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Validity of self-reported history of endodontic treatment in the Baltimore Longitudinal Study of Aging

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Abstract

Introduction—Self-reported history of endodontic treatment (SRHET) has been used as a simplified method to estimate history of endodontic disease and treatment. This study aimed to quantify the validity of SRHET, as reported in the Baltimore Longitudinal Study of Aging (BLSA), as a method to: 1- identify individuals who experienced endodontic treatment (ET); and 2- identify individuals who present with apical periodontitis (AP).

Methods—SRHET was collected through the BLSA questionnaire in 247 participants. Data on ET and AP were determined from panoramic radiographs. The total number of ET, AP and missing teeth were recorded for each individual. Validity of SRHET was determined based on ET and AP, separately. Accuracy, efficiency, sensitivity, specificity, positive and negative predictive values (+PV, −PV) and positive and negative likelihood ratios (+LR, −LR) were calculated according to standard methods.

The authors deny any conflicts of interest related to this study.

Results—After exclusions, 229 participants were available for ET analysis and 129 for AP analysis. The SRHET validity values were: sensitivity (ET=0.915; AP=0.782), specificity (ET=0.891; AP=0.689), +PV (ET=0.824; AP=0.353), −PV (ET=0.949; AP=0.936), +LR (ET=8.394; AP=2.514) and −LR (ET=0.095; AP=0.316).

Conclusions—SRHET was found to be a highly accurate method to predict ET but a weak predictor of the presence of AP among participants in the BLSA.

Keywords

self-report; endodontic treatment; apical periodontitis; validity

Introduction

Self-reported health status is widely used in surveys of populational studies. Epidemiological investigations use self-report approaches in the assessment of a variety of systemic diseases and health-related conditions, such as diet (1), rheumatoid arthritis (2), hypertension (3), smoking habit (4), and others (4, 5). Recently, self-reported oral health status has been increasingly used in epidemiological studies in dentistry (6–11).

Self-report measures have been shown to provide accurate estimates for number of teeth (7, 8, 12–16), periodontal disease (17, 18), dental fillings (8) and the presence of dentures or prosthetic appliances (8, 12, 14, 16, 19). Self-report measures, however, have not always been found to accurately reflect the number of replaced teeth (19), periodontal disease (8, 20, 21) or dental agenesis (22). Vered and Sgan-Cohen (23) have shown that self-perception levels of oral health tends to be higher than that of oral disease.

The development of epidemiological investigations of endodontic disease and treatment in large populations has been limited by the need for a detailed clinical and radiographic examination. Current diagnostic strategies require high cost, long time, equipment and trained staff, as well as radiation exposure to participants, which, in part, explains the relatively low number of epidemiological studies in this area.

Accordingly, the assessment of self-reported history of endodontic treatment (SRHET) has been recently used as a simplified method to estimate patient's endodontic treatment (ET) experience and history of endodontic disease (6, 24). It is considered that radiographic evidence of ET provides information related to an individual's past experience with pulp pathology and/or apical periodontitis (AP). The validity of this assumption, however, is yet to be tested.

The validity of a self-reported health measure is best described by its sensitivity and specificity, whereas its clinical usefulness in a given population is best described by its positive and negative predictive values (25, 26). Sensitivity is the proportion of cases identified correctly by means of the self report. For example, if SRHET had a sensitivity of 80 percent, it would mean that 80 percent of patients who have undergone ET responded positively to SRHET. Conversely, specificity is the proportion of noncases identified correctly by means of the self-report. For example, if SRHET had a specificity of 70 percent, it would mean that 70 percent of patients who had never undergone ET responded negatively to SRHET. Positive predictive value is the proportion of positive SRHET results that are cases. For example, if SRHET had a positive predictive value of 90 percent, it would mean that 90 percent of individuals that responded positively to SRHET were patients who have undergone ET, so the remaining 10 percent would be false-positive results (that is, they would be individuals that responded positively to SRHET despite had never undergone ET). On the other hand, negative predictive value is the proportion of negative SRHET results

that are noncases. For example, if SRHET had a negative predictive value of 60 percent, it would mean that 60 percent of individuals that responded negatively to SRHET were patients who have never undergone ET, so the remaining 40 percent would be falsenegative results (that is, they would be individuals that responded negatively to SRHET despite had undergone ET). Caplan and colleagues (6) could not validate SRHET data, whereas Pitiphat and coworkers (8) reported a relatively high correlation between self-reported number of teeth with ET and clinical records. No studies have explored the validity of SRHET as a predictor of AP.

