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Java project on periodontal diseases: causes of tooth loss in a cohort of untreated individuals

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Abstract

Objective: To assess the relative contribution of caries and periodontal disease to tooth loss over 24 years in a cohort deprived of regular dental care.

Material & Methods: The study population consisted of 98 subjects from a tea estate on West Java, Indonesia, that had been part of a prospective longitudinal study and provided full datasets of clinical assessments between 1987, 1994 and 2002. In 2011, complete sets of dental radiographs were made which was combined with the survey forms and clinical slides from the previous assessments in order to estimate reasons for tooth loss.

Results: Thirty-seven subjects lost no teeth, whereas 61 subjects lost 185 teeth. In this group, 45.9% lost ≤2 teeth, 32.8% lost 3 to 4 teeth and 19.7% lost ≥5 teeth. The majority of teeth were lost due to caries. In five subjects, tooth loss could be attributed solely to periodontitis, whereas in four subjects teeth were lost due to both caries and periodontits. Analyses of the predictor variables age, gender, smoking, education, presence of caries and severe periodontitis showed that male gender and caries were significantly associated with tooth loss.

Conclusion: The majority of teeth in this population were lost due to caries.

Key words: caries; periodontitis; tooth loss; untreated disease

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Tooth loss impairs aesthetics and chewing function and as a consequence has a negative effect on the quality of life (Gerritsen et al. 2010). Cross-sectional epidemiological studies identified, in addition to caries and periodontal disease, a number of risk indicators for tooth loss, e.g. smoking (Mai et al. 2013), education level (Urzua et al. 2012) and socioeconomic status (Wennström et al. 2013). However, tooth survival has been related to frequent supportive periodontal therapy (Saminsky et al. 2015). In most cases, teeth are not spontaneously lost but extracted by dentists or physicians for reasons of pain, caries, periodontal disease, endodontic complications or as part of orthodontic and prosthodontic treatments. In general, caries and periodontal disease are regarded as the main reasons for tooth loss although the relative contribution of these two diseases varies between studies. In this respect, numerous studies have been carried out all over the world. Many studies concluded that caries is the main reason for tooth extraction (Corbet & Davies 1991, Hull et al. 1997, Chestnutt et al. 2000, McCaul et al. 2001, Jovino-Silveira et al. 2005, Chrysanthakopoulos 2011, Jafarian & Etebarian 2013, Lee et al. 2015). However, several other studies showed the opposite, where periodontal disease was found to be the main reason for tooth extraction

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(Reich & Hiller 1993, Phipps & Stevens 1995, Murray et al. 1996, Haddad et al. 1999, Akhter et al. 2008). In addition, it has also been reported that caries and periodontal disease are equally important reasons for tooth extraction (Angelillo et al. 1996, Ong et al. 1996, Aida et al. 2006). These dissimilar results are most likely due to differences between study populations in terms of, e.g. socioeconomic status, oral healthcare delivery systems, dental awareness and the dentist to population size ratio.

Due to all the above-mentioned variables, it is difficult to study the natural history of tooth loss. Therefore, prospective longitudinal studies evaluating tooth loss in populations deprived of professional oral health care are very valuable. In this respect two studies are of interest, i.e. the study on the natural history of periodontal disease in humans in Sri Lanka (Löe et al. 1978) and the study of Baelum et al. (1997) in a population of rural Chinese. In the Sri Lankan study, the rate of natural periodontal destruction was evaluated in a population free of caries (Neely et al. 2005), whereas in the Chinese population caries was found to be the predominant cause of tooth loss. Another prospective study on the natural history of periodontal disease has been carried out in Java, Indonesia (Van der Velden et al. 2006). The first evaluation was carried out in 1987 with follow-up assessments in 1994 and 2002. In 2011, a supplementary study on this population was initiated with the aim to investigate alveolar and periapical bone loss as visible on radiographs in relation to demographic, lifestyle, dietary and subgingival microbial variables as well as some blood chemistry parameters. The results of the 2011 evaluation concerning alveolar bone loss and related potential predictors (plasma vitamin C, vitamin D_3, HbA1c and CRP, the haptoglobin phenotype, presence of putative periodontopathic bacteria and viruses, dietary habits, smoking and anthropometrics) have been described in a separate paper (Amaliya et al. 2015). The purpose of the present study was (1) to investigate the relative contribution of caries and periodontal disease to tooth loss over the 24-year period, and (2) to analyse the prevalence of caries and its sequelae on the radiographs taken in 2011.

