Dental Functional Status in a Southern Vietnamese Adult Population—A Combined Quantitative and Qualitative Classification System Analysis

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Purpose: The aim of this study was to explore the dental functional status of a Southern Vietnamese adult population using a new quantitative- and qualitative-based classification system. ***Materials and Methods:*** The sample consisted of 2,809 dentate subjects aged ≥ 20 years from urban and rural areas of Southern Vietnam. Dentitions were classified by a dichotomized five-level step-by-step branching hierarchy reflecting functionality. Cut-offs were as follows: level I (dentition level) = 1 tooth present in each arch, level II (arch level) = 10 teeth in each arch, level III (anterior region) = all 12 anterior teeth present, level IV (premolar region) = ≥ 3 premolar posterior opposing pairs (POPs) present, and level V (molar region) = 1 molar POP bilaterally. ***Results:*** Of the 2,809 subjects, 44% met all criteria for a functional dentition and 16% met none. Of subjects meeting level II, 81% had a complete anterior region, 74% had a sufficient premolar region, and 66% had a sufficient molar region. For subjects not meeting level II, these figures were 9%, 15%, and 8%, respectively. For patients meeting level II who were between 20 and 35 years of age, a mean 29.2 ± 2.4 teeth and 7.9 ± 2.1 POPs were present; subjects 65 years of age and older had a mean 25.6 ± 3.2 teeth and 5.9 ± 2.1 POPs. For patients not meeting level II, these numbers were 18.6 ± 2.9 teeth and 3.1 ± 1.8 POPs and 12.8 ± 5.4 teeth and 0.9 ± 1.4 POPs for 20- to 35-year-olds and those 65 years of age and older, respectively. Intraclass correlation coefficients for number of teeth and POPs showed fair to good group homogeneities. ***Conclusions:*** The World Health Organization goal of retaining at least 20 teeth throughout life is not achieved in Southern Vietnam; above the age of 44, less than 75% of subjects presented with 20 or more teeth. The presented classification system is a useful framework for mapping the functionality of dentitions by applying additional criteria for dental regions. *Int J Prosthodont 2011;24:30–37.*

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The high prevalence of missing teeth in Southern Vietnamese adults, together with a constant and low prevalence of decayed and filled teeth, indicates that extraction is the most common treatment for tooth decay in Southern Vietnam. As a result, reduced dentitions are common: 86% of the adult Southern Vietnamese population has at least one missing tooth, with the mean number of missing teeth increasing almost linearly from 2 at the age of 30 years to approximately 16 in the elderly.[1]

The World Health Organization (WHO) has considered the number of teeth to be a key indicator for oral health status[2,3] and has developed a strategic goal comprising the retention of no less than 20 teeth throughout life. In addition, the Fédération Dentaire Internationale (FDI) has set a similar goal, adding that 50% of individuals 65 years of age and older should retain 20 or more natural teeth.[4]

However, since different types of teeth have different functions, the question arises of whether simply the number of teeth present is adequate to describe the status of dentitions in terms of functionality. It has been demonstrated that the impact of missing teeth on oral functions and oral health–related quality of life is only partially dependent on the number of missing teeth.[5–8] Location and tooth type are also relevant in this respect. The dental literature has provided circumstantial evidence that 20 well-distributed teeth can yield adequate oral function.[9–11] The wording "well-distributed teeth" is mainly qualitative. Several authors have made attempts to quantify this term, among them Eichner,[12] who was the first to combine the presence and location of teeth with occlusal support. In fact, concepts of dental occlusion have been debated for more than 100 years.[13] "Well-distributed teeth" more or less implies an equal and symmetric distribution of teeth within the arches.[14] In a recent systematic review relating dental status with oral function, it was concluded that adequate oral function is not only associated with having a minimum of 20 teeth, but also with having 9 or 10 opposing pairs of teeth, including those in the anterior region.[15] Loss of anterior teeth impairs esthetics and satisfaction markedly, while satisfaction is most likely to be achieved in people who also retain premolars.[9,15–17] Absent molars are considered to have a relatively small impact on oral function and quality of life.[16–18] Although numerous studies investigating the relationship between the number of posterior occluding pairs (POPs) and masticatory function produced ambiguous results with respect to the exact number needed for adequate chewing function,[13,19–22] this has been recognized to be a key variable toward masticatory function. Recent reports on dental status of a large Japanese population emphasized this recognition. It was concluded that maintaining 20 or more natural teeth with at least 8 functional tooth units is important in reducing the likelihood of chewing difficulties.[20–23]

