Absolute restoration failure was defined as a clinically unacceptable defect of the restoration that required its replacement.

Results

In 153 patients (71 females and 82 males), with a mean age of 52 years (range: 27–78), a total of 189 indirect resin composite onlay restorations were placed on root filled posterior teeth. Thirty-one premolars and one hundred and fifty-eight molars (n = 189) with primary root canal treatment and composite onlay restorations were included. The observation period ranged between 24 and 52 months with a median observation time of 37 months (Table 2). Amongst the 189 restored teeth, tooth survival was 100% as no caries, fractures, periodontal issues or extractions were noted at the follow-up examination.

The results of the evaluation of the 189 restorations are presented in Table 3. According to modified USPHS evaluation criteria, at the time of recall all, onlay restorations obtained an A rating for the 'maintenance of the anatomical form at the interproximal surfaces', the 'presence of secondary caries' and 'marginal discolouration'. Additionally, no fracture was detected at the restoration margins. The percentage of

restorations with A rating for the remaining evaluation criteria was 97.9% for 'retention', 83.1% for 'colour match', 97.4% for 'marginal adaptation at the occlusal surfaces and the interproximal surfaces', 92.1% for the 'marginal discolouration at the interproximal surfaces', 91% for the 'occlusal anatomical structure' and 99% for the 'body fracture'.

Four onlay restorations (2.1%) lost retention within the first week of cementation with a range of 3–7 days and were recemented. These restorations were intact at the time of re-evaluation and were included in the functional restoration survival.

Two of the restorations (1.1%), one on a mandibular first molar and one on a maxillary second molar experienced a body fracture in one functional cusp and in both functional cusps, respectively, and were replaced. The time of the fracture was after 26 months for the maxillary molar and 36 months for the mandibular molar. There were no fractures noted in premolars.

Root canal treatments were clinically and radiographically assessed. Two cases required nonsurgical root canal retreatment. In these two cases, the restorations were intact therefore it was decided to proceed with access preparation *in situ*, through the onlay. Following completion of retreatment, the onlays were repaired directly with composite resin (Gradia Direct, GC, Tokyo, Japan). According to descriptive analysis, the restoration survival was 96.8% (183/189) and the functional restoration survival was 98.9% (187/189) for the recall period of 24–52 months. Absolute restoration failure was estimated to be 1.1% (2/189).

Table 3 Evaluation of the onlay restorations ($N = 189$) according to modified USPHS criteria

	Criteria rating (*n*)		
Modified USPHS criteria	A	B	C
Retention	185 (97.9%)	0	4 (2.1%)
Colour match	157 (83.1%)	29 (15.3%)	3 (1.6%)
Occlusal marginal adaptation	184 (97.4%)	5 (2.6%)	0
Interproximal marginal adaptation	184 (97.4%)	5 (2.6%)	0
Occlusal Marginal discoloration	189 (100%)	0	0
Interproximal marginal discoloration	174 (92.1%)	15 (7.9%)	0
Interproximal anatomical structure	189 (100%)	0	0
Occlusal anatomical structure	172 (91%)	17 (9%)	0
Secondary caries at the occlusal surface	189 (100%)	0	–
Secondary caries at the interproximal surfaces	189 (100%)	0	–
Marginal fracture	189 (100%)	0	–
Body fracture	187 (99%)	2 (1%)	

Discussion

The outcome of a root canal treatment and tooth survival is positively associated with the quality of the coronal restoration (Salehrabi & Rotstein 2004). Salehrabi & Rotstein (2004) evaluated root canal treatment outcome in more than one million patients and showed that 85% of the teeth that had to be extracted had no full coronal coverage. They also found a sixfold increase in failure rate in posterior teeth with no crowns (i.e. no restoration at all or large composite/amalgam restorations) compared with posterior teeth with a crown restoration. Results from a systematic review suggest that the odds for healing of apical periodontitis increase with both adequate root canal treatment and adequate restorative treatment (Gillen *et al.* 2011). The need for timely placement of the permanent restoration after completion of the root canal treatment is also well reported in the literature (Safavi *et al.* 1987, Uranga *et al.* 1999, Gillen *et al.* 2011). In the present study, preparation of the onlay restorations was performed 1 week following root filling in all patients.