The Baltimore Longitudinal Study of Aging (BLSA) is America's longest-running scientific study of human aging (starting in 1958), in which several detailed systemic conditions were assessed concurrently with oral clinical examinations, oral radiographs and oral-health related questionnaire. Hence, the BLSA provides an important database for evaluating the validity of self-report measures of oral health in predicting prior ET experience and radiographic findings of AP. The purpose of this study was to quantify the validity of SRHET as a method to: 1- identify individuals who experienced ET; and 2- identify individuals who present with AP in the BLSA.

Methods

This project was submitted to the Institutional Review Board of the National Institute of Aging (NIA) prior to its development. Informed consent was obtained from all participants enrolled in the BLSA. The data was deidentified prior to analysis. The present study comprised an initial sample of 325 subjects who were administered both the BLSA oral questionnaire and clinical examination, and who had a panoramic radiography on chart close to the date of the exam. Detailed information on dental data was collected between 1978 and 1995.

Among the initial sample, 36 individuals were excluded due to poor quality of panoramic radiographs. Of the 289 remaining subjects, 26 had less than 10 teeth and were not included, so the sample size reduced to 263 individuals. Among these, 16 participants did not answer the question regarding SRHET in the BLSA questionnaire and were also excluded from the analysis, leaving a total of 247 subjects.

Main exposure SRHET was obtained from the 26th item of BLSA questionnaire: "Have you ever had any endodontic treatment?". The possible answers were: 0=No, 1=root canal treatment, 2=endodontic surgery, 3=root canal treatment and surgery. For analytic purposes, the SRHET variable was dichotomized (0=No, 1=Yes).

The outcome was obtained from the radiographic analysis, conducted by an experienced endodontist examiner (M.S.G.), calibrated for analysis of panoramic radiographs and blinded to the SRHET data. The following radiographic endodontic parameters, adapted from De Moore and colleagues (27), were observed:

- (ET) endodontic treatment: 0=Absent, when there is absence of radiopaque material inside the root canal system; 1=Present, when there is the presence of radiopaque material inside the root canal system. Note: in multi-rooted teeth, when a score of 1 was assigned to any of the roots, then a score of 1 was assigned to that tooth.
- (AP) apical periodontitis: 0=Absent, when there is integrity of the periapical lamina dura and the width of the periodontal ligament space is ≤ 2 mm; 1=Present, when there is the presence of periapical radiolucency compatible with bone destruction adjacent to the periodontal ligament space, which width is > 2 mm, as well as lack

of integrity of lamina dura. Note: in multi-rooted teeth, when a score of 1 was assigned to any of the roots, than a score of 1 was assigned to that tooth.

Panoramic radiographs of the BLSA participants were in a digital format. The viewing conditions for the radiographic analysis were standardized. The images were projected on a 17" widescreen with a graphic card NVIDIA GeForce GT 425M, 32 bit color and 1600 × 900 resolution, in a darkened room. Magnification was used when necessary. Prior to the radiographic analysis, the examiner underwent a period of calibration, using 34 images other than the BLSA radiographs. Calibration period was performed by two examiners, both experienced specialists in Endodontics. The examiners independently evaluated the panoramic radiographs twice, with a period of 45 days between the first and the second evaluation. Inter and intra-examiner agreement levels were calculated.

The parameters of ET and AP were analyzed for each tooth in each participant. Where the examiner deemed it was impossible to clearly define the parameters of AP or ET due to limitations of the radiographic exam (e.g. overlaps, important distortions), then the unit was considered "undefined". The total number of ET and AP, as well as the total number of missing teeth were recorded for each individual. If the percentage of teeth with "undefined" parameters of ET and AP was equal or higher than 10% of the remaining teeth, then the individual was excluded from analysis of the respective variable.

Validity of the main exposure SRHET was calculated based on ET and AP data assessed through the radiographic outcome, separately. Accuracy, sensitivity, specificity, positive and negative predictive values, efficiency, positive and negative likelihood ratios were determined. In addition, Pearson's correlation (*r*) was calculated between SRHET and ET, SRHET and AP, and ET and AP.