The present cross-sectional epidemiologic study investigates the extent to which the WHO goal of retaining at least 20 teeth is achieved in a Southern Vietnamese population and how this implicates functional dentitions comprising three to four POPs. It was hypothesized that dentitions with 20 teeth do not a priori provide the functional minimum of three to four POPs. For this purpose, a hierarchical classification system was developed, based on easily computable conditional probabilities, that reflects the functionality of the different tooth types and the requirements for a functional dentition, as described in the dental literature.[9,13–16,24–28]

Table 1 Number of Subjects per Province

	Provinces			
	Can Tho	An Giang	Ho Chi Minh	Total
Residence				
Urban	703	446	412	1,561
Rural	538	556	418	1,512
Sex				
Male	603	495	384	1,482
Female	638	507	446	1,591
Total	1,241	1,002	830	3,073

Materials and Methods

Sample Construction

A cluster-stratified sampling design was used to draw subjects aged ≥ 20 years from urban and rural areas of three provinces in Southern Vietnam: Can Tho, An Giang, and Ho Chi Minh. The sample construction has been described in detail in a previous report.[1] A total of 3,073 subjects participated in the epidemiologic study (Table 1). Urban subjects were selected randomly from lists of factory employees and administrative lists of citizens obtained from local authorities; rural subjects were selected randomly from representative villages using administrative lists of citizens from local authorities.

Clinical Examination

After obtaining verbal consent, subjects underwent an oral examination. One calibrated examiner performed the examinations in natural light with the subjects seated in an ordinary chair. A headlight was used when the natural light was felt to be insufficient. Of all variables recorded, only the presence of teeth (including third molars), tooth type, and number and location of POPs were considered in the present study. A tooth root was considered as an absent tooth. A POP was defined as a posterior opposing pair of natural teeth. The research was carried out in compliance with the Helsinki Declaration. The Educational Scientific Committee of Can Tho University of Medicine and Pharmacy granted ethics approval (decision no. 390/QĐ. ĐHYDCT).

Table 2 Levels and Criteria for Dichotomization of the Step-by-Step Branching Hierarchy

Level	Meeting criterion		Dichotomy
	Yes	No	
I: Dentition level	≥ 1 tooth present in each arch	Edentulous arch(es)	≥ 1 tooth vs no teeth
II: Arch level	≥ 10 teeth in both mandible and maxilla	< 10 teeth in mandible or maxilla	≥ 10 teeth vs < 10 teeth
III: Anterior level	All 12 anterior teeth present	< 12 anterior teeth	Complete vs incomplete
IV: Premolar level	3 or 4 occluding pairs of premolars	≤ 2 occluding pairs of premolars	Sufficient vs impaired
V: Molar level	≥ 1 occluding pair of molars at both left and right side of the dentition	No occluding pairs of molars at left or right side of the dentition	Sufficient vs impaired

Dental Functional Status Classification System

Dentitions were classified based on a dichotomized five-level step-by-step branching hierarchy in which the criteria, as applied on the levels, were based on conditions that reflect functionality (Table 2). The conditions used were the number of natural teeth, the tooth types present, and the number of POPs.