Material and Methods

In 2011, 123 subjects of the original Indonesian study population (Van der Velden et al. 2006) were retrieved and informed in detail about the objectives of the present study. Thereafter, they were asked if they would be willing to participate. The study was approved by the Ethics Committee of the Hasan Sadikin Hospital Bandung-West Java, Indonesia. The subjects' who volunteered signed an informed consent form. Subsequently, several variables were assessed including age, gender, smoking habits and education level. Non-smokers included three former smokers who quit smoking in the previous 9 months, 3 years and 18 years respectively. Details on the study protocol and results on periodontal bone loss in relation to environmental and systemic conditions have been reported previously (Amaliya et al. 2015).

In order to determine the cause for tooth loss, first the absence of teeth was assessed on a full set of dental radiographs taken for this study in 2011 (Amaliya et al. 2015). Next, the survey forms of the research carried out in 1987, 1994 and 2002 were used, which contained relevant information for all teeth except the third molars. These forms included not only the periodontal parameters, but also the presence/absence of teeth as well as an annotation for teeth that, from a periodontal point of view, were impossible to evaluate due to extreme tooth decay. Also, open caries (cavitation of a tooth with obvious visible dentin without restoration) and root remnants of a particular tooth were noted. In addition, clinical photographs (anterior, left and right lateral view as well as an occlusal view in case of open caries) were used to check and confirm the notes on the survey forms. A tooth was considered to be lost due to caries if in previous examinations (1) open caries was noted together with ≤4 mm attachment loss, (2) a note was made that no periodontal measures could be performed because the tooth was already present as root remnant, (3) if no note of caries was made but the patient showed caries at other teeth and the tooth in question had in all previous examinations ≤4 mm attachment loss and (4) if the tooth was missing on the radiographs of 2011 while at other teeth a radiographic diagnosis of caries was made and the missing tooth showed in all previous examinations ≤4 mm attachment loss. A tooth was considered to be lost due to periodontitis if in the preceding examinations the presence of caries and/or root remnant of the tooth were never noted and if the tooth showed an increased pocket depth as well as attachment loss during the follow-up years, resulting in the last examination before the tooth was lost in pockets ≥6 mm with attachment loss ≥5 mm. When a tooth fulfilled both the criteria for tooth loss due to caries as well as periodontitis, tooth loss was considered to be the result of both diseases. All assessments and decisions were made by author UVdV. The dataset obtained at the 1987 examination was used to assess to what extent the participants of the present study differed from the non-retrieved population.

Radiographic examination

A full set of dental radiographs, including vertical bitewings, were made of each subject using a long cone paralleling technique (Gnatus Timex 70 X-Ray Mobile Column, Brazil). At each tooth radiolucencies representing caries and its sequelae were scored in the following way:

1 No caries as evidenced by absence of radiolucencies at teeth,
2 Caries into the dentine as evidenced by radiolucency,
3 Caries into the pulp as evidenced by radiolucency with no widened periodontal ligament space,
4 Caries into the pulp as evidenced by radiolucency with widened periodontal ligament space,
5 Caries into the pulp as evidenced by radiolucency with evident periapical radiolucency,
6 Root remnant in the bone with no/widened periodontal ligament space,
7 Root remnant in the bone with evident periapical radiolucency,
8 Root remnant not in contact with the jaw bone.

Caries as predictor variable for tooth loss was assessed as presence or absence at a subject level. As reported previously (Amaliya et al. 2015), alveolar bone loss (ABL) was assessed mesially and distally of all teeth, except for the third molar, and the percentage of ABL relative to the root length was determined. For each individual, the number of teeth showing mesially or distally ABL ≥50% was determined. Severe periodontitis as predictor variable for tooth loss was defined as presence of ABL ≥50% at ≥2 teeth.