Full crown restoration has been the treatment of choice for most clinicians for the treatment of root filled permanent posterior teeth (Reeh *et al.* 1989a, Eckerbom & Magnusson 2001, Dammaschke *et al.* 2003, Seow *et al.* 2003, Lynch *et al.* 2004, Naumann *et al.* 2006). In search of less invasive treatments, enamel-bonded resin has been found to be an alternative treatment option for posterior teeth that have

Table 2 Frequency distribution of examined teeth (n) according to follow-up period

	Follow-up time in months (*t*)						
Teeth ($n = 189$)	$t = 24$	$24 < t < 36$	$t = 36$	$36 < t < 48$	$t = 48$	$48 < t < 52$	$t = 52$
Premolars	2	11	0	17	1	0	0
Molars	6	69	6	70	1	3	3

limited loss of tooth structure (Mannocci *et al.* 2002). Additionally, a randomized clinical trial showed that restorations with fibre posts and composite were superior in preventing fractures compared with amalgam restorations; however, they were less effective in preventing secondary caries (Mannocci *et al.* 2005). In the present study, all restorations received an A rating for secondary caries, after a median observation time of 37 months. The difference between the results of this study and the results of Mannocci *et al.* (2005) is consistent with the inherent polymerization shrinkage of direct resin restorations in comparison with the minimized effect of polymerization shrinkage of indirectly fabricated restorations (Bortolotto *et al.* 2007).

The survival of root filled teeth restored with indirect composite has not been previously investigated. Descriptive analysis showed 100% tooth survival, 96.8% restoration survival and 98.9% functional restoration survival for the indirect composite onlay restorations during the medium-term follow-up presented in this study. The favourable response of the restorations can be attributed to the characteristics of the restorative material as well as the cuspal-coverage design of the onlays. Indirect composite restorations have been reported as being very promising for the restoration of root filled teeth (Krejci *et al.* 2003). Indirect resin composite expresses a lower elastic modulus compared with ceramics or gold alloys allowing the reduction in the stresses occurring in the dentinal walls (Jiang *et al.* 2010). Furthermore, the higher degree of polymerization of the indirect resin composite allows the fabrication of accurate restorations with response to the functional and aesthetic demands of the patient (Huth *et al.* 2011). Regarding restoration design, onlays minimize the risk of fracture of root filled teeth when compared to inlay restorations (Dejak *et al.* 2007). Moreover, *in vitro* data have shown that indirect composite onlays have significantly higher mean fracture resistance than direct composite coverage or direct combined composite amalgam coverage and that the fracture resistance is similar to that of intact teeth (Shaflei *et al.* 2011).

Shortcomings of the onlay restorations evaluated in this study were infrequent, with absolute restoration failure being approximately one per cent. Two restorations on molar teeth experienced cuspal fractures and were replaced. This may infer that there is an increased risk for fracture in the molar region even though specific statistical analysis was not carried out. Additionally, failed colour match (C rating) was recorded for three restorations. This was not considered a reason for the replacement of the restoration, as long as it met the remaining evaluation criteria, and the patient(s) remained satisfied with the aesthetic outcome.

The results of the present retrospective study show that the use of indirectly fabricated onlay with composite resins can be a reliable alternative for the restoration of root filled teeth. Onlay restorations are commensurate with the more contemporary concept of minimally invasive dentistry. Owing to the mechanical stability of the composite resins and the characteristics of new generation adhesive systems, onlays may be used for the restoration of root filled teeth without the need of removing a substantial amount of dental tissues. This study showed a high percentage of onlay restorations (96.8%) survived after 24–52 months observation period, that is similar to the high survival rate (95.6%) reported for metal-ceramic crowns with at least 3 years observation period (Pjetursson *et al.* 2007). Longitudinal randomized clinical trials that will compare onlays to metal-ceramic crowns for the restoration of endodontically treated teeth are crucial to validate these data.

Conclusions

Onlay restorations fabricated with indirect resin composite may be a viable option for the restoration of endodontically treated teeth. Further randomized, controlled clinical trials are required to validate the present clinical findings.

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