The first level in the classification (level I) presupposes the presence of at least one natural tooth in both the mandible and maxilla (cut-off: 1 tooth in each arch). The second level (level II) is based on the "20 well-distributed teeth" concept and the assumption that for adequate oral function, a distribution of at least 10 teeth in each arch is required to allow for 9 to 10 opposing pairs of teeth (cut-off: 10 teeth in each arch).[5] The third level (level III) is based on the assumption that a complete anterior region should be present for esthetics and psychofunctional well-being (cut-off: 12 anterior teeth).[9,15,16] Level IV describes the premolar region, which was considered to provide sufficient oral function if 3 or 4 pairs of premolars were present (cut-off: 3 premolar POPs).[15,24,25] The fifth level (level V) is based on the recognized but relative low impact of molars.[15,26–28] Therefore, the molar region was considered sufficient if at least 1 occluding pair was present bilaterally (cut-off: 1 molar POP bilaterally).

Data Analysis

Since urban and rural subjects showed no significant difference in the number of missing anterior, premolar, and molar teeth,[1] they were combined for the present analysis. From the previous report on this sample, it is known that women have fewer missing teeth in each dental region than men, but no marked differences in the pattern of missing teeth were found. Therefore, configurations of dentitions resulting from tooth loss were not analyzed by social background or sex separately. Only the biologic variable of age was used in addition to the dental variables in the analysis of configurations of dentitions.

The percentage of subjects having at least 20 teeth for the entire dentition and those having at least 10 teeth in each arch were counted for the total population sample. For the subsequent analysis of configurations of dentitions, only subjects with at least 1 tooth in each arch were included. The percentage of subjects meeting or not meeting the criteria, the mean number of teeth present, and the mean number of POPs were calculated for four age categories (20 to 35 years, 36 to 55 years, 56 to 65 years, and 66 years and older) for each level of the branching hierarchy. Subjects who were edentulous in one or both arches were not analyzed further.

Intraclass correlation coefficients (ICCs) were calculated as a measure for the homogeneity[29] of the groups after dichotomization at each level with respect to number of teeth (ICC-t) and POPs (ICC-p). The homogeneity of groups or categories after dichotomization is considered a measure that reflects the significance of the cut-off. A bootstrap procedure with 1,000 resamplings was used to determine the standard errors for the respective ICCs.

With the purpose of exploring the relative value of the cut-off of "10 teeth in each arch" for this population, it was compared to the cut-offs of 20 and 21 teeth present in the entire dentition. ICCs for the levels in the branching hierarchy were calculated for all cut-offs. Finally, the mean number of POPs and the percentage of subjects with 10 or more teeth present in each arch were plotted as functions of the number of teeth present.

Results

Of the total sample of 3,073 subjects initially included in the study, 11 subjects were excluded because of incomplete data sets. Two hundred fifty-three subjects (8%) were edentulous in the mandible and maxilla. This left 2,809 dentate subjects (92%) for further analysis.

The percentage of dentate subjects having at least 10 teeth in each arch or having 20 or more teeth in the

entire dentition decreased from almost 100% in subjects in their early 20s to less than 20% in subjects in their late 70s (Fig 1). In patients younger than 30, the two curves are quite close; above 30, the difference between the percentages is approximately 5%.

The branching hierarchy (Fig 2) describes 77% of all dentate subjects up to level IV (premolar region) and 68% up to level V (molar region). Categories not meeting the cut-offs in the "≥ 10 teeth" branch, as well as categories with relatively low prevalence, were not further dichotomized to the next level. Forty-four percent of the total sample met all criteria for a sufficient functional dentition (meeting all cut-offs up to level V); 16% met none of the criteria.

Of the subjects with at least 10 teeth in each arch, 81% (55% of the total sample) had an intact anterior region, 74% (50% of the total sample) met the criterion for a sufficient premolar region, and 65% (44% of the total sample) met that for a sufficient molar region (Fig 2). Of the subjects with an incomplete anterior region but who had at least 10 teeth in each arch (n = 404), 82% had a sufficient premolar region. In contrast, of the subjects with less than 10 teeth in each arch, 91% (21% of the total sample) had an incomplete anterior region, 78% (18% of the total sample) did not met the criterion for a sufficient premolar region, and 70% (16% of the total sample) had an impaired molar region.