Statistical analysis

Descriptive statistics and data analyses were performed with statistical software from SPSS (version 19.0; IBM SPSS Inc., Chicago, IL, USA). For comparison of the demographics and clinical characteristics in 1987 between the present population and the non-retrievable part of the population, chi-square test and *t*-test were employed where appropriate. The relationship between the dependent variable presence or absence of tooth loss (at a subject level) in 2011 and the predictor variables age, gender, smoking habits (smoker/non-smoker), education level (elementary school completed/non-completed), caries (absent/present at a subject level) and severe periodontitis (absent/present) was assessed in a binary logistic regression analysis (forward stepwise with $p \leq 0.05$ to enter and $p \geq 0.10$ to leave). For all outcome analyses, *p*-values <0.05 were considered statistically significant.

Results

Of the 123 retrieved inhabitants of the Purbasari tea estate, 98 subjects volunteered to participate in the present investigation. Analysis of the background data obtained of the 255 subjects in 1987 showed that the present 98 subjects were on average 2 years older and had received less education than the individuals that were not available for the follow-up assessment ($N = 157$) (Table 1). No differences were present regarding the number of teeth, the clinical periodontal parameters and prevalence of putative periodontal pathogens. The smoking status was not recorded in 1987. The present cohort population included 53 woman and 45 men with a mean age of 45.6 years, ranging from 39 to 50 years. Evaluation of the radiographs showed complete absence of dental restorations and a mean number of 1.9 (±2.2) lost teeth. A relatively high percentage of the population suffered from caries and severe periodontitis, 74.5% and 40.8% respectively, while in 31.6% both conditions were present. Presence of tooth loss and number of lost teeth in relation to gender, smoking habits, education level, caries and severe periodontitis at the subject level are presented in Table 2. In subjects with caries and severe periodontitis, 88.6% lost at least one tooth resulting in a mean number of 3.72 (±2.37) lost teeth. The results of the logistic regression analysis showed that only male gender and the presence of caries were significantly related with tooth loss; odds ratio 3.97 and 11.79, respectively, however the confidence intervals were wide (Table 3).

Table 1. Demographics and clinical characteristics in 1987 of the initial population, the present study population and original participants that were not available for the current examination

Variable mean (SD) or number (%)	All subjects, $N = 255$	Subjects absent in 2011, $N = 157$	Subjects present in 2011, $N = 98$
Age (years)	20.0 (3.2)	19.3 (3.1)	21.2 (3.1)*
Male gender	129 (50.6)	86 (54.8)	45 (45.9)
Elementary school not completed	114 (44.7)	58 (36.9)	54 (55.1)**
No. teeth present	27.6 (0.74)	27.6 (0.82)	27.7 (0.58)
Plaque score	0.98 (0.44)	0.97 (0.44)	1.00 (0.45)
Bleeding on probing	0.78 (0.33)	0.79 (0.33)	0.76 (0.34)
No. sites with subgingival calculus	1.05 (0.43)	1.03 (0.44)	1.07 (0.41)
Pocket depth (mm)	3.24 (0.49)	3.26 (0.52)	3.20 (0.45)
Attachment loss (mm)	0.36 (0.40)	0.37 (0.45)	0.35 (0.31)
Presence of bacteria			
Motile microorganisms	255 (100)	157 (100)	98 (100)
Spirochetes	225 (88.2)	141 (89.8)	84 (85.7)
A. actinomycetemcomitans	146 (57.3)	93 (59.2)	53 (54.1)
P. gingivalis	221 (86.7)	134 (85.4)	87 (88.8)
P. intermedia	225 (100)	157 (100)	98 (100)

*$p = 0.004$, **$p = 0.012$.

In 2011, 37 subjects had lost no teeth at all, whereas 185 teeth were lost in the other 61 subjects. Of these 47.5% of the subjects lost ≤2 teeth, whereas 32.8% lost 3 to 4 teeth and 19.7% lost ≥5 teeth (Table 4). Retrospectively, at baseline in 1987, already 19 teeth were lost in 12 subjects. In 1994, this number increased to 31 in 21 subjects and in 2002 to 76 lost teeth in 37 subjects. Critical analysis of the data revealed that in the majority of subjects most teeth were lost due to caries and its subsequent sequelae (Table 5). In only five subjects tooth loss could be attributed solely to periodontal disease, whereas in four subjects teeth were most likely lost due to both caries and periodontal disease. Molar teeth were most frequently lost (80.0%), followed by premolars (12.4%) and anterior teeth (7.6%). The predominant influence of caries is also reflected in an increase in number of root remnants during the study follow-up from 1987 to 2011. This number was in 2011 almost equal to the number of teeth already lost (Table 6). When root remnants and lost teeth are taken together, 20 subjects still had a full dentition in 2011, whereas 78 subjects lost the equivalent of one or more functional teeth ranging from 1 to 13 (mean 3.7 ± 3.59).

