Original Article

Estimated Tooth Loss Based on Number of Present Teeth in Japanese Adults Using National Surveys of Dental Disease

**Koichi Yoshino¹⁾, Yoichi Ishizuka¹⁾, Kakuhiro Fukai²⁾, Toru Takiguchi³⁾
and Naoki Sugihara¹⁾**

¹⁾ *Department of Epidemiology and Public Health, Tokyo Dental College,
2-9-18 Misaki-cho, Chiyoda-ku, Tokyo 101-0061, Japan*

²⁾ *Fukai Institute of Health Science,
3-86 Hikonari, Misato-shi, Saitama 341-0003, Japan*

³⁾ *Department of Health Informatics, Niigata University of Health and Welfare,
1398 Shimami, Kita-ku, Niigata 950-3198, Japan*

Received 25 August, 2014/Accepted for publication 4 November, 2014

Abstract

Oral health instruction for adults should take into account the potential effect of tooth loss, as this has been suggested to predict further tooth loss. Therefore, the purpose of this study was to determine whether further tooth loss could be predicted from the number of present teeth (PT). We employed the same method as in our previous study, this time using two national surveys of dental disease, which were deemed to represent a generational cohort. Percentiles were estimated using the cumulative frequency distribution of PT from the two surveys. The first was a survey of 704 participants aged 50–59 years conducted in 2005, and the second was a survey of 747 participants aged 56–65 years conducted in 2011. The 1st to 100th percentiles of the number of PT were calculated for both age groups. Using these percentiles and a generational cohort analysis based on the two surveys, the number of teeth lost per year could be calculated. The distribution of number of teeth lost generated a convex curve. Peak tooth loss occurred at around 12–14 PT, with 0.54 teeth being lost per year. The percentage of teeth lost (per number of PT) increased as number of PT decreased. The results confirmed that tooth loss promotes further tooth loss. These data should be made available for use in adult oral health education.

Key words: Tooth loss—Present teeth—Percentile

Introduction

Many studies have shown that tooth loss increases with age^{1,2,4,5,7,10–12,18)}. This also holds true among patients undergoing long-term

periodontal maintenance⁴⁾. Age, however, is not the only factor that can be used to predict tooth loss. Eklund and Burt⁶⁾ reported that tooth loss was influenced by the cumulative effect of all the disease experience and treat-

ment choices made in any given patient. A bivariate analysis by Worthington *et al.*¹⁷⁾ revealed a negative relationship between the number of present teeth (PT) and number of teeth lost over a 5-year period in adults regularly attending dental clinics. In a 28-year cohort study, Burt *et al.* noted that only the baseline number of PT and baseline gingivitis were significant risk factors in predicting tooth loss³⁾. These reports indicate that the risk of tooth loss increases as the number of PT decreases. Tooth loss is influenced not only by age, but also oral health status factors such as number of teeth^{3,6,17,22)}. In other words, tooth loss accelerates further tooth loss. This indicates the need for patients to receive instruction on the necessity of maintaining an adequate number of teeth.

In our previous study²²⁾, we estimated tooth loss from the number of PT in Japanese adults using two national dental surveys^{9,15)}. The resulting distribution of number of teeth lost generated an asymmetrical convex curve. Peak tooth loss occurred at around 14–16 PT. The percentage of teeth lost (per number of PT) increased as number of PT decreased.

That study was based on another previous study¹⁹⁾ in which we observed present and sound teeth in an adult population over a 10-year period. There, the participants were serialized by number of present and sound teeth at baseline and then divided into tertiles (1st–33rd, 34th–67th, and 68th–100th percentiles). Observing the participants over a 10-year period, it became clear that it was rare for one to shift up or down into a different tertile. We concluded that when a participant was at a given baseline cumulative relative frequency of PT, they would still be at the same percentile 10 years later.

In the present study, we again used the same method as in our more recent previous study²²⁾, this time using two national surveys of dental disease in Japan conducted in 2005 and 2011, which were deemed to represent a generational cohort. The goal of this study was to investigate whether further tooth loss could be calculated from the number of PT based on the hypothesis that tooth loss pre-

dicts new tooth loss. We believe that such information would be of value in adult oral health instruction.

Materials and Methods

Data were obtained from two national surveys of dental disease conducted in 2005¹⁵⁾ and 2011¹⁶⁾. The cumulative frequency distribution of PT was calculated from these two surveys. The 2005 survey consisted of 704 participants aged 50–59 years (of both sexes)¹⁵⁾ and the 2011 survey 747 participants aged 56–65 years (of both sexes)¹⁶⁾. The two sets of data were deemed to represent a generational cohort.

