Number of Non-vital Teeth as Indicator of Tooth Loss during 10-year Maintenance: A Retrospective Study

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Abstract

The purpose of this study was to investigate whether number of non-vital teeth was an indicator of tooth loss during maintenance. Thirty-three general practitioners provided data on 321 patients undergoing maintenance over 10 years. The number of present teeth (PT), smoking status, level of bone loss, number of non-vital teeth, and reason for tooth loss during that period were investigated. Multiple logistic regression was performed to identify whether the number of non-vital teeth was associated with tooth loss. The average number of lost teeth was 1.07 ± 1.82; that of PT at baseline was 24.4 ± 3.9; and that of non-vital teeth at baseline was 5.4 ± 4.5. Multiple logistic regression revealed a significant association between >8 non-vital teeth and tooth loss during maintenance (odds ratio [OR]: 2.40; 95% confidence interval [CI]: 1.18–4.87). It also demonstrated relationships between >8 non-vital teeth and root fracture or caries (OR: 3.90; 95%CI: 1.68–9.03 or OR: 2.85, 95%CI: 1.14–7.10, respectively). The number of non-vital teeth was associated with tooth loss during maintenance. The results suggest that patients with many non-vital teeth before commencement of maintenance are particularly at risk of tooth loss due to root fracture or caries. Therefore, the number of non-vital teeth offers a useful indicator of potential tooth loss.

Key words: Endodontically treated teeth — Maintenance — Non-vital teeth — Permanent teeth — Risk factors
Introduction

The number of present teeth (PT) is often used as an indicator of oral health\(^1\). For example, the 8020 campaign, enacted in Japan, encourages elderly people to retain at least 20 teeth until 80 years of age\(^2\). Again, one of the WHO/International Dental Federation Goals for the Year 2000 was the retention of a functional, aesthetic, and natural dentition of 20 teeth without prostheses throughout life as an important goal of oral health\(^3\). Therefore, maintaining the number of PT is crucial.

In this respect, it has been reported that long-term dental attendance is effective in preventing tooth loss\(^4\). This indicates that patients would benefit from undergoing a program of maintenance aimed at reducing such loss and maintaining the number of PT. Such programs cannot, however, prevent all tooth loss. Previous reports have discussed factors associated with tooth loss during maintenance. For example, in one retrospective study of 120 patients undergoing maintenance for 10 years or more, it was reported that age and smoking were associated with periodontal tooth loss\(^5\). Meanwhile, in another retrospective study of 1,400 patients, Yoshino et al. found that appointment adherence, sex, hypertension, and number of PT were associated with patients with 2 or more extracted teeth\(^6\). Thus, various factors have been reported to be associated with tooth loss during maintenance.

Meanwhile, in one case-control study concerning non-vital teeth, Caplan and Weintraub reported that patients who had lost a root canal-filled (RCF) tooth had more missing teeth than those who had not\(^7\). In addition, Faggion et al. reported that diabetes mellitus, alveolar bone levels, tooth mobility, multiple roots, and non-vital pulp were significant predictors of tooth loss during supportive periodontal therapy\(^8\). None of these reports, however, specified number of non-vital teeth as an indicator of tooth loss. Therefore, we hypothesized that the number of non-vital teeth was a useful indicator of potential tooth loss during maintenance.

Materials and Methods

1. Study design

This was a retrospective cohort study.

2. Participating dentists

Questionnaires were sent to 33 dentists, all of whom were members of the Japan Health Care Dental Association, general practitioners, and engaged in patient recall for maintenance to prevent tooth loss. Fifteen of the dental offices were located in the Kanto region, 7 in the Kinki region, 3 in the Shikoku region, 2 in the Tohoku region, 2 in the Chubu region, 2 in the Kyushu region, and 2 in the Chugoku region.