In Table 7, data on the prevalence of severe periodontitis as well as caries and its sequelae are presented per tooth type. The upper second molars (right 17.3% and left 26.2%) and lower first incisors (right 15.5% and left 18.4%) were the teeth most frequently affected by severe periodontitis. Most teeth present were caries free, varying between 71.6% for the upper right second molar to 100% of almost all lower incisors. With respect to all teeth present, crown caries was rare.

Table 2. Tooth loss in 2011 in relation to background and clinical characteristics at the subject level

Variables	Number (%) of subjects with lost teeth	Mean (SD) number of lost teeth in subjects with tooth loss
All subjects (N = 98)	61 (62.2)	3.03 (2.06)
Gender		
Female (N = 53)	29 (54.7)	3.41 (1.90)
Male (N = 45)	32 (71.1)	2.69 (2.16)
Smoking		
Non-smokers (N = 54)	32 (59.2)	3.25 (1.90)
Smokers (N = 44)	29 (65.9)	2.79 (2.23)
Education: elementary school		
Not completed (N = 54)	35 (64.8)	3.14 (2.34)
Completed (N = 44)	26 (59.1)	2.88 (1.63)
Caries		
Present (N = 73)	54 (74.0)	3.13 (2.07)
Absent (N = 25)	7 (28.0)	2.29 (1.98)
Severe periodontitis		
Present (N = 40)	29 (72.5)	3.65 (2.32)
Absent (N = 58)	32 (55.2)	2.47 (1.63)

Table 3. Odds ratio and confidence intervals of significant variables for presence or absence of tooth loss by means of a binary logistic stepwise regression analysis (N = 98)

Variable	Regression coefficient	SE	p-value	Odds ratio	Confidence interval
Male gender	1.38	0.55	0.012	3.97	1.35, 11.69
Presence of caries	2.47	0.61	<0.001	11.79	3.59, 38.74
Model constant	−1.88	0.62	0.003	0.15	

Table 4. Total number of lost teeth by subject (N = 98) at the surveys in 1987, 1994, 2002 and 2011

Number of lost teeth per subject	Year of survey and number of subjects			
	1987	1994	2002	2011
0	86	77	61	37
1	7	14	15	21
2	3	5	11	8
3	2	1	5	7
4		1	6	13
5				4
6				4
7				3
10				1
>10				—
Total number of lost teeth	19	31	76	185

Only 1.7% showed caries into the dentin and 1.4% into the pulp chamber. Root remnants were more frequently encountered since these amounted to 6.7% of the teeth still present. Evident periapical lesions related to teeth with caries into the pulp chamber and root remnants were found in 0.7% and 3.3% of all teeth respectively. No or minimal periapical lesions (widened periodontal ligament space) at teeth with caries and root remnants amounted to 0.7% and 1.9% respectively. Root remnants that were no longer in contact with the jaw bone amounted to 1.5% of all teeth. Remarkably, two root remnants present on the radiographs in 2011 had already been present as root remnants at the first clinical examination, 24 years earlier, in 1987.

Discussion

In most studies that have evaluated the cause of tooth loss, dentists were asked to record the reason for tooth extraction and to provide this information to the researchers (Angelillo et al. 1996, Chestnutt et al. 2000, McCaul et al. 2001, Aida et al. 2006). A more reliable method to investigate the cause of tooth loss is to collect teeth extracted by dentists with the information why the tooth was extracted (Hull et al. 1997). In epidemiological studies in developing countries it appears much more difficult to assess with certainty the reason for tooth loss and the researcher has to rely on the information provided by those examined (Baelum & Fejerskov 1986). The strength of the present study is that the reason for tooth loss could be assessed over a 24 years period. The results showed that in the population under investigation, not receiving any regular dental care, most teeth were lost due to caries and its sequelae. Notably, the finding that dental restorations were absent, confirms that this rural population was deprived of regular dental care. Also, the relatively high number of root remnants with various diseased conditions that in some cases had been present for many years, supports the view of little to none professional dental interventions. Nevertheless, the possibility cannot be ruled out that some teeth were extracted as emergency treatment for severe toothache because at the tea estate a small hospital was present for medical care of the residents living in the surrounding villages on the estate. In the early days of the study general physicians and in more recent years visiting dentists may have been consulted by residents having severe pain which may have subsequently resulted in tooth extraction. According to discussions with medical staff members at the hospital this was, however, a rare phenomenon. A weakness of the present study is that the observations were made with 7–9 year interludes between examinations. During these intermediate periods rapid caries, rapid periodontal destruction or a combination of both may have resulted in tooth loss. Such a phenomenon can obviously not be excluded but is also impossible to assess. However, on the basis of the criteria used for causes of tooth loss, the available documentation and the discussions with the medical staff members of the hospital, it is likely that the causes of tooth loss could be assessed with a relatively high degree of certainty.

