Bull Tokyo Dent Coll (2013) 54(2): 89–95

Original Article

Estimated Percentile Curves of Occluding Pairs in an Adult Population

Koichi Yoshino, Yoichi Ishizuka, Hidehiko Watanabe*, Kakuhiro Fukai, Naoki Sugihara and Takashi Matsukubo**

Department of Epidemiology and Public Health, Tokyo Dental College, 1-2-2 Masago, Mihama-ku, Chiba 261-8502, Japan
* *Department of Adult Restorative Dentistry, University of Nebraska Medical Center, College of Dentistry, 40th and Holdrege Sts, Lincoln, Nebraska 68583-0750, USA*
** *Fukai Institute of Health Science, 3-86 Hikonari, Misato, Saitama 341-0003, Japan*

Received 2 November, 2012/Accepted for publication 30 January, 2013

Abstract

The purpose of this study was to provide the estimated percentile curves of occlusal pairs (OPs) in adults for use in oral health instruction. Data on number of present teeth (PT) were obtained from the National Report on the Survey of Dental Disease in 2005. Data from 1,535 males and 2,248 females, ranging in age from 18 to 82, were analysed. The mean number of OPs were used from our previous report. In that report we can be estimated OPs from the number of PT. In this study, PT data were replaced by the mean number of OPs. Estimated percentile curves in males, the 10th percentile of OPs was 13.7 at 60 years of age and 12.5 at 70. The 50th percentile of OPs was 12.2 at 50 years of age, 11.2 at 60 and 5.4 at 70. The 90th percentile of OPs was 7.6 at 50 years of age, 2.1 at 60 and 0 at 70. There appeared to be a cut off point after 10 OPs where the 50th to 97th percentile curves of OPs dropped off rapidly. In females, the 10th percentile of OPs was 13.4 at 60 years of age and 12.7 at 70. The 50th percentile of OPs was 11.5 at 50 years of age, 10.2 at 60 and 6.2 at 70. The 90th percentile of OPs was 7.1 at 50 years of age, 2.4 at 60 and 0 at 70. In females again the percentile curves dropped off after 10 OPs. Our results suggest that the loss of OPs may be accelerated when the number of OPs drops below 10. This means that patients need at least 10 OPs in order to maintain a stable oral status. The estimated percentile curves given in this study should be made available for use in adult oral health education.

Key words: Percentile curves — Occlusal pairs — Present teeth — Adults

Introduction

Percentile curves of height and weight are commonly used as indicators of infant growth. They are included in child health handbooks for mothers in Japan. In dental health as well, Osada *et al.*[14] used percentile curves when they reported numbers of present teeth

Table 1 Percentile values of PT in males and females

	PT value corresponding to each percentile													
	Males							Females						
	97	90	75	50	25	10	3	97	90	75	50	25	10	3
Age														
18–22	25.3	27.1	27.4	28.0	29.5	31.1	31.7	23.1	25.2	27.0	27.6	28.8	30.8	31.6
23–27	26.8	27.2	27.6	28.8	30.4	31.5	31.8	26.0	26.9	27.4	28.2	29.7	30.7	31.4
28–32	25.3	26.7	27.5	28.5	29.7	31.1	31.7	23.2	25.6	27.0	27.8	29.0	30.5	31.5
33–37	25.3	26.9	27.3	27.9	29.1	30.7	31.6	23.3	25.2	26.7	27.6	28.7	29.9	31.5
38–42	21.0	24.6	26.7	27.7	29.2	30.4	31.3	20.8	24.2	26.1	27.4	28.3	29.5	30.9
43–47	17.4	22.3	25.5	27.2	28.3	29.7	31.4	19.0	23.9	25.6	27.1	28.0	29.2	30.8
48–52	10.8	20.8	24.4	26.6	27.8	29.5	30.9	12.7	19.9	23.5	25.8	27.5	28.3	29.8
53–57	1.2	14.3	21.6	25.6	27.6	28.7	29.8	5.8	16.3	22.7	25.7	27.4	28.1	29.1
58–62	2.8	12.4	21.1	25.3	27.2	28.7	30.5	3.9	13.0	19.1	24.0	26.6	27.8	29.6
63–67	0	5.4	15.3	22.7	26.1	27.8	29.6	0	4.2	13.3	21.3	25.6	27.4	28.8
68–72	0	0	7.5	17.1	24.3	26.8	28.6	0	0	7.3	18.7	24.4	27.1	28.2
73–77	0	0	2.9	14.2	23.3	26.7	29.1	0	0	1.1	8.9	21.8	25.3	27.4
78–82	0	0	0	7.2	21.1	25.3	27.6	0	0	0	4.5	13.5	20.9	26.2

