Association of Endodontic Involvement with Tooth Loss in the Veterans Affairs Dental Longitudinal Study

Yan Zhong, DMD, PhD, Raul Garcia, DMD, MMSc,† Elizabeth K. Kaye, PhD, MPH,† Jianwen Cai, PhD,‡ Jay S. Kaufman, PhD,§ Martin Trope, DMD,‖ Tim Wilcosky, PhD,§ and Daniel J. Caplan, DDS, PhD¶*

Abstract

Introduction: The effect of endodontic involvement on tooth loss has not been quantified, so the present study aimed to assess this relationship after controlling for other relevant risk factors for tooth loss. **Methods:** We analyzed data from 791 participants (18,798 teeth) in the Veterans Affairs Dental Longitudinal Study. Potential tooth-level and person-level covariates were fitted into marginal proportional hazards models, including both apical radiolucencies (AR) and root canal therapy (RCT) status as time-dependent variables. Survival curves were plotted for teeth according to their AR and RCT status. **Results:** Both current AR and RCT status were associated with increased risk of tooth loss ($P < .01$), after controlling for baseline levels of periodontal disease, caries, tooth type, number of proximal contacts, number of teeth, age, education, and smoking history. Root canal filled (RCF) teeth seemed to have better survival than non-RCF teeth among teeth with AR but worse survival than non-RCF teeth among teeth without AR. **Conclusions:** Endodontic involvement was associated with tooth loss, controlling for other potential risk factors. Additional prospective studies are needed to provide better evidence as to the impact of endodontic involvement on tooth loss. *(J Endod 2010;36:1943–1949)*

Key Words

Apical radiolucency, endodontics, epidemiology, root canal therapy, survival analysis, tooth loss

Tooth loss results from a combination of factors, including periodontal disease and caries (1–3), tooth type (1, 4–6), number of teeth at baseline (7), age (7–9), education level (9, 10), gender (7, 8), income (8, 11), race (8), oral hygiene behaviors (6, 12), and smoking (3, 9, 13). Tooth loss caused by periodontal disease also is reported to be associated with diabetes, hypertension, and rheumatoid arthritis (6). Endodontically treated teeth are at risk for loss as a result of additional mechanisms; factors related to loss of root canal filled (RCF) teeth include absence of crown (14–17), number of proximal contacts (18, 19), incomplete root canal therapy (RCT) (20), quality of root fillings (1, 21), and use of posts (1, 14, 17).

The role of endodontic involvement (eg, periapical inflammation, RCT) in tooth loss has not been examined extensively. In previous studies, RCF teeth were lost significantly more often than teeth without RCT (1, 22, 23), and periapical lesions have been found to be related to a higher risk of tooth loss (1, 17). Despite these observational findings, periapical lesions often are not defined as a specific cause for tooth loss but rather as a sequel to dental caries. Some studies have mentioned "failed endodontic treatment" or "pain" as causes of extraction without explicitly recognizing periapical lesions (24); others used RCT only as an indicator of pulpal involvement (23), but RCT is not warranted for all endodontically involved teeth (eg, teeth with hopeless periodontal status), and RCT sometimes is performed on non-endodontically involved teeth. Thus, it is advisable to evaluate periapical inflammation and RCT as 2 distinct factors when studying the impact of endodontic involvement on tooth loss.

Gaps in the relevant literature include the following. First, in general, these studies do not account for correlations among teeth within the same individual in their analytic approaches; doing so would avoid incorrect inferences in hypothesis testing (25, 26). Second, conventional analytic methods used in tooth loss studies such as logistic or linear regression cannot accommodate common features existing in survival data such as timing of events, censoring, and time-dependent covariates (TDC) (27, 28). Rather than simply discarding information on censored teeth, survival analysis uses all the information up to the time the tooth is censored and thus is a preferable analytic approach. Third, periapical status often has not been considered or has been combined with caries, as related to tooth loss; little has been done to evaluate its role as a separate factor in tooth loss. Finally, no data are available to evaluate the effect of RCT on tooth loss after adjusting for periapical conditions on individual teeth.

The purpose of the present study was to investigate the association of endodontic involvement with tooth loss, after controlling for other tooth-level and person-level risk

From the *Department of Oral Epidemiology, University of North Carolina, Chapel Hill, North Carolina; †VA Boston Healthcare System and the Henry M. Goldman School of Dental Medicine, Boston University, Boston, Massachusetts; ‡Department of Biostatistics, §School of Public Health, University of North Carolina, Chapel Hill, North Carolina; ‖Department of Endodontics, School of Dentistry, University of North Carolina, Chapel Hill, North Carolina; and ¶Department of Preventive & Community Dentistry, College of Dentistry, University of Iowa, Iowa City, Iowa.

Dr Kaufman is currently affiliated with the Department of Epidemiology, Biostatistics, and Occupational Health, McGill University, Montreal, Canada.

Address correspondence to Dr Yan Zhong, 1441 Shoal Dr, San Mateo, CA 94404. E-mail address: yanzhong06@gmail.com.

0099-2399/$ - see front matter

doi:10.1016/j.joen.2010.08.051

factors for tooth loss at baseline (our hypothesis was that both RCT and periapical lesion status would be associated with tooth loss).