Table 5. Cause for tooth loss as assessed in 2011 by subject ($N = 61$), teeth and tooth type

Cause for tooth loss	Number of subjects (%)	Number of teeth (%)	Molars (*N*)	Premolars (*N*)	Anteriors (*N*)
Caries	52 (85.2%)	149 (80.5%)	126	16	7
Periodontitis	5 (8.2%)	12 (6.5%)	7	2	3
Caries and periodontitis	4 (6.6%)	24 (13.0%)	15	5	4

Table 6. Total number of root remnants by subject ($N = 98$) at the surveys in 1987, 1994, 2002 and 2011

Number of root remnants per subject	Year of survey (number of subjects)			
	1987	1994	2002	2011
0	79	65	51	34
1	14	19	13	23
2	2	6	12	15
3	2	5	7	10
4	1	1	7	4
5		0	0	4
6		2	1	3
7			0	2
8			1	1
9			1	2
>9				—
Total number of root remnants	28	62	109	177

The first examination of the subjects of the present study took place in 1987 when the age of the study population ranged between 15 and 25 years. At that time most third molars, if present, were partially erupted and therefore not included in the study. Comparison of the baseline data in 1987 with the present study population and the population not retrieved for follow-up showed that the present population was 2 years older and had received less education. Most likely this is due to increasing opportunities for younger people with a higher level of education of this former remote area to have contacts with the outside world and to leave for the relatively nearby city of Bandung. However, the number of lost teeth, periodontal condition and microflora were comparable between the retrieved and non-available subjects. Taken together, these data suggest that the results of the present study are representative for the natural history of tooth loss in this population under the given living conditions.

Results of the present study, with the population now aged 39–50 years, show that no one has become edentulous. The mean number of 1.9 truly lost teeth (out of in total 28) is not particularly high. When the number of root remnants have been added to the number of missing teeth, this results in 3.7 functional teeth that are lost. It is interesting to compare the average number of truly lost teeth (1.9) with other study populations also having limited access to professional dental health care and being of approximately the same age. For example, a mean of five lost teeth (out of 32) has been reported in adult Tanzanians with an age range of 40–49 years (Baelum & Fejerskov 1986). In a rural Chinese population with the same age range, on average, four teeth (out of 32) were lost (Baelum et al. 1997) and in a remote living indigenous population in Guatemala aged 45–54 years, 3.8 teeth (out of 32) were lost (Dowsett et al. 2001). Higher figures have been found in rural populations of Sri Lanka. In the classical study of Löe et al. (1978), 5.8 teeth (out of 28) were lost at the 20 years follow-up evaluation (Neely et al. 2005). At that time, the age range was 35–50 years. Furthermore, Amarasena et al. (2003) reported a mean loss of four teeth (out of 28) in the age group 35–44 and of 8.3 teeth in 45–54 year olds. Even higher tooth loss numbers were found in an isolated rural population in Brazil (Corraini et al. 2009). In this population, the age group 40–49 years had lost 13 (out of 28) teeth.