3. Participants

The participants in this study comprised patients initially visiting the above dental clinics between January 2003 and November 2005 and again between July and December 2015. All were aged between 40 and 65 years. Treatment was completed in all cases by December 2005. All the patients subsequently visited the same dental clinic for maintenance over a period of 10 years and were dentulous. It has been reported that some patients undergoing maintenance are only irregular attenders\(^9\). Therefore, only those keeping at least 70% of their appointments during the 10-year period were included in the present study in accordance with the method of Miyamoto\(^10\). In addition, patients in whom no X-ray imaging was performed were also excluded from the study.

4. Data collection

The participating dentists were required to provide information on the oral status of each
patient between January 2003 and November 2005 together with a record of appointment adherence over the stipulated 10-year observation period spanning 2005 to 2015. The observation period for tooth loss was from January 2005 to July 2015. In other words, information on tooth loss was obtained during the maintenance period. The protocol of this study was approved by the Ethics Committee of Tokyo Dental College (approval number, 599).

5. Items surveyed

Number of PT\(^{20}\), smoking status\(^{5}\), and periodontal disease\(^{14}\) are associated with tooth loss during maintenance. Therefore, these factors were selected as confounding factors. Data on age, number of PT, number of non-vital teeth, and bone loss were obtained at the initial visit. The patients were divided into 2 groups based on age: 40–54 years and 55–65 years. The first cut-off point was set at 40 years as tooth loss generally begins to increase at around this age\(^{18}\). The second cut-off point was set at 55 years as this is the median of age.

The patients were further divided into 2 groups based on number of PT: <25 teeth and \(\geq 25\) teeth. The extracted third molars were excluded. The median cut-off point was set at 25 teeth. The number of non-vital teeth and bone loss were determined by evaluating a periapical X-ray or panoramic dental radiograph. Evaluation was performed by each dentist at their dental clinic. The number of non-vital teeth was defined as follows: the number of RCF teeth and those with obvious apical periodontitis. A further 4 groups were established based on number of non-vital teeth by referencing the 25th, 50th, and 75th percentiles as follows: 0–2 teeth, 3–4 teeth, 5–8 teeth, and \(>8\) teeth.

Bone loss was defined according to the method of an earlier study\(^{15}\): Class 1, bone loss around the tooth at less than one-third of the length of the distance from the cementoenamel junction to the apex of the tooth; Class 2, bone loss around the tooth at one-third to one-half of the distance from the cementoenamel junction to the apex of the tooth; and Class 3, bone loss around the tooth at over one-half of the distance from the cemento-enamel junction to the apex of the tooth. The maximum class among all teeth was taken to indicate the overall level in each patient.

Smoking status was investigated by using a questionnaire when the patients visited the clinic again in 2015. In defining tooth loss, only permanent teeth were targeted, with extracted third molars excluded from the analysis. Cases of root resection were counted as one lost tooth. Extraction of additional roots from the same tooth, however, was not counted as tooth loss. Each dentist also provided the main reasons for tooth loss, which were categorized as follows: root fracture (including complete or incomplete and vertical or horizontal fracture); caries (crown or root displaying advanced destruction, failed root treatment); periodontal disease (loss of function or pocketing due to periodontal disease requiring tooth extraction); and others (such as orthodontics or any other factor that did not come under the other categories).

6. Maintenance procedure

Recall intervals ranged from 3 to 6 months and were decided based upon risk of periodontal disease or cavities in each patient and the patient’s wishes. Each maintenance procedure took 30 to 60 min. The maintenance protocol was not standardized. The following procedures, however, were performed at each dental clinic by a dental hygienist: 1) subgingival and supragingival plaque and calculus removal using hand-held instruments and an ultrasonic scaler; 2) mechanical tooth cleaning; and 3) examination for periodontal disease, cavities, and prosthodontics, including periodontal pocket examination. If necessary, the following was also performed: 4) X-ray examination; 5) tooth brushing instruction; 6) fluoride varnish; 7) examination of occlusion; and 8) adjustment of partial dentures.