Materials and Methods

Study Population

Data analyzed in this study were from the Veterans Affairs Dental Longitudinal Study (VADLS), an ongoing, closed-panel longitudinal study of oral health and disease among 1,231 adult men aged 25–85 years at baseline in the 1960s. The cohort was established through community-based recruitment of adult men from the greater Boston metropolitan area. Participants were not patients of the VA system; rather, they received dental and medical care through the private sectors.

One goal of the VADLS is to identify determinants of oral health in an aging population. Participants had varying oral conditions at baseline, although all were free of chronic medical conditions. Since baseline, study participants have been seen once every 3 years for comprehensive dental and medical examinations. Dental examinations include both clinical and radiographic components. The clinical component was conducted by a trained and calibrated VADLS periodontist examiner. Data collected included decayed, missing, or filled coronal tooth surfaces (DMFS) and detailed measures of periodontal status. The radiographic component includes a full-mouth series of intraoral radiographs (29).

To date, this cohort has been under observation for more than 30 years. The average interval between VADLS exams has been approximately 38 months, and there were about 200 men who had a cycle 11 examination (corresponding to 30 years after baseline) by January 2004 (3). The present study used the electronic VADLS database to identify participants who were dentate at baseline, all of whom had a complete radiographic record for each of the 32 permanent teeth or tooth spaces at baseline and each subsequent examination cycle. Because of time considerations, the sample size was restricted to 853 randomly selected participants. The protocol for this study was reviewed and approved by the Institutional Review Board on Research Involving Human Subjects at the VA Boston Healthcare System.

Follow-up Period

Our analysis included all teeth present at baseline, regardless of whether they were endodontically involved. For each tooth, follow-up started at the subject's baseline cycle and ended when the tooth was lost or the date of most recent examination before data collection, whichever came first.

Data Collection

Tooth-level and person-level covariates were obtained from the VADLS data set, whereas variables describing endodontic status and treatment were made solely from available radiographs of diagnostic quality. Two second-year endodontic residents from Boston University independently reviewed subjects' intraoral radiographs. Before data collection, a training and calibration session for the radiographic examiners was conducted to ensure adequate reliability and to evaluate diagnostic criteria for endodontic measurements. Kappa values describing interexaminer reliability were excellent for the endodontic variables, ranging from 0.80–1.00, depending on the variable (30). Diagnostic criteria for radiographic evaluation of endodontic variables were adapted from Odesjo et al (31).

Endodontic Variables

At each examination cycle, endodontic involvement was assessed according to the following 2 variables: (1) RCT status, ie, whether the tooth had RCT; and (2) apical radiolucency (AR) status, which was categorized into 3 levels on the basis of the size of periapical rarefaction: no AR (ie, apical periodontal ligament space <1 mm thick), 1–3 mm, and ≥4 mm. AR was used as a general indicator of periapical inflammation because of the established correlation between AR and histologically confirmed inflammatory status of the periapical tissues (32). For a tooth with RCT at baseline, the tooth would remain "RCT = yes" throughout the rest of its life; whereas for a tooth without RCT at baseline, the tooth could become "RCT = yes" at any cycle after baseline. In addition, because growth and healing of periapical lesions are dynamic processes, a tooth's AR status could vary within 3 levels during the follow-up, regardless of its AR value at baseline, eg, an existing AR could resolve or worsen, or a new AR could develop. To describe endodontic variables in more accurate detail, both RCT and AR status were treated as TDCs in the analysis. Their time-dependent values were incorporated with the partial likelihood methods adopted in survival analysis (27, 33). Additional variables related to each tooth's RCT included whether RCT was complete (yes/no), extension and density of root fillings (34), type of filling material, number of posts, and year of RCT. These RCT treatment-related variables were considered as TDCs as well because they only applied to teeth with RCT (33). Other RCT-related variables (eg, perforation, broken instruments) were not included in the analysis because too few events had occurred.

Covariates

A large number of tooth-level and person-level variables were available from the parent VADLS data set. Baseline tooth-level covariates included whether a tooth had an existing crown (yes/no), tooth type (anterior/premolar/molar), number of proximal contacts (ie, 0, 1, or 2 adjacent teeth), coronal caries (yes/no), and periodontal status (ie, alveolar bone loss, gingival bleeding, mobility, plaque score, and probing pocket depth). Except for crowns, there were no data to indicate other types of overlay restorations. Baseline person-level covariates included number of teeth, patient age, income, education, race, smoking history, diabetes, hypertension, body mass index, and oral hygiene behaviors (ie, frequency of brushing, flossing, history of periodontal treatment, and history of cleaning).

Statistical Analyses

The tooth was the unit of analysis. Statistical analyses were performed in 3 stages: (1) univariate description of data by using frequencies and percentages; (2) bivariate associations between each covariate individually and tooth loss, and tests of survival differences among subgroups of each covariate by using the log-rank test and Cox-type models; and (3) multivariable marginal proportional hazards models (extended Cox-type regression models for correlated survival data) to evaluate joint associations of tooth loss with various factors (25). Time to tooth loss was the dependent variable, with current RCT and AR status as the explanatory variables of main interest in the full model. We were interested in studying the association of current endodontic involvement with tooth loss after adjusting for baseline covariates. Current RCT and AR status are approximated by the status obtained at the beginning of that cycle. The adjustment is to ensure that the other covariates (ie, potential confounders) were balanced at the beginning of the follow-up. For example, the interpretation for the estimated coefficient for RCT is the log hazard ratio of tooth loss for comparing the tooth that currently has RCT with the tooth that currently has no RCT,