(PT) in 1990. Percentile curves are useful indicators because they allow individual clients and patients to visibly recognise and understand their own oral health status compared to that of the general population. Osada[13] also introduced smoothed percentile curves for PT in 1999. They estimated percentile curves and values on the basis of the distribution of numbers of missing teeth in 5,036 subjects aged 40–79. Primary data on subjects' missing teeth was based on the National Report on the Survey of Dental Disease in 1987[4].

Yoshino *et al.*[19] introduced percentile curves of present and sound teeth for use in providing oral health instruction to office workers. Yoshino *et al.*[20] also proposed percentile curves of PT in smokers and non-smokers. The percentile curves for PT were not only useful indicators in assessing the population, but may also be used in oral health instruction for office workers.

Occlusal pairs (OPs) have been used to assess oral health status for the past three decades[6]. A number of studies have demonstrated that maintaining OPs is important for masticatory efficiency, masticatory ability, oral health-related quality of life, dental arch stability, temporomandibular disorders, and nutrition-related psychosocial factors such as satisfaction[2,6]. However, there have been few materials developed for educating patients about the importance of OPs.

In previous reports, we showed that there is likely to be a direct relationship between the number of PT and OPs[23]. In the report, we can be estimated OPs from the number of PT. To be sure, there are age and gender differences, but the differences were very small[22]. The Survey of Dental Diseases in Japan[17] provides important data concerning oral health status, but it does not include any data about occlusal condition. Using the mean number of OPs by number of PT, we can estimate OPs of the Survey. The purpose of this study was to provide the estimated percentile curves of OPs in an adult population for use in oral health instruction.

Methods

1. Calculation of percentile values

Present teeth (PT) data were obtained from the National Report on the Survey of Dental Disease in 2005. Data from 1,535 males and 2,248 females, aged 18 to 82,

Table 2 Number of OPs corresponding to each PT value

PT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
OPs	0	0	0	0.25	0.13	0.38	0.38	0.67	0.00	1.07	1.07	1.87	2.42	3.06	4.71	4.20
PT	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
OPs	5.38	5.81	6.41	7.18	7.69	8.71	9.22	10.2	10.9	11.7	12.6	13.7	13.7	14.2	15.0	16.0

Table 3 Percentile value of OPs in males and females

	OPs value corresponding to each percentile													
	Males							Females						
	97	90	75	50	25	10	3	97	90	75	50	25	10	3
Age														
18–22	11.2	12.7	13.0	13.7	14.0	15.1	15.7	9.4	11.1	12.6	13.2	13.7	14.9	15.6
23–27	12.4	12.8	13.3	13.7	14.5	15.5	15.8	11.7	12.5	13.0	13.7	14.0	14.7	15.4
28–32	11.2	12.3	13.1	13.7	14.0	15.1	15.7	9.4	11.4	12.6	13.4	13.7	14.6	15.5
33–37	11.1	12.5	13.0	13.6	13.8	14.8	15.6	9.5	11.1	12.3	13.2	13.7	14.1	15.5
38–42	7.7	10.7	12.3	13.3	13.8	14.6	15.3	7.6	10.3	11.8	13.0	13.7	14.0	15.0
43–47	5.6	8.8	11.3	12.9	13.7	14.1	15.4	6.4	10.1	11.4	12.7	13.7	13.8	14.8
48–52	1.1	7.6	10.5	12.2	13.5	14.0	14.9	2.3	7.1	9.7	11.5	13.1	13.7	14.1
53–57	0	3.5	8.3	11.4	13.3	13.7	14.1	0.3	4.6	9.1	11.4	13.0	13.7	13.8
58–62	0	2.1	7.8	11.2	12.8	13.7	14.6	0.2	2.4	6.5	10.2	12.2	13.4	14.0
63–67	0	0.2	4.6	9.1	11.8	13.4	14.0	0	0.2	2.6	8.0	11.4	13.0	13.7
68–72	0	0	0.5	5.4	10.4	12.5	13.7	0	0	0.5	6.2	10.5	12.7	13.7
73–77	0	0	0	3.3	9.5	12.3	13.8	0	0	0	0.1	8.5	11.2	13.0
78–82	0	0	0	0.4	7.8	11.2	13.3	0	0	0	0.2	2.7	7.7	11.9

were analysed. Participants were divided into 13 age groups, in 5-year increments. Percentile values of each group were calculated in accordance with methods used in previous studies[13,14,19,20] (Table 1).

