



ORIGINAL ARTICLE



## Patients' self-report on post-retained restoration is more valuable than expected! Explorative analysis of an 11-year follow-up

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### ABSTRACT

**Objective:** Assessment of long-term clinical data regarding post-endodontic restorations is essential for the evaluation of different post-and-core concepts. The aim of the present study was to assess the diagnostic accuracy of patient self-reporting on post-endodontic restorations after 11 years of clinical service.

**Materials and methods:** Twenty-nine patients (61 ± 15 years old) with endodontic glass-fibre and titanium post-endodontic restorations were examined within the 11-year follow-up of a randomized controlled trial. Restorations were assessed by self-reports during a telephone interview (one item), the completion of a four-item questionnaire and clinical and radiographic examination. A gold standard for restoration *in situ* or 'failure' was defined by clinical and radiographic examination. Diagnostic accuracy of patients' self-reports was evaluated by calculating the sensitivity, specificity, and positive (PPV) and negative predictive values (NPV).

**Results:** After a mean observation time of 137 months (min/max: 125/154 months), 25 (86.2%) restorations were *in situ* and 4 (13.8%) failures were detected. Self-report during a telephone interview and the four-item questionnaire correctly identified all *in situ* restorations (specificity = both 100%, NPV = 92.6%/96.2%). Self-report during a telephone interview identified two out of four failures (sensitivity = 50%, PPV = 100%), and self-report on the four-item questionnaire identified three out of four failures (sensitivity = 75%, PPV = 100%).

**Conclusions:** When the clinical examination is not feasible, patients' self-report shows valuable diagnostic potential in the identification of the post-endodontic failure.

### ARTICLE HISTORY

Received 31 December 2017  
Revised 25 March 2018  
Accepted 24 June 2018

### KEYWORDS

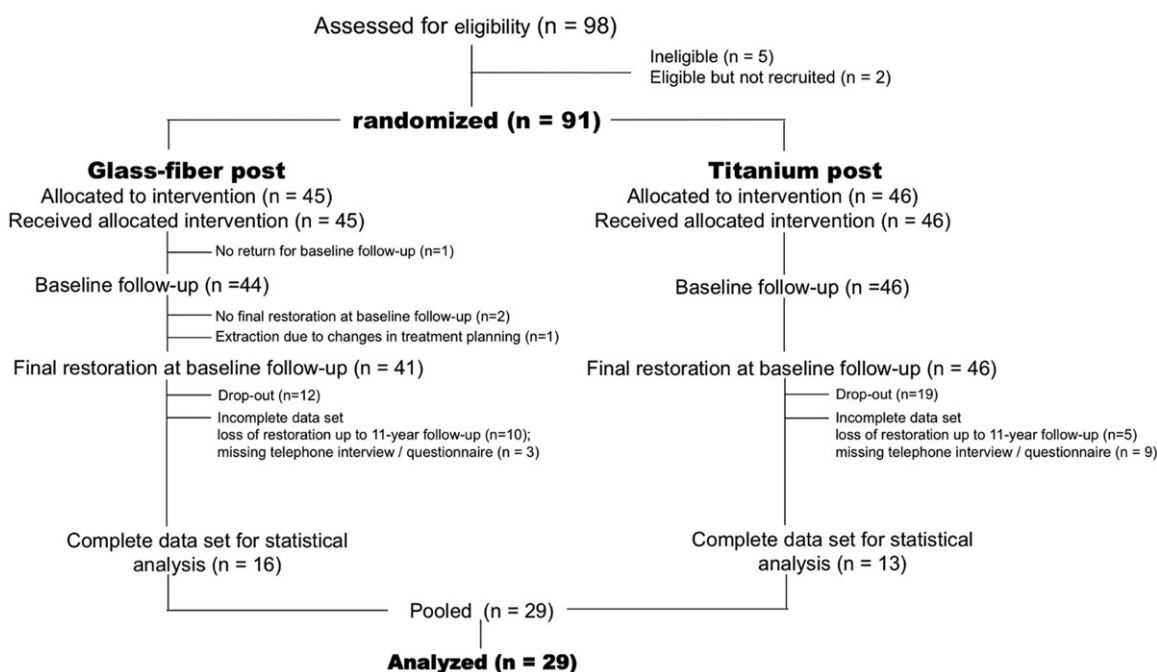
Endodontic post;  
endodontically treated  
teeth; long-term clinical  
trial; post-endodontic  
restorations; self-report