In the above-mentioned studies, the main reason for tooth loss considerably varied between caries and periodontal disease. In the Tanzanian study (Baelum & Fejerskov 1986), the primary cause of tooth loss was caries. In Sri Lanka, the prevalence of caries has been shown to be extremely low (Ekanayaka 1984) and even absent in the subjects of the classical study on the natural history of periodontal disease (Neely et al. 2005). In the Brazilian study from Corraini et al. (2009) it was concluded that both caries and periodontal disease were significant explanatory variables for the extensive tooth loss. The results of the present study showed that the majority of teeth were lost due to caries, which is not surprising in a population in which 75% suffer from caries and is deprived from regular dental care. Nevertheless, 40% of this population suffered from severe periodontitis which may have consequences for future tooth loss because, apparently, it takes many years before spontaneous exfoliation occurs of teeth that have been affected by periodontitis. Taking into account the present low prevalence of crown caries in this population, it may be expected that in the future in this population most likely more teeth will be lost due to periodontal break down. In other words, apparently first the carious susceptible teeth are lost followed by the teeth susceptible to periodontitis. In this respect a relatively older population may show more lost teeth as a result of periodontitis.

It is an intriguing question why the cause of tooth loss is so different between the study population of the natural history of periodontal disease in Sri Lanka (Neely et al. 2005) and the present Indonesian study population. Both populations are tea estate workers in relatively remote mountainous areas approximately 1500 m above sea level and both populations drink tea sweetened with sugar. Löe et al. (1978) mentioned that the fluoride content of the drinking water at the Sri Lanka tea estate was 0.02–0.07 ppm. Analysis

Table 7. Total number of teeth in 98 subjects and the prevalence of severe periodontitis as well as caries and its sequelae by tooth type

Tooth type	No. teeth present	No. teeth (%) with severe periodontitis	No. teeth (%) with no caries	No. teeth (%) with caries into dentin	No. teeth (%) with caries in pulp and no/minimal periapical lesion	No. teeth (%) with caries in pulp and evident periapical lesion	No. root remnants (%) with no or minimal periapical lesion	No. root remnants (%) with evident periapical lesion	No. root remnants (%) not in contact with jaw bone
17	81	14 (17.3)	58 (71.6)	6 (7.4)	1 (1.2)	–	5 (6.2)	9 (6.9)	2 (1.5)
16	81	12 (14.8)	62 (76.5)	1 (1.2)	1 (1.2)	–	4 (3.1)	9 (6.9)	4 (3.1)
15	92	6 (6.5)	84 (91.3)	1 (1.1)	–	1 (1.1)	3 (3.3)	2 (2.2)	1 (1.1)
14	91	6 (6.6)	81 (89.0)	1 (1.1)	–	1 (1.1)	4 (4.4)	4 (4.4)	–
13	96*	1 (1.1)	88 (91.7)	3 (3.1)	2 (2.1)	–	1 (1.0)	2 (2.1)	–
12	94*	5 (5.3)	89 (94.7)	3 (3.2)	–	1 (1.1)	–	1 (1.1)	–
11	93	7 (7.5)	90 (96.8)	2 (2.2)	–	–	1 (1.1)	–	–
21	96	9 (9.4)	92 (95.8)	3 (3.1)	–	–	1 (1.0)	–	–
22	96	6 (6.3)	87 (90.6)	5 (5.2)	1 (1.0)	–	1 (1.0)	2 (2.1)	–
23	95†	2 (2.1)	92 (96.8)	2 (2.1)	–	–	–	1 (1.1)	–
24	94*	6 (6.4)	80 (85.1)	–	3 (3.2)	–	4 (4.3)	7 (7.4)	–
25	93	6 (6.5)	80 (86.0)	–	–	–	6 (6.5)	4 (4.3)	3 (3.2)
26	83	11 (13.3)	61 (73.5)	1 (1.2)	–	1 (1.2)	2 (2.4)	15 (18.1)	3 (3.6)
27	84	22 (26.2)	66 (78.6)	2 (2.4)	1 (1.2)	2 (2.4)	4 (4.8)	6 (7.1)	3 (3.6)
37	76	6 (7.9)	63 (82.9)	–	3 (3.9)	2 (2.6)	3 (3.9)	2 (2.6)	3 (3.9)
36	79	1 (1.3)	64 (81.0)	–	1 (1.3)	4 (5.1)	1 (1.3)	3 (3.9)	6 (7.6)
35	95	3 (3.2)	86 (90.5)	1 (1.1)	3 (3.2)	3 (3.2)	–	–	2 (2.1)
34	98	1 (1.0)	91 (92.9)	1 (1.0)	–	–	2 (2.0)	3 (3.1)	1 (1.0)
33	98	1 (1.0)	97 (99.0)	–	–	1 (1.0)	–	–	–
32	98	7 (7.1)	98 (100)	–	–	–	–	–	–
31	98	18 (18.4)	98 (100)	–	–	–	–	–	–
41	97*	15 (15.5)	97 (100)	–	–	–	–	–	–
42	98	10 (10.2)	97 (99.0)	–	–	–	–	1 (1.0)	–
43	98	3 (3.1)	94 (95.9)	3 (3.1)	–	–	–	1 (1.0)	–
44	97	3 (3.1)	92 (94.8)	2 (2.1)	–	1 (1.0)	2 (2.1)	–	–
45	97	3 (3.1)	88 (90.7)	1 (1.0)	1 (1.0)	1 (1.0)	1 (1.0)	4 (4.1)	1 (1.0)
46	83	2 (2.4)	67 (80.7)	2 (2.4)	–	1 (1.2)	2 (2.4)	6 (7.2)	5 (6.0)
47	72	2 (2.8)	61 (84.7)	2 (2.8)	–	–	2 (2.8)	3 (4.2)	4 (5.6)
Total (%)	2553+ 2 impacted 4 agenetic = 2559	188	2303 (90.2)	42 (1.7)	36 (1.4)		172 (6.7)		