1. Determining percentile values

The percentile values were calculated in accordance with Osada's method^{14,21)} and our previous study²²⁾.

2. Projected number of teeth lost at a given cumulative relative frequency

The projected number of teeth lost was obtained as follows. The 2005 and 2011 surveys of dental disease were deemed to represent a generational cohort. We hypothesized that participants in the 2005 survey at a given cumulative relative frequency (percentile B) of PT would still be at the same percentile in 2011. Therefore, to calculate the projected number of teeth lost over 6 years, we subtracted the 2005 value for number of PT at percentile B from that for 2011.

$$N(B) = 2005P(A) - 2011P(A)$$

N(B): Number of teeth to be lost at cumulative relative frequency B

B: 1 to 100

2005P(A): Percentile value at B in 2005

2011P(A): Percentile value at B in 2011

3. Estimation of tooth loss from number of PT

Tooth loss by number of PT was estimated in the following way. Figure 1 shows how the number of teeth to be lost was calculated from the number of PT. The actual number

Number of teeth to be lost

Fig. 1 Method for estimating tooth loss from number of PT (K)

of PT is always an integer, but the percentile values for percentiles 1 to 100 are usually decimals. In order to calculate tooth loss from actual numbers of PT, therefore, we used the following expression:

$$L(K) = L(A) + \{L(A-1) - L(A)\} \times \{P(A) - K\} / \{P(A) - P(A-1)\}$$

$L(K)$: Number of teeth to be lost calculated from number of PT

$P(A)$: Percentile value of cumulative relative frequency (A)

$L(A)$: Number of teeth to be lost calculated from $P(A)$

$P(A) > K > P(A-1)$: K is the number of PT, between 32 and 1.

4. Percentage of teeth lost relative to number of PT

The percentage of teeth lost (per number of PT) was calculated using the following formula:

$$\text{Percentage of teeth lost (\%)} = L(K) / K \times 100$$

K: Number of PT (between 32 and 1)

$L(K)$: Number of teeth to be lost calculated from number of PT

In this study only a few participants had a low number of PT (especially in the 0 to 20 PT range). Therefore, in order to obtain a

greater number of participants for the analysis, they were divided into 11 groups based on number of PT as follows: 30–32, 27–29, 24–26, 21–23, 18–20, 15–17, 12–14, 9–11, 6–8, 3–5, and 0–2. Tooth loss was estimated as an average for each of these groups.

Results

The mean number of PT for all participants was 24.11 in 2005 and 23.11 in 2011. Therefore, the mean number of teeth lost over the 6-year period was 1.00 (0.17/year).

The cumulative relative frequency and relative frequency of number of PT in 2005 and 2011 are shown in Fig. 2. No large differences were observed in relative frequency between 2005 and 2011. The cumulative relative frequency generated an S-shaped curve, with the curve for 2011 located to the right of the one for 2005, indicating that the number of PT decreased at all cumulative relative frequency points. The length of the arrows shows the number of teeth lost. The group with 12–14 PT lost more teeth than any other group.

Figure 3 shows tooth loss per year calculated from the number of PT. The resulting

Fig. 2 Cumulative relative frequency and relative frequency of number of PT in 2005 and 2011

Fig. 3 Per year tooth loss calculated from number of PT

distribution of number of teeth lost formed a convex curve. Peak tooth loss occurred at 12-14 PT, with 0.54 teeth being lost per year.

From 30-32 PT, tooth loss increased as PT decreased until the 12-14 PT point. From that point to 0-2 PT, tooth loss decreased as

Fig. 4 Percentage of teeth lost (per number of PT) per year

PT decreased.

Figure 4 shows the percentage of teeth lost per year relative to number of PT. The percentage of teeth lost increased as PT decreased.

Discussion

The mean number of teeth lost in this study (0.17/year) was lower than that in our previous study (0.37/year)²²⁾. This difference is likely a reflection of changes in the dental status of the Japanese population. The number of PT in adults has been increasing with each national survey^{9,15,16)}. This is also why the average number of PT at baseline in this study (24.1) was higher than that in our previous study (21.3). We believe that it is likely that these factors influenced the number of teeth lost here.