### Introduction

A widely expressed demand in dentistry is the publication of long-term clinical results based on well-designed studies [1,2]. In particular, randomized controlled trials (RCTs) are required to strengthen the evidence of outcomes from different treatment approaches [1,3,4]. These requirements are evident; however, it is challenging to develop, perform and report clinical trials, irrespective of whether a study is randomized or non-randomized [5–7]. It was described, that loss to follow-up is inevitable [8]. The effects of attrition of study participants could affect results, such as loss of power and conclusions. Aspects of loss to follow-up should be explicitly discussed when analyzing follow-up studies [8,9].

Long-term RCTs on post-endodontic restorations are scarce [10,11]. Diverse studies have been carried out to generate long-term data on post-restored endodontically treated teeth (ETT) by deviating from an RCT design. Fokkinga et al.

published a 17-year follow-up study performed by 17 calibrated dentists in a multi-practice setting [12]. After analyzing data of 257 patients with different post-and-core restorations the showed that after 15 years 68% of the teeth were available, and after 17 years this number had reduced to 28%. Another 10-year observational study evaluated post-endodontic restorations with glass-fibre posts by including a total of 149 posts placed in 119 patients [13]. Up to 120 months of follow-up 34 patients were lost. Moreover, Bateli et al. reported results on survival of teeth restored with endodontic zirconia posts from a 10-year retrospective study, showing an approximate 50% drop-out rate [14]. Furthermore, another 19.5-year retrospective study by Raedel et al., focusing on the survival of ETT restored with cast post and cores showed that survival rates of restorations (mean survival time 13.5 years) of a proportionally large cohort of 343 patients were able to be calculated, despite the methodological limitations of the study [15]. Short- and medium-



**Figure 1.** Flow diagram of participants according to study design. Inclusion for statistical analysis required per participant a full data set of one-item questionnaire, four-item questionnaire and results from clinical and radiographic examination.

term studies with follow-up periods of 32 months [16], 4 years [17] and 5 years [18] discontinued reporting prior to the 10-year end point. The reasons for this may be very complex; however, one co-factor may have been the drop-out rate, which was relatively high at the 5-year follow-up [18].

Patient self-reporting has been shown to provide valid estimates for numbers of remaining teeth, fillings, root canal therapy and fixed and removable dental prostheses [19], with a sensitivity and specificity for the presence of root canal therapy of 90.0% and 92.1%, respectively. Another study focused on the ascertainment of periodontal disease by patients self-reports and found that several self-reported items in questionnaire form may be useful for the determination of periodontal disease in epidemiological studies [20]. Gomes et al. evaluated the validity of questionnaire-based self-reported history of endodontic treatments and found that is an accurate method for the prediction of endodontic treatment (sensitivity 91.5%, specificity 89.1%), but weak for the prediction of apical periodontitis (sensitivity 78.2%, specificity 68.9%) [21].

To the best of our knowledge, the value of self-reported status of post-endodontic restorations has not yet been investigated.

The aim of this explorative study was to evaluate the diagnostic accuracy of the patients' self-report on post-endodontic restorations after eleven years *in situ*.

## Materials and methods

### Study design, setting and subject

The present explorative study was conducted during the 11-year follow-up of a pilot RCT evaluating long-term survival of endodontic glass-fibre and titanium post-endodontic restorations (registered in clinicaltrials.gov No. NCT01520766) [22]. Trial design, methods and primary outcomes are reported

according to the revised Consolidated Standards of Reporting Trials (CONSORT) statement [23,24] updated in 2010 [24] by Sterzenbach et al. [25].

Between January 2003 and April 2004, 98 potential participants were consecutively recruited for post-endodontic treatment at the Department of Prosthodontics, Geriatric Dentistry and Craniomandibular Disorders, Charité – Universitätsmedizin Berlin, Germany. Ninety-one participants were included for randomization (Figure 1). Inclusion criteria have been previously described [25]. Participants received post-endodontic restorations with either glass-fibre or titanium posts. One single operator performed post-endodontic treatment procedures including consideration of a root canal filling of at least 4mm after post space preparation, an adhesively luted endodontic post, a 2 mm ferrule design, and a biological width of 2–3mm. Final restorations (single crowns, fixed dental prostheses, removable dental prostheses) were placed in the dental student course.