*Agenesis of one tooth.
†Impaction of two cuspids.

of a representative cup of tea of the Indonesian population contained approximately 0.45 ppm fluoride (Van der Velden et al. 1993). Also, both populations seem to have a comparable diet consisting mainly of rice and vegetables with some meat or fish (Löe et al. 1978, Amaliya et al. 2015). Unfortunately, the food frequency questionnaire as used in this Indonesian population was primarily developed to assess the vitamin C content of the diet (Amaliya et al. 2007) and not in particular the sugar intake. Therefore, author A. Amaliya returned to the village and was informed by the management of the village that the tea workers during their working day frequently chewed on *kalua jeruk*, which is candied orange peel. This habit was in fashion long before 1987 and provided the tea workers energy for their toil. This manner of additional sugar consumption in the Indonesian population could explain the differences in cause of tooth loss between the Indonesian and Sri Lanka population.

In agreement with the observation in other studies on tooth loss in rural populations (Baelum & Fejerskov 1986, Baelum et al. 1997, Corraini et al. 2009), it was found in the present study that molars were the most frequently missing teeth. Also, when teeth were present, the molars showed the highest number of root remnants. It was interesting to note that at root remnants still in the jaw bone, in approximately half of the cases no or minimal periapical radiolucencies were found. At the other root remnants, evident and sometimes very large periapical lesions were found that may have been present for many years. It has been reported that caries, periodontal diseases, pulpal disease and apical periodontitis may have broad implications on oral health-related quality of life (Beikler & Flemmig 2011). Worldwide, the prevalence of dental caries among adults is high as the disease affects nearly 100% of the population in the majority of countries (Petersen et al. 2005). In the present study population 80% of the subjects had lost on average almost four functional teeth, mostly molars, due to caries and its sequelae. In conjunction with the relatively high prevalence of periodontitis in this population (Amaliya et al. 2015), it is likely that this oral condition (caries, periodontitis and reduction of functional teeth) has had a negative effect on the quality of life. If oral disease burdens are to be reduced or preferably prevented, significant changes in approaches, concepts and policies are required (Benzian et al. 2011).

In conclusion, results of the present study showed that in this Indonesian population of tea workers on Java, deprived of regular dental care, tooth loss over a period of 24 years was limited. Although this population suffered from moderate to severe periodontitis, a minority of teeth were lost due to periodontal disease, whereas caries was the major reason for tooth loss. Improvement of dental awareness and education in reducing of sugar intake and oral self-care measures in such populations might reduce both diseases and could subsequently improve the quality of life.

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Clinical Relevance

Scientific rationale for the study: In populations deprived of regular oral health care, causes of tooth loss can be studied more objectively because a number of variables do not play such an important role, e.g. health care delivery systems, dental awareness and dentist to population size ratio.
Principal findings: In the study population with a mean age of 45.6 years, 20% of the subjects had a full intact dentition, whereas the remaining population lost on average close to four functional teeth, primarily due to caries.
Practical implications: Improvement of dental awareness and education in oral self-care in populations deprived of regular dental care should help reduce both diseases.