2. Determining the values of PT to OPs

The data of OPs, as in our previous reports[22,23], were based on a periodontal disease examination carried out under a health promotion law in a city located northeast of Tokyo, Japan, in 2005. Data from a total of 5,156 (1,745 male and 3,411 female) 40, 50 and 60-year-old participants were analysed. The number of occluding pairs was determined by analysing the dental records of the abovementioned subjects. Any opposing pair of maxillary and mandibular teeth with the same tooth number was counted as one pair, so that the maximum of number of opposing pairs in a 32-tooth dentition was 16. The mean number of OPs by PT was calculated by using all data, irrespective of age and gender (Table 2).

3. Estimated the percentile values of PT with mean number of OPs

The PT data was replaced by mean number of OPs, which was obtained in the following way. The actual number of present teeth is always an integer, but the percentile values for percentiles 3, 10, 25, 50, 75, 90 and 97 are usually decimals. The mean number of OPs for each PT value was also usually a decimal. In order to calculate OPs from the percentile values of PT, therefore, we used the following equation. The estimated percentile values of OPs are shown in Table 3.

$$EOP(K) = OP(A) + \{OP(A+1) - OP(A)\} \times (K-A)$$

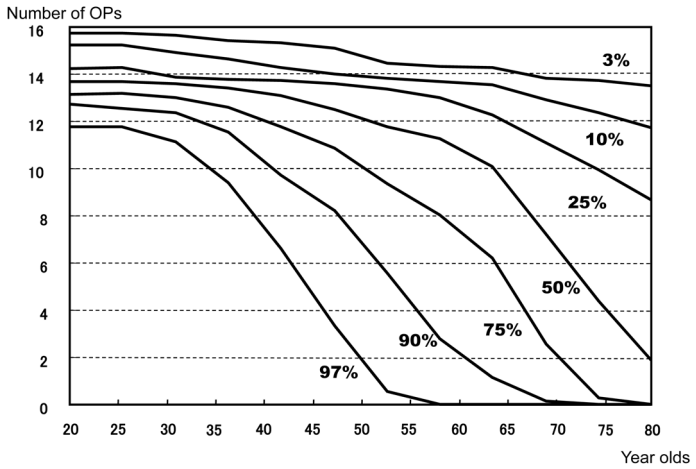

Fig. 1 Percentile curves of occluding pairs in males (n=1,535)

EOP(K): Estimated number of OPs, calculated from K number of PT

OP(A): Mean number of OPs at A number of PT

K is the percentile value of PT at percentiles 3, 10, 25, 50, 75, 90 and 97. A is the integer such that A=<K<A+1

4. Curve smoothing

The resulting lines connecting the percentile points plotted on the graph were jagged or irregular, partly due to sampling variations. Therefore, statistical smoothing procedures were applied to the observed data to generate smoothed curves for selected percentiles and to generate parameters that could be used to produce additional percentiles. The percentile curves were plotted with Excel Ver. 2003 (Microsoft Ltd., Chicago, IL, USA), and the moving average method was used for smoothing.

Results

Figure 1 shows the estimated percentile curves of OPs in males. The 10th percentile of OPs was 13.7 at 60 years of age and 12.5 at 70. The 50th percentile of OPs was 12.2 at 50 years of age, 11.2 at 60 and 5.4 at 70. The 90th percentile of OPs was 7.6 at 50 years of age, 2.1 at 60 and 0 at 70. There appeared to be a cut-off point after 10 OPs, where the 50th to 97th percentile curves dropped off rapidly.

The estimated percentile curves of OPs in females are shown in Fig. 2. The 10th percentile of OPs was 13.4 at 60 years of age and 12.7 at 70. The 50th percentile of OPs was 11.5 at 50 years of age, 10.2 at 60 and 6.2 at 70. The 90th percentile of OPs was 7.1 at 50 years of age, 2.4 at 60 and 0 at 70. As in males, the percentile curves for females also dropped off after 10 OPs.