The 11-year follow-up was performed by one calibrated operator (MvS) and included a step-wise procedure of contacting participants. If an initial telephone contact was unsuccessful, one letter was sent to participants without a second reminder. In the case of invalid postal contact data, a web-based search was performed to enhance the possibility of locating participants. In the case of success through letter or web-based contact, a telephone call was performed. Patients were offered a free check-up, additionally a free professional tooth cleaning, in addition to reimbursement of travel expenses.

The present research was conducted in accordance with accepted ethical standards for research practice, undergoing review and approval by the local Institutional Review Board. Written informed consent was obtained from all participants prior to their enrolment.

### Assessment of the clinical survival of the restoration

Survival of the restoration was rated based on clinical and radiographic examination. Clinical examinations were performed with a dental probe and medical loupe (2.5× magnification) to detect marginal gap formations of restorations. Probing depths were measured at four sites with a manual probe (UNC #UNC15 hdl; Hu-Friedy, Chicago, IL), although literature defined a standard measurement at six sites for premolars and molars [26]. Radiographs were taken when indicated and evaluated by one experienced examiner (MN) to exclude the possibility of radiographic signs of failure (e.g. periodontal or periapical lesions). Post-endodontic restorations were recorded as 'failure' in the case of restoration loss for any reason: tooth loss, post debonding, post fracture, vertical or horizontal root fracture, radiographic signs of endodontic or peri-radicular conditions requiring endodontic retreatment, secondary caries and failure of core build-up, and loss of restoration due to technical failures. If no failure was detected, the restoration was evaluated as *in situ*.

### Assessment of patient self-reports

Two different approaches were applied to gain information from the patient regarding the condition of the tooth and the restoration. Firstly, a one-item questionnaire was administered during a telephone interview (Table 1) adhering to a predefined procedure: The examiner (MvS) described in simple terms the tooth that was treated in the study (upper/lower small or large molar, upper/lower incisor) and the type of final restoration (single crown, fixed dental prostheses, removable dental prostheses). Subsequently, the operator asked one global question concerning the condition of the tooth that was treated in the study (Do you think that everything is OK with this tooth?) with the response options 'yes' or 'no'. If the participant answered 'yes', the post-endodontic restoration was defined as self-reported *in situ*. If the participant answered 'no', 'failure' was recorded. Nine participants responded only to the one-item questionnaire and had no appointment. In one case, the operator did not ask the oral question for personal reasons.

Secondly, at the beginning of the appointment prior to the clinical examination, the participant received a four-item paper-based questionnaire for self-administration (Table 1). This questionnaire contained an opening statement with a description and declaration of the tooth, analogous to the introduction during the telephone interview. The first item on this questionnaire was identical to the item administered during the telephone interview. The remaining three items

focused more specifically on the endodontic condition (Do you think that the root canal filling of this tooth is OK?), periodontal condition (Do you think that your gums on this tooth is OK?) and condition of the restoration (Do you think that the crown on this tooth is OK?). When a minimum of one item was answered with 'no', 'failure' was recorded. In two cases, the paper-based questionnaire was not available prior to the clinical examination.

A total of 29 (33%) participants with a complete data set of the one-item and four-item questionnaires and results from clinical and radiographic examination were included for analysis.

### Statistical analyses

Descriptive statistics of participants and tooth characteristics were calculated using the statistical software package IBM SPSS Statistics 23 (SPSS Inc, Chicago, IL). The combined evaluation of the clinical and radiographic examinations was deemed the gold standard (restoration *in situ* or 'failure' for any reason) for the assessments of test accuracy. The one-item questionnaire applied during the telephone interview and the self-administered, paper-based four-item questionnaire was considered the diagnostic tests. Measures of diagnostic test accuracy such as sensitivity, specificity, and positive (PPV) and negative predictive values (NPV) were determined for both tests, separately.