Results

During the calibration period, inter-examiner agreement after the second examination was Kappa=0.912 for ET and Kappa=0.801 for AP. The intra-examiner agreement (M.S.G) for panoramic radiographic analysis was found to be very high: Kappa=0.983 for ET and Kappa=0.959 for AP. From the 247 subjects analyzed, 18 presented 10% or more of the remaining teeth with undefined parameters of ET and 118 individuals presented 10% or more of the remaining teeth with undefined parameters of AP; these participants were excluded from the analysis of each respective variable. Thus, the final sample size was 229 for ET and 129 for AP.

Characteristics of the studied sample are shown in Table 1. Mean age was 53.2 (±16.5), ranging from 22 to 89 years, with females representing 51.1% of the participants. Participants of white ethnicity predominated (96.5%), and almost half (49.3%) of the individuals had a high level of education, with an average of 16.06 (±2.57) years of formal education.

Mean number of teeth among participants was 25.8 (±4.4). The majority of the individuals (60.3%) reported no history of ET. The prevalence of individuals with one tooth presenting ET was 20.1% and with more than one tooth presenting ET was 15.6%. In total, 82 patients (35.7%) presented ET. The prevalence of individuals with one tooth presenting AP was 13.2% and with more than one tooth presenting AP was 4.6%, representing a total of 23 subjects (17.8%) with at least one AP. Medical characteristics of the sample, such as smoking, hypertension, obesity, diabetes, and cardiovascular disease are very similar to previous studies in the BLSA (28, 29) and were not detailed in this study.

Table 2 is the contingency table for SRHET in relation to ET and AP. Among individuals who reported no history of ET, 131 (94.9%) did not present ET in the radiographic exam, and among those who reported history of ET, 75 (82.4%) showed ET radiographically. In relation to AP, 73 participants (93.6%) who answered negatively to SRHET did not present AP in the radiographic exam, whereas only 18 individuals (35.3%) who answered positively to SRHET presented radiographic signs of AP.

Table 3 shows values of accuracy, sensitivity, specificity, positive and negative predictive values, efficiency, positive and negative likelihood ratios for SRHET in relation to ET and AP. Noteworthy are the high ET values for sensitivity (0.91), specificity (0.89), negative predictive value (0.90) and positive likelihood ratio (8.39), as well as the low AP positive predictive value (0.35). The r values between SRHET and ET and AP were 0.789 ($p<0.001$) and 0.369 ($p<0.001$), respectively.

Table 4 shows the mean number of teeth in participants with true positive, true negative, false positive and false negative results for SRHET in relation to ET and AP. For ET diagnosis, individuals with true positive and true negative results showed higher crude averages regarding number of teeth (25.4 and 26.6, respectively) when compared to the group of individuals with false positive and false negative results (21.7 and 23.1, respectively). In relation to AP variable, the highest mean number of teeth was observed among individuals with true negative results (27.5), whereas the lowest mean was between subjects with false negative results (22.0).

Table 5 shows the contingency table between ET and AP. Among 23 participants with findings of AP, 18 (78.3%) also presented ET. Of the 106 participants with healthy periapical status, 82 (77.4%) did not exhibit ET. Among the 42 individuals presenting ET, 24 (57.1%) presented no AP. The correlation between ET and AP was $r = 0.454$ ($p<0.001$).

Discussion

The results of this study indicate that SRHET is a valid method to identify individuals who experienced ET in the BLSA. In contrast, SRHET was a poor predictor of AP in this population. To our knowledge, this study is novel in providing data on the validity of SRHET in predicting both ET and AP.

The higher predictive ability of SRHET in identifying ET, when compared to AP, may be attributable to several factors. First, ET is a technically complex procedure, which requires usually more than one extended appointment, with a relatively high cost, factors that together enhance the patient's perception about the treatment. Second, an ET can be indicated in vital teeth (eg, trauma or irreversible pulpitis), where no AP is present. Third, when an ET is indicated due to infection and the presence of AP, it usually provides healing and consequent disappearance of the lesion's radiographic image. Fourth, AP often presents as an asymptomatic disease, which may delay treatment seeking; as a consequence, a negative answer to SRHET may occur even in the presence of AP, allowing false negative results. Fifth, AP is a lesion that can be treated through ET or extraction; thus, tooth loss is a confounder in the SRHET detection of AP. In addition, teeth with unsuccessful ET and refractory AP may also be extracted; in conjunction, these factors tend to increase the possibility of false results for both AP and ET. The results appear to confirm the latter premise, since AP false negatives and ET false positives showed the lowest mean number of teeth. The potential for these factors to impact treatment outcome is consistent with the relatively low correlation observed between ET and AP.