Discussion

In an evaluation of the function of dentitions, OPs might be a more directly influencing factor than the number of present teeth[3]. Steele *et al.*[16] have proposed, on the basis of their study, that many of the principles of the shortened dental arch (SDA) are consistent with good function in the elderly. It has been proposed that 10 occluding pairs, specifically arranged from premolar to premolar, should satisfy function at a suboptimal but acceptable level for older people[7,8]. The number of occluding pairs has been shown in the

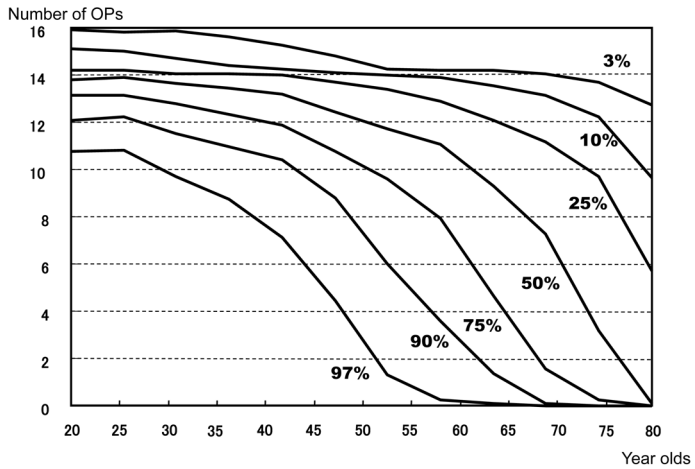

Fig. 2 Percentile curves of occluding pairs in females (n=2,248)

elderly in England to affect their selection of food[15]. Lin *et al.*[10] reported that the elderly residents of Guangdong more commonly reported difficulties in chewing hard foods when they had fewer than 8 occluding tooth pairs. Patients need to be instructed about the importance of maintaining a minimum number of OPs.

In this study, the percentile curves dropped off steeply after 10 OPs. Several studies have confirmed a relationship between the number of OPs and dental arch stability[6,9]. Käyser[9] conducted a cross-sectional study of 118 subjects including 90 with SDA. This study concluded that there was sufficient adaptive capacity to maintain adequate oral function in SDA when at least four OPs remain in molar regions, preferably in a symmetrical position. Gotfredsen and Walls[6] also reported that for most people, occlusal support and stability are obtained with three to four functional posterior units with a symmetrical pattern of tooth loss, or five to six units with an asymmetrical pattern. These reports, as well as the results of the current study, suggest that it is necessary to maintain around 10 OPs (including incisors) for dental arch stability and that if the number of OPs drops below this level, occlusal status will deteriorate.

As the number of PT decreases, the likelihood of losing more teeth increases. Yoshino *et al.*[21] performed a 6-year generational cohort analysis in which they estimated future tooth loss based on the number of PT. They found that the rate of tooth loss increased as the number of PT decreased. Eklund and Burt[5] 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 the 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. Yamamoto *et al.*[18] reported retrospectively on tooth loss during maintenance at a university hospital. Patients who lost teeth were older, showed a higher prevalence of severe periodontal disease and hypertension, and had a lower number of present teeth at the start of the maintenance.

It is well known that loss of PT due to periodontal disease increases with age[1,11,12]. Morita *et al.*[12] reported that periodontal disease

became prevalent in males between ages 46 and 65. McCaul *et al.*[11] also reported that upper and lower second molars were more frequently extracted due to periodontal disease than first molars in aged patients. Ando *et al.*[1] indicated that the percentage of teeth extracted due to periodontal disease increased as the number of PT decreased. These reports suggest that a decreasing number of PT places a burden on the remaining teeth. This increases the risk of periodontal disease and thereby triggers the further loss of OPs.

Using these figures, we can motivate patients concerning the necessity of maintaining an adequate number of OPs for masticatory efficiency, masticatory ability, oral health-related quality of life, dental arch stability, and prevention of temporomandibular disorders. The figures will also be useful when discussing with patients the treatment options (such as dental implants or autotransplantation of teeth) for recovering adequate occlusal status.