The mean number of teeth lost in this study was 0.17 per year, yielding a higher incidence than that found in studies of patients undergoing maintenance. Axelsson *et al.*¹⁾ found that tooth mortality during 30 years of main-

tenance was 0.7 (0.02/year) in the 36 to 50-year age group and 1.8 (0.06/year) in the 51 to 65-year age group. Fardal *et al.*⁷⁾ reported on the oral health status of patients in Norway after 9–11 years of maintenance. A total of 36 (1.5%) of the teeth present after completion of active periodontal treatment were lost during the maintenance period due to periodontal reasons. This amounted to 0.36 (0.04/year) lost teeth per patient. Patients undergoing regular check-ups, as well as those visiting dental clinics irregularly, should have a lower incidence of tooth loss than those who do not. This suggests that the participants in the present study (patients who took part in the 2005 and 2011 surveys of dental disease) did not receive regular check-ups.

The percentage of teeth lost increased as number of PT decreased, which was consistent with the tendency reported in our previous study²²⁾. It also agrees with the findings of Eklund and Burt⁶⁾, who reported that among baseline oral conditions related to total tooth loss, the most convincing association came with the number of remaining

teeth. Those with 1–7 teeth at baseline were nearly 20 times more likely to become totally edentulous than those with 24 or more teeth, and this relative risk was unaffected by age. This means that younger people with few teeth were just as likely to become edentulous as older people with few teeth. In multivariate analyses, the number of remaining teeth at baseline stood out as a remarkably stable predictor of edentulism, even when many other variables were assessed simultaneously. Baelum *et al.*²⁾ reported on the incidence of tooth loss over a 10-year period in a population of rural Chinese initially aged between 20 and 80 years. Logistic regression analysis of the 10-year incidence of tooth loss was performed on selected potential predictor variables. The dependent variable was losing all remaining teeth in 10 years. The results revealed that the best baseline predictors of subsequent loss of all remaining teeth were at least 1 tooth with an attachment loss of 7 mm and 27 or fewer PT. Yamamoto *et al.*¹⁸⁾ reported retrospectively on tooth loss during maintenance at a university hospital. Patients with experience of tooth loss were older, showed a higher prevalence of severe periodontitis and hypertension, and had a lower number of PT at the start of maintenance.

In the present study, tooth loss increased as PT decreased until the 12–14 PT point. From there, tooth loss decreased as PT decreased. The peak of tooth loss was different from that in our previous study²²⁾, which placed the peak at 14–16 PT. Fewer participants with lower numbers of teeth may have contributed to this difference. Future research is needed to clarify this point. This trend for tooth loss to decrease as the number of PT decreases after a certain threshold number of PT has been reached, is also consistent with the results of our previous study²²⁾. However, there is no clear evidence to explain why this occurs. Gotfredsen and Walls⁸⁾ evaluated the relationship between dentition and oral function and reported that masticatory efficiency (assessed as comminution efficiency) and masticatory ability (self-reported) were both linked to the number of teeth. A minimum of 20 teeth with

9–10 pairs of contacting units (including anterior teeth) is associated with adequate efficiency and ability. Tooth numbers below that level cause impaired masticatory efficiency and are likely to result in reduction in reported masticatory ability. Notani *et al.*¹³⁾ conducted a clinical survey of variously designed removable dentures, focusing on problems such as fractured roots of teeth and broken dentures. Patients who experienced such problems had 7–16 missing teeth and 7–8 occlusal contact points. Furthermore, Yoshino *et al.*²⁰⁾ reported the percentile curves of occlusal pairs (OPs) in adults. There appeared to be a cut-off point after 10 OPs where the percentile curves of OPs dropped off rapidly. The loss of OPs may be accelerated when the number of OPs drops below 10. The present results taken together with these earlier findings suggest that an increased number of missing teeth results in masticatory overload on the remaining occlusal contact teeth.

We believe that the results of the present study offer dental professionals a useful body of evidence with which to increase patient awareness of the importance of maintaining an adequate number of teeth, the benefits of which will include improved masticatory ability and efficiency, oral health-related quality of life, and dental arch stability. In conclusion, the results of this study confirm that tooth loss promotes further tooth loss, indicating the importance of encouraging patients to maintain an adequate number of teeth and instructing them on how that might be achieved. The data on tooth loss estimated from the number of PT provided in this study should be made available for use in adult oral health education.

References

- 1) Axelsson P, Nyström B, Linde J (2004) The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years of maintenance. *J Clin Periodontol* 31:749–757.