7. Statistical analysis

In the first phase, descriptive statistics were performed to investigate the characteristics of the study population. In the second phase,
multiple logistic regression was used to investigate whether the number of non-vital teeth was associated with tooth loss during maintenance. In the final phase, 4 multiple logistic regressions were performed for each reason for tooth loss to identify associations between number of non-vital teeth and each reason. The dependent variable in the second phase was the presence or absence of tooth extraction during the observation period, whereas that in the final phase was the presence or absence of tooth extraction for each reason. After adjusting for age, number of PT, level of bone loss, and smoking status, the number of non-vital teeth were entered into the multiple logistic regression as independent variables. Multiple logistic regression was performed using the forced-entry method. Data were analyzed using the computerized statistical package SPSS, version 22.0 (SPSS Japan, Inc., Tokyo, Japan), and a significance level of 5% was used.

**Results**

A total of 33 dentists provided data on a total of 321 patients. The mean number of patients per clinic was $9.7 \pm 6.5$. Over the 10-year observation period, a total of 340 teeth were extracted in 321 patients. The average number of lost teeth was $1.07 \pm 1.82$; that of PT at baseline was $24.4 \pm 3.9$; that of non-vital teeth at baseline was $5.4 \pm 4.5$. The characteristics of the patients are shown in Table 1. The percentage of female patients was 61.1%. The dominant groups of patients were 55–65 years old, non-smokers, $\geq 25$ PT, and a level of bone loss of less than one-third (53.0, 76.0, 63.2, and 36.8%, respectively).

Table 2 shows the distribution of the number of extracted teeth based on number of non-vital teeth. Periodontal disease was the dominant reason for tooth loss in patients with 0–2, 3–4, and 5–8 non-vital teeth, at 62.6, 50.0, and 55.8%, respectively. Meanwhile, root fracture was the main reason for tooth loss in patients with $>8$ non-vital teeth (34.5%).

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>125</td>
<td>(38.9)</td>
</tr>
<tr>
<td>Female</td>
<td>196</td>
<td>(61.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age group (years) at baseline</th>
<th>n</th>
<th>(%)</th>
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<tbody>
<tr>
<td>40–54</td>
<td>151</td>
<td>(47.0)</td>
</tr>
<tr>
<td>55–65</td>
<td>170</td>
<td>(53.0)</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Smoking status</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smokers or ever smokers</td>
<td>77</td>
<td>(24.0)</td>
</tr>
<tr>
<td>Non-smokers</td>
<td>244</td>
<td>(76.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of present teeth at baseline</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>118</td>
<td>(36.8)</td>
</tr>
<tr>
<td>$\geq 25$</td>
<td>203</td>
<td>(63.2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bone loss level at baseline</th>
<th>n</th>
<th>(%)</th>
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</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>118</td>
<td>(36.8)</td>
</tr>
<tr>
<td>Class 2</td>
<td>88</td>
<td>(27.4)</td>
</tr>
<tr>
<td>Class 3</td>
<td>115</td>
<td>(35.8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>321</td>
<td>(100.0)</td>
</tr>
</tbody>
</table>

Table 3 shows distribution of number of non-vital teeth based on age and sex. In male patients, 0–2 was the highest number of non-vital teeth in both 40–54-year-olds and 55–65-year-olds (45.5 and 44.3%, respectively). In female patients, 0–2 was the highest number of non-vital teeth in 40–54-year-olds (36.5%), whereas $>8$ was the highest number in 55–65-year-olds (35.0%).

Table 4 shows distribution of number of non-vital teeth and reason for tooth loss based on sex. In both male and female patients with $>8$ non-vital teeth, root fracture was the most common reason for tooth loss (29.4 and 36.2%, respectively).

Table 5 presents the results of the multiple logistic regression analysis on tooth loss during the 10-year observation period. After adjusting for sex, age, number of PT, smoking status, and level of bone loss, $>8$ non-vital teeth was found to be significantly associated with tooth loss during maintenance (odds ratio [OR]: 2.40; 95% confidence interval [CI]: 1.18–4.87).

The results of 4 multiple logistic regression analyses for each reason for tooth loss are
presented in Table 6. A total of >8 non-vital teeth was found to be significantly associated with root fracture and caries (OR: 3.90; 95% CI: 1.68–9.03 and OR: 2.85, 95% CI: 1.14–7.10,
respectively) after adjusting for confounding factors.