In conclusion, our results suggest that the loss of OPs may be accelerated when the number of OPs drops below 10. Therefore, 10 OPs should be considered the minimum level required for maintaining stability in the oral status. The estimated percentile curves presented in this study should be made available for use in adult oral health education.

References

1) Ando Y, Aida J, Morita M, Aoyama S, Masui M (2005) Report of reason for permanent teeth extraction. Tokyo, 8020 Promotion Foundation. (in Japanese)
2) Baba K, Igarashi Y, Nishiyama A, John TM, Akagawa Y, Ikebe K, Ishigami T, Kobayashi H, Yamashita S (2008) The relationship between missing occlusal units and oral health-related quality of life in patients with shortened dental arches. Int J Prosthodont 21:72–74.
3) Battistuzzi PG, Käyser AF, Kanters N (1987) Partial edentulism, prosthetic treatment and oral function in a Dutch population. J Oral Rehabil 14:549–555.
4) Dental Health Division of Health Policy Bureau Ministry of Health, Labour and Welfare Japan (1987) Report on the survey of dental diseases.
5) 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.
6) Gotfredsen K, Walls AW (2007) What dentition assures oral function? Clin Oral Implants Res 18:34–45.
7) Käyser AF (1984) Minimum number of teeth needed to satisfy functional and social demands, Public health aspects of periodontal disease, Frandsen A ed., pp. 135–147, Quintessence, Chicago.
8) Käyser AF (1989) Shortened dental arch: a therapeutic concept in reduced dentitions and certain high risk groups. Int J Periodontics Restorative Dent 9:426–449.
9) Käyser AF (1981) Shortened dental arches and oral function. J Oral Rehabil 8:457–462.
10) Lin HC, Corbet EF, Lo ECM, Zhang HG (2001) Tooth loss, occluding pairs, and prosthetic status of Chinese adults. J Dent Res 80: 1491–1495.
11) McCaul LK, Jenkins WM, Kay EJ (2001) The reasons for the extraction of various tooth types in Scotland: a 15-year follow up. J Dent 29:401–407.
12) Morita M, Kimura T, Kanegae M, Ishikawa A, Watanabe T (1994) Reasons for extraction of permanent teeth in Japan. Community Dent Oral Epidemiol 22:303–306.
13) 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)
14) Osada H, Tazawa M, Takaesu Y (1990) Percentile curves for the numbers of permanent teeth and their significances. J Dent Health 40:319–324. (in Japanese)
15) Sheiham A, Steele JG, Marcenes W, Finch S, Walls AW (1999) The impact of oral health on stated ability to eat certain foods; findings from the National Diet and Nutrition Survey of Older People in Great Britain. Gerodontology 16:11–20.
16) Steele JG, Ayatollahi SM, Walls AW, Murray JJ (1997) Clinical factors related to reported satisfaction with oral function amongst dentate older adults in England. Community Dent Oral Epidemiol 25:143–149.
17) The Statistical Analysis Committee on the Survey of Dental Diseases. Comprehensive Guide to the Survey of Dental Diseases 2005 (2007). Tokyo, Oral Health Association. (in Japanese)

18) Yamamoto T, Tsuneishi M, Murakami C, Watanabe T (2007) Retrospective study on tooth loss during maintenance care in a university hospital. J Dent Health 57:632–639.
19) Yoshino K, Matsukubo T, Takaesu Y (2000) Evaluation of remaining and sound teeth of office workers with percentile parameters. J Dent Health 50:40–51. (in Japanese)
20) 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.
21) 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. J Dent Health 50:159–164. (in Japanese)
22) Yoshino K, Watanabe H, Fukai K, Sugihara N, Matsukubo T (2012) Age- and sex-specific differences in ratio of occluding pairs to number of present teeth. Bull Tokyo Dent Coll 53: 197–202.
23) Yoshino K, Watanabe H, Fukai K, Sugihara N, Matsukubo T (2011) Number of occlusal units estimated from number of present teeth. Bull Tokyo Dent Coll 52:155–158.

Reprint requests to:
Dr. Koichi Yoshino
Department of Epidemiology and Public Health,
Tokyo Dental College,
1-2-2 Masago, Mihama-ku,
Chiba 261-8502, Japan
Tel: +81-43-270-3746
Fax: +81-43-270-3748
E-mail: ko-yoshi@d8.dion.ne.jp