- 2) Baelum V, Luan WM, Chen X, Fejerskov O (1997) Predictors of tooth loss over 10 years in adults and elderly Chinese. *Community Dent Oral Epidemiol* 25:204–210.
- 3) Burt BA, Ismail AI, Morrison EC, Beltran ED (1990) Risk factors for tooth loss over a 28-year period. *J Dent Res* 69:1126–1130.
- 4) Chambrone L, Chambrone D, Lima LA, Chambrone LA (2010) Predictors of tooth loss during long-term periodontal maintenance: a systematic review of observational studies. *J Clin Periodontol* 37:675–684.
- 5) Chen X, Hodges JS, Shuman SK, Gatewood LC, Xu J (2010) Predicting tooth loss for older adults with special needs. *Community Dent Oral Epidemiol* 38:235–243.
- 6) Eklund SA, Burt BA (1994) Risk factors for total tooth loss in the United States; longitudinal analysis of national data. *J Public Health Dent* 54:5–14.
- 7) Fardal Ø, Johannessen AC, Linden GJ (2004) Tooth loss during maintenance following periodontal treatment in a periodontal practice in Norway. *J Clin Periodontol* 31:550–555.
- 8) Gotfredsen K, Walls AW (2007) What dentition assures oral function? *Clin Oral Implants Res* 18:34–45.
- 9) Health Policy Bureau of the Ministry of Health, Labour and Welfare, Japan (2001) Report on the survey of dental diseases 1999, Oral Health Association of Japan, Tokyo. (in Japanese)
- 10) Katz R, Gustavsen F (1986) Tooth mortality in dental subjects in a US urban area. *Gerodontology* 2:104–107.
- 11) Kawamura Y, Shinsho F, Fukuda H (2007) Factors related to tooth loss during long-term maintenance program at dental clinics. *Koku Eisei Gakkai Zasshi* 57:159–165. (in Japanese)
- 12) Marcus SE, Kaste LM, Brown LJ (1994) Prevalence and demographic correlates of tooth loss among the elderly in the United States. *Spec Care Dentist* 14:123–127.
- 13) Notani K, Saito M, Miura Y (1997) Clinical survey of variously designed removable partial dentures—Part 1 Introduction—. *Nihon Hotetsu Shika Gakkai Zasshi* 41:945–957. (in Japanese)
- 14) Osada H (1999) Percentile curves and values of remaining teeth as indicators of oral health in the adult population. *Shikwa Gakuho* 99: 573–589. (in Japanese)
- 15) The Statistical Analysis Committee on the Survey of Dental Diseases (2007) Comprehensive Guide to the Survey of Dental Diseases 2005, Oral Health Association of Japan, Tokyo. (in Japanese)
- 16) The Statistical Analysis Committee on the Survey of Dental Diseases (2013) Comprehensive Guide to the Survey of Dental Diseases 2011, Oral Health Association of Japan, Tokyo. (in Japanese)
- 17) Worthington HV, Clarkson JE, Davies RM (1999) Extraction of teeth over 5 years in regularly attending adults. *Community Dent Oral Epidemiol* 27:187–194.
- 18) Yamamoto T, Tsuneishi M, Murakami C, Watanabe T (2007) Retrospective study on tooth loss during maintenance care in a university hospital. *Koku Eisei Gakkai Zasshi* 57:632–639. (in Japanese)
- 19) Yoshino K, Fukai K (2012) Ten-year tertile shift of middle-aged males by number of present teeth and sound teeth. *Health Science and Health Care* 12:84–87.
- 20) Yoshino K, Ishizuka Y, Watanabe H, Fukai K, Sugihara N, Matsukubo T (2013) Estimated percentile curves of occluding pairs in an adult population. *Bull Tokyo Dent Coll* 54: 89–95.
- 21) Yoshino K, Osada H, Matsukubo T, Takaesu Y (2006) Percentile curves for present teeth in smokers and non-smokers in an adult male population. *Bull Tokyo Dent Coll* 47:51–55.
- 22) Yoshino K, Sakurai M, Muramatsu Y, Tanabe Y, Kagami N, Sugihara N, Matsukubo T (2009) Estimated tooth loss based on number of teeth present in Japanese adults using national dental surveys in 1999 and 2005. *Koku Eisei Gakkai Zasshi* 59:159–164. (in Japanese)

Reprint requests to:

Dr. Koichi Yoshino
Department of Epidemiology and
Public Health,
Tokyo Dental College,
2-9-18 Misaki-cho, Chiyoda-ku,
Tokyo 101-0061, Japan
Tel: +81-3-6380-9272
E-mail: ko-yoshi@d8.dion.ne.jp