Several methodological features warrant consideration. Since tooth loss is an important confounder, we included only individuals with 10 or more teeth. Another methodological

decision was to exclude individuals presenting 10% or more of the remaining teeth with undefined parameters of ET and AP. The relatively high number of teeth with undefined scores of ET, AP or both occurred mainly due to image distortion in the anterior midline region, which impact was limited primarily to anterior teeth. These methodological steps restricted our sample size but strengthened the consistency of our results.

One important aspect is related to the radiographic analysis and its inherent limitations, particularly for the detection of AP (30). Although several epidemiological studies have used panoramic radiographs (27, 31, 32), a complete intra-oralradiographic series or cone-beam computed tomography (CBCT) results in a higher accuracy for the diagnosis of AP (33–35). In addition, periapical radiographs and CBCT allow increased accuracy only for the diagnosis of incipient and small lesions, not for medium or large sized AP (34). Nevertheless, considering the low radiation doses, costs, and field of interest, the panoramic radiograph provides a valuable survey film for this type of investigation. Furthermore, it must be considered that BLSA's dental data was collected between 1978 and 1995, when CBCT was not available. Additionally, the detection of ET - our main outcome variable - through panoramic radiographs is well established, rarely prone to errors, which is confirmed by a number of studies which focused on the prevalence of ET in different populations using panoramic radiographs (27, 31, 32).

Another consideration with respect to interpretation is that cross-sectional radiological detection of AP, whether through panoramic, periapical or CBCT evaluation, does not provide information on the activity of the disease. A detectable radiolucent area compatible with the diagnosis of AP may be an active inflammation, a healing process or simply a stable scar (30). Only a histological exam or longitudinal assessments can establish the definitive diagnosis of AP activity.

The present study used a single experienced examiner to perform the radiographic analysis. This examiner underwent a rigorous previous calibration period, demonstrating very high intra-examiner agreement scores for both ET and AP variables. Adding a second or third examiner would add variability but not necessarily quality to the radiographs assessments of the BLSA.

SRHET exhibited a high (0.82–0.95) sensitivity, specificity, positive predictive value and negative predictive value, as well as positive likelihood ratio (8.39) for ET. The latter findings parallel those found in a previous study (8) on the validity of self-reported oral health measures, in which self-reported ET had sensitivity of 90%, specificity of 92,1%, positive predictive value of 85.7% and negative predictive value of 94.6%. However, the study of Pitiphat and colleagues (8) did not focus exclusively on endodontic variables such as the present study. Furthermore, the sample size was smaller and SRHET was not evaluated as a predictor of AP, but only as a predictor of ET. It is of interest to note that the validity values of SRHET in our study are higher than the corresponding predictive values of cold and electric pulp tests for the assessment of pulp vitality (26), which are widely accepted methods in endodontic and clinical practice.

Some limitations must be considered regarding the external validity of the present results. The BLSA population consists largely of well-educated north-American white adults, which have access to dental treatment. These characteristics possibly contributed to increased levels of true positive and true negative results. Extrapolation of our findings to populations with different patterns of education, culture and access to dental care are likely prone to differences.

Notable similarities are found in participants in the BLSA and the Atherosclerosis Risk in Communities Study (6). Both studies were conducted in well-educated, north-American

adult populations during a similar period. Therefore, these studies confirm the validity of SRHET in the detection of ET experience in this general study population. Furthermore, the present study reinforces the consistency of Caplan and colleagues' (6) results concerning the association between SRHET and coronary heart disease, since that study could not validate SRHET. Thus, SRHET appears to provide an effective measure for determining the association of ET and general health diseases or risk factors in large populations.