## Results

### Subject characteristics

Of the 29 participants in the present study, 16 had glass-fibre and 13 had titanium post-endodontic restorations (Figure 1). Each participant responded to the one-item and four-item questionnaires and received a clinical and radiographic examination. The distribution of gender was balanced, and the type of final restoration was predominantly represented by single crowns ( $n = 19$ ) and fixed dental prostheses ( $n = 7$ ; Table 2). The overall mean observation time was 137 months (SD: 6; range: 125–154 months).

### Restoration survival and patients' self-reports

Twenty-five restorations were clinically and radiographically evaluated as *in situ* and four restorations were evaluated as a failure (two root fractures, one endodontic failure with periapical periodontitis, one combined periodontal-endodontic lesion; Table 3). The prevalence of a failure (13.8%) was

**Table 1.** Items of self-report from the telephone interview and questionnaire.

Type of self-assessment	Possible answers	
One-item questionnaire (telephone interview)		
• Do you think that everything is OK with this tooth?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Four-item questionnaire (self-administered)		
• Do you think that everything is OK with this tooth?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
• Do you think that the root canal filling of this tooth is OK?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
• Do you think that your gums on this tooth is OK?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
• Do you think that the crown on this tooth is OK?	<input type="checkbox"/> Yes	<input type="checkbox"/> No

**Table 2.** Descriptive data of participants and tooth characteristics.

	Participants/teeth (N = 29) Mean SD or N (%)
Age (years)	61.4 ± 14.9
Gender	
Female	14 (48.3)
Male	15 (51.7)
<i>Tooth characteristics</i>	
Tooth type	
Incisor	9 (31.0)
Canine	3 (10.3)
Premolar	11 (37.9)
Molar	6 (20.7)
Final restoration	
Single crown	19 (65.5)
FDP	7 (24.1)
Single crown and RDP	2 (6.9)
FPD and RPD	1 (3.4)

FDP: fixed dental prostheses; RDP: removable dental prostheses; SD: standard deviation.

**Table 3.** Survival of restorations according to clinical and radiographic examination (gold standard) and the two diagnostic tests (patients' self-reports).

Diagnostic test	Gold standard	
	<i>In situ</i> (n = 25) (86.2%)	Failure (n = 4) (13.8%)
One-item questionnaire (telephone interview)		
<i>In situ</i> (n = 27) (93.1%)	25	2
Failure (n = 2) (6.9%)	0	2
Four-item questionnaire (self-administered)		
<i>In situ</i> (n = 26) (89.7%)	25	1
Failure (n = 3) (10.3%)	0	3

underestimated when using the questionnaires (6.9% for one-item questionnaire, 10.3% for four-item questionnaire).

### Diagnostic test accuracy

The one-item questionnaire showed a sensitivity of 50% (Table 4). A single global question on the phone was not strong enough to correctly detect a failure by patients' self-report. The four-item questionnaire showed a higher accuracy with 75% sensitivity in cases of clinically and radiographically examined failure. Both types of self-report have a specificity of 100%; in case of a clinically and radiographically evaluated intact post-endodontic restoration, all participants correctly reported it *in situ*. The NPVs also showed a high probability (92.6% for a telephone interview and 96.2% for self-administered questionnaire) that in the case of patient self-reporting as *in situ*, the restoration was confirmed to be clinically and radiographically intact. In the case of failure being reported by the participant during the telephone interview or self-administered questionnaire, the probability (PPV) that was detected correctly by the participant was 100%.

### Discussion

This is the first study that evaluates the diagnostic accuracy of the patients' self-report on post-endodontic restorations during a long-term follow-up. The findings of this explorative study indicate that patients' self-report presents a promising approach for use in clinical trials to detect failures of ETT

**Table 4.** Sensitivity, specificity, positive and negative predictive values (PPV and NPV) for the two diagnostic tests.

Test	%			
	Sensitivity	Specificity	PPV	NPV
One-item questionnaire (telephone interview)	50.0	100.0	100.0	92.6
Four-item questionnaire (self-administered)	75.0	100.0	100.0	96.2

after 11 years, with a better diagnostic accuracy of a four-item questionnaire than a one-item version.