### Discussion

The results of the present study revealed an association between number of non-vital teeth and tooth loss during maintenance, even after adjusting for age group, smoking status, number of PT, and level of bone loss. The average number of teeth lost per year was almost the same as in past reports investigating number of teeth lost during maintenance. In terms of non-vital teeth, Tsuneishi et al. reported that the average number of RCF teeth was 5.4 ± 4.8 among 672 patients visiting a university dental hospital. In the present study, the number of non-vital teeth was similar. Thus, there was no difference between our results and those of previous reports with regard to number of teeth lost and non-vital teeth. As for differences in distribution of number of non-vital teeth based on age and sex (see Table 3), women have been reported to visit dental clinics more frequently. The present data, which were collected at baseline, also suggest that women seek dental treatment more often than men.

Non-vital teeth have been reported to be at risk of tooth loss. Caplan et al. reported that RCF teeth had worse survival than non-RCF teeth. Moreover, in another case-control study of 216 patients, Caplan and Weintraub reported that patients who had lost RCF teeth had more missing teeth than those who had not. In a study on the relationship between non-vital teeth and tooth loss in 198 patients, Faggion et al. reported that non-vital teeth were associated with tooth loss during supportive periodontal therapy. Sjögren et al. indicated that 31% of root-filled teeth were extracted due to root fracture in 356 patients at between 8 and 10 years after treatment.

With regard to the relationship between the reason for tooth loss and maintenance period, Axelsson et al. reported the main reason for tooth loss during 30 years of maintenance to

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### Table 5

<table>
<thead>
<tr>
<th>Number of non-vital teeth at baseline</th>
<th>OR</th>
<th>95% CI</th>
<th>p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–2</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3–4</td>
<td>1.19</td>
<td>0.57–2.48</td>
<td>0.638</td>
</tr>
<tr>
<td>5–8</td>
<td>1.52</td>
<td>0.78–2.95</td>
<td>0.197</td>
</tr>
<tr>
<td>&gt;8</td>
<td>2.40</td>
<td>1.18–4.87</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Adjusted for sex, age, number of present teeth, smoking status and bone loss level.

### Table 6

<table>
<thead>
<tr>
<th>Number of non-vital teeth at baseline</th>
<th>Root fracture</th>
<th>Caries</th>
<th>Perio</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–2</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>3–4</td>
<td>1.31</td>
<td>0.48–3.55</td>
<td>0.563</td>
<td></td>
</tr>
<tr>
<td>5–8</td>
<td>1.26</td>
<td>0.51–3.12</td>
<td>0.583</td>
<td>0.403</td>
</tr>
<tr>
<td>&gt;8</td>
<td>3.90</td>
<td>1.68–9.03</td>
<td>0.001</td>
<td>2.85</td>
</tr>
</tbody>
</table>

Adjusted for sex, age, number of present teeth, smoking status and bone loss level.
be root fracture\(^3\). Taken together, these reports indicate that the number of non-vital teeth is a risk factor for tooth loss and that the reason for tooth loss tends to be root fracture during maintenance. In the present study, number of non-vital teeth was significantly associated with tooth loss. Moreover, >8 non-vital teeth was associated with tooth loss due to root fracture or caries. This suggests that patients with many non-vital teeth are at high risk of losing teeth due to root fracture or caries during maintenance.

There were several limitations to this study, however. The data were collected from multiple dental clinics, so inter-examiner error may have occurred. In addition, the patients were not selected at random, so a selection bias may have affected the results. Thus, these results may not be representative of all dental clinics in Japan. Moreover, this study was retrospective in nature. Hence, it might include incorrect information. In addition, potential confounders, such as social position, sugar consumption, and brushing with fluoride toothpastes were not included in the analysis.

**Conclusion**

The results of the present study suggest that number of non-vital teeth offers a useful predictor of potential tooth loss during maintenance. This may be particularly so in the case of patients with many non-vital teeth prior to commencing maintenance, with loss occurring due to root fracture or caries. These results may offer an effective tool in predicting tooth loss during maintenance and explaining the potential for such to patients.

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