In contrast, SRHET was found to be a poor predictor of AP in this study. Only 35% of participants reporting a history of ET in the questionnaire presented AP in the radiographic analysis. However, the negative predictive value of SRHET for AP was very high (0.94), reflecting that nearly 95% of the participants with no SRHET were found to have no radiographic evidence of AP. SRHET appears to provide an accurate method for predicting the absence of periapical disease. Interestingly, this finding is consistent with the hypothesis that self-perception levels of oral health tend to be higher than that of oral disease (23).

Some studies concerning self-reported periodontal health status verified that one single question is not as accurate as a combination of multiple questions in the detection of periodontal disease (17, 21). It was suggested a model including different self-reported variables and other related periodontal risk factors in a multivariable prediction rule for a valid assessment of periodontal disease. In our study, a single question related to SRHET was applied in the assessment. It is possible that an approach using a combination of questions and endodontic risk factors would provide even more accurate results for endodontic self-reported measures in upcoming epidemiological studies, particularly for the detection of AP history.

The findings of this study suggest that the SRHET provides an accurate and cost-effective method for assessing the prevalence of ET in similar population-based surveys and epidemiological studies.

Conclusion

SRHET was found to be an accurate method to predict ET experience but a weak predictor of the presence of AP in participants of the BLSA.

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Table 1

Socio-demographic and dental characteristics of participants. Age, education and number of teeth are shown as mean ± standard deviation. N=229, except for AP, which N=129.

Variables	N (%)*
Socio-demographic	
Age	
years	53.23 ± 16.49
Gender	
female	116 (51.1)
male	111 (48.9)
Ethnicity	
white	219 (96.5)
others	007 (03.5)
Education	
years	16.06 ± 2.57
Dental	
Number of teeth	25.78 ± 4.42
Self-reported history of ET	
yes	091 (39.7)
no	138 (60.3)
Number of teeth with ET present	
zero	147 (64.3)
1	046 (20.1)
>1	036 (15.6)
Number of teeth with AP present	
zero	106 (82.2)
1	017 (13.2)
>1	006 (04.6)

(*) valid percentages.

Table 2

The contingency table (N/%) for self-reported history of endodontic treatment (SRHET) in relation to the presence of endodontic treatment (ET) and apical periodontitis (AP).

SRHET	Presence of ET		Total	Presence of AP		Total
	No	Yes		No	Yes	
No	131 / 94.9	7 / 5.1	138 / 60.3	73 / 93.6	5 / 6.4	78 / 60.5
Yes	16 / 17.6	75 / 82.4	91 / 39.7	33 / 64.7	18 / 35.3	51 / 39.5
Total	147 / 64.2	82 / 35.8	229 / 100	106 / 82.2	23 / 17.8	129 / 100

Table 3

Quantification of accuracy, sensitivity, specificity, positive predictive value, negative predictive value, efficiency, positive likelihood ratio and negative likelihood ratio for self-reported history of endodontic treatment (SRHET) in relation to the presence of endodontic treatment (ET) and apical periodontitis (AP).

	ET (N=229)	AP (N=129)
Accuracy	0.899	0.705
Sensitivity	0.915	0.782
Specificity	0.891	0.689
Positive Predictive Value	0.824	0.353
Negative Predictive Value	0.949	0.936
Efficiency	0.903	0.736
Positive Likelihood Ratio	8.394	2.514
Negative Likelihood Ratio	0.095	0.316

Table 4

Average number of teeth in the samples with true positive, true negative, false positive and false negative results for self reported history of endodontic treatment (SRHET) in relation to endodontic treatment (ET) and apical periodontitis (AP) variables.

	Number of teeth mean ± standard deviation (N)	
	ET (N=229)	**AP (N=129)**
True Positive	25.41 ± 4.07 (75)	24.28 ± 5.44 (18)
True Negative	26.63 ± 3.92 (131)	27.49 ± 2.86 (73)
False Positive	21.75 ± 6.26 (16)	24.97 ± 5.56 (33)
False Negative	23.14 ± 6.18 (7)	22.00 ± 7.45 (5)

Table 5

The contingency table (N/%) correlating the presence of endodontic treatment (ET) and the presence of apical periodontitis (AP).

Presence of ET	Presence of AP		Total
	No	Yes	
No	82 / 77.4	5 / 21.7	87 / 67.4
Yes	24 / 22.6	18 / 78.3	42 / 32.6
Total	106 / 82.2	23 / 17.8	129 / 100