Comparison of the present results with those reported in the literature is limited to only a few trials evaluating patients' self-report on the history of endodontic treatment. Gomes et al. found that the self-reported history of endodontic treatment was highly accurate in the prediction of a received endodontic treatment (accuracy = 89.9%) but was a weak predictor of the presence of apical periodontitis (PPV = 35.3%) [21]. In the present study, one participant reported an intact post-endodontic restoration but showed apical periodontitis following the radiographic examination. This one false negative result had a strong impact on the sensitivity of a test with only four overall cases of failure, indicating that, a self-report alone can underestimate a failure or need for clinical treatment. Farmer et al. compared self-reported and clinically diagnosed dental treatment needs [27] using data from the Canadian Health Measures Survey from ~5600 individuals, obtained through a self-reporting computer-assisted interview. It was found that self-reports have a suitable diagnostic accuracy for the prediction of endodontic needs. In contrast to this epidemiological study design, we focused on participants of an RCT with post-endodontic restorations who potentially had a greater awareness of the tooth of interest than a representative population. However, with respect to the confirmation of non-needs, our results support these previous findings since the one-item and four-item questionnaires showed a high specificity.

The evaluation of patients' self-reports either during a telephone interview [28,29] or by itemized questionnaires [30] shows its potential for consideration as a surrogate parameter for clinical survival and has already been integrated into epidemiological investigations such as food frequency [31] and rheumatoid arthritis [32]. Due to the fact that no standardized questionnaires were available for self-reports on the condition of post-endodontic restorations, we developed a one-item questionnaire for telephone-based self-reports and constructed a four-item version of a paper-based questionnaire. The design of both the interview and self-administered questionnaires was not verified regarding reliability, and thus may be a methodological limitation [33]. Another limitation of the study is the fact that only four cases of failure could be included in diagnostic tests. Failure scenarios over the course of the present RCT were catastrophic, being mainly root fractures and endodontic failures [25]. In the case of a root fracture, the participant immediately consulted the study centre or dentist. Even if endodontic failures could occur with sub-clinical symptoms, there was a high chance of detection through radiography over the course of the study, during the

patients' regular check-ups. In other words, in the case of a failure, the probability was proportionally high that it would be promptly detected by the participant, the study centre, or the dental practitioner. Accordingly, the analysis of the present 11-year follow-up study was based on cases in which participants had no major problems with their restored tooth, which is reflected in the proportion of 25 *in situ* to 4 'failure' cases.

The applied criteria for restorations *in situ* and failed restorations should be further considered. At study outset, 'failure' as a primary endpoint was very widely defined, including endodontic complications or peri-radicular lesions, which are not a typical post-endodontic-related problem; consequently, *in situ* was defined as the absence of any possible adverse event. A weighting of failures, technical or biological, and their distinction with respect to real post-failures is missing from the present study.

Moreover, the initial distinction between survival and success would have been such a weighting of events. Survival of a post-retained restoration could be defined as 'post and crown still in function'. Success criteria may include technical complications such as post-debonding, post fracture, failure of core build-up, biomechanical complications as vertical or horizontal root fracture, and biological complications as secondary caries or radiographic signs of endodontic or peri-radicular conditions requiring endodontic retreatment. If the definition of survival 'post and crown still in function' had been chosen when preparing the data for analysis, the questionnaires may have shown a higher specificity. This is important in the context of interviewing a much larger collective. Furthermore, when discussing biological complications, the method of radiographic examination includes potentially undetected lesions compared with the diagnostic accuracy of CBTC scans [34].

Despite a relatively low sensitivity, the high specificity of both the one-item and four-item questionnaires, and the positive predictive values of 100% strengthen the diagnostic potential of the patients' self-report. The lower prevalence of failures when using the questionnaires can be evaluated as a weak point of these methods. Both questionnaires should be validated with respect to their robustness to detect failures. The use of the four-item questionnaire during a telephone interview should also be assessed, and the inclusion of an open question considered. The potential of oral self-reporting by telephone is supported by the fact that nine additional participants responded to the oral one-item questionnaire but refused to make an appointment for a clinical and radiographic examination.

The patient's self-report on the survival of a restoration as a surrogate parameter could be incorporated into clinical follow-up appointments during long-term clinical trials in endodontics and restorative dentistry and proves to have potential to supplement clinical data.

## Conclusions

Patients' self-report on post-endodontic restorations assessed using questionnaires shows valuable diagnostic potential; however, further evaluation is required.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Funding

The study was registered at clinicaltrials.gov (No. NCT01520766).

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