Subjects meeting level II had a mean number of 29.2 ± 2.4 teeth and a mean 7.9 ± 1.8 POPs in the youngest age group (20 to 35 years, Fig 2). In the oldest age category, the mean number of teeth was 25.6 ± 3.2, providing a mean 5.9 ± 2.1 POPs. Of the subjects having at least 10 teeth in each arch, the lowest mean number of POPs was seen for the impaired premolar group (3.1 ± 1.6 POPs for subjects 56 to 65 years of age). All other age groups in the "≥ 10 teeth in each arch" branch showed higher mean numbers of POPs. It can be seen from Fig 2 that the decrease in percentage of subjects in each age group that met higher levels of functionality is relatively low for the youngest age group but high for the other age groups.

In subjects not meeting the criterion "≥ 10 teeth in each arch," the mean number of teeth was 18.6 ± 2.9 in the youngest age group, providing 3.1 ± 1.8 POPs. In the oldest age category, these numbers were 12.8 ± 5.4 teeth and 0.9 ± 1.4 POPs. For patients not meeting level II, all categories showed an average of less than 20 teeth present for the entire dentition, with the exception of the small group of patients (2% of the population) with a complete anterior region (means for age groups between 22.7 and 19.6 teeth). The lowest mean numbers of teeth and POPs were found in dentate subjects not meeting any of the criteria: 16.8 ± 2.9 teeth and 1.4 ± 0.9 POPs for the youngest (n = 13) and 11.2 ± 4.9 teeth and 0.4 ± 0.7 POPs for the oldest age groups (n = 141).

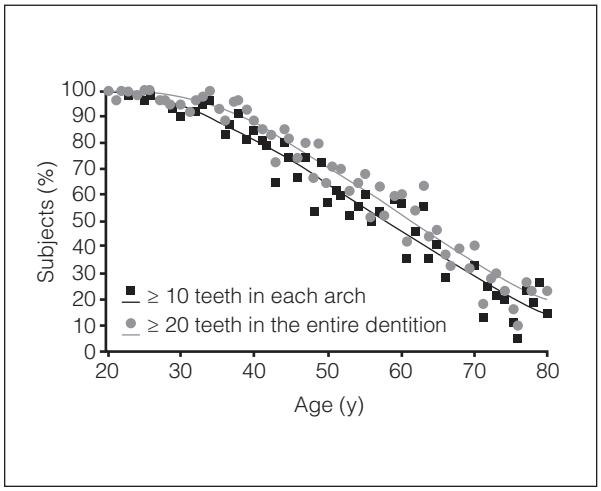

Fig 1 Percentage of dentate subjects (n = 2,809) having at least 10 teeth in each arch and that with at least 20 teeth in the entire dentition according to age.

The homogeneities of the dichotomized groups after branching varied substantially (ICCs ranging from 0.000 ± 0.010 for POPs [ICC-p] after branching subjects with less than 10 teeth in each arch to 0.859 ± 0.005 for the number of teeth [ICC-t] after branching the subjects with ≥ 10 teeth in both arches) (Fig 2). For instance, the dichotomy for a complete or incomplete anterior region for subjects with 10 teeth in each arch led to poor group homogeneity (ICC-t = 0.428 ± 0.025 and ICC-p = 0.165 ± 0.025), while the group homogeneity created by "sufficient molar occlusion" after meeting the three previous criteria was good (ICC-t = 0.713 ± 0.017, ICC-p = 0.766 ± 0.010).

Comparison of homogeneities after branching with different cut-offs for the main branching, ie "≥ 10 teeth in each arch" vs "< 10 teeth in each arch," "≥ 20 teeth" (entire dentition) vs "< 20 teeth" and "≥ 21 teeth" vs "< 21 teeth," showed no substantial differences (Table 3). ICCs for the 20 and 21 teeth cut-offs were slightly higher at the main level (different cut-offs) but did not differ significantly at other levels, except for ICC-p after dichotomization at the level of "anterior region complete" (ICC-p was higher for cut-offs at 20 and 21 teeth than 10 teeth in each arch, indicating higher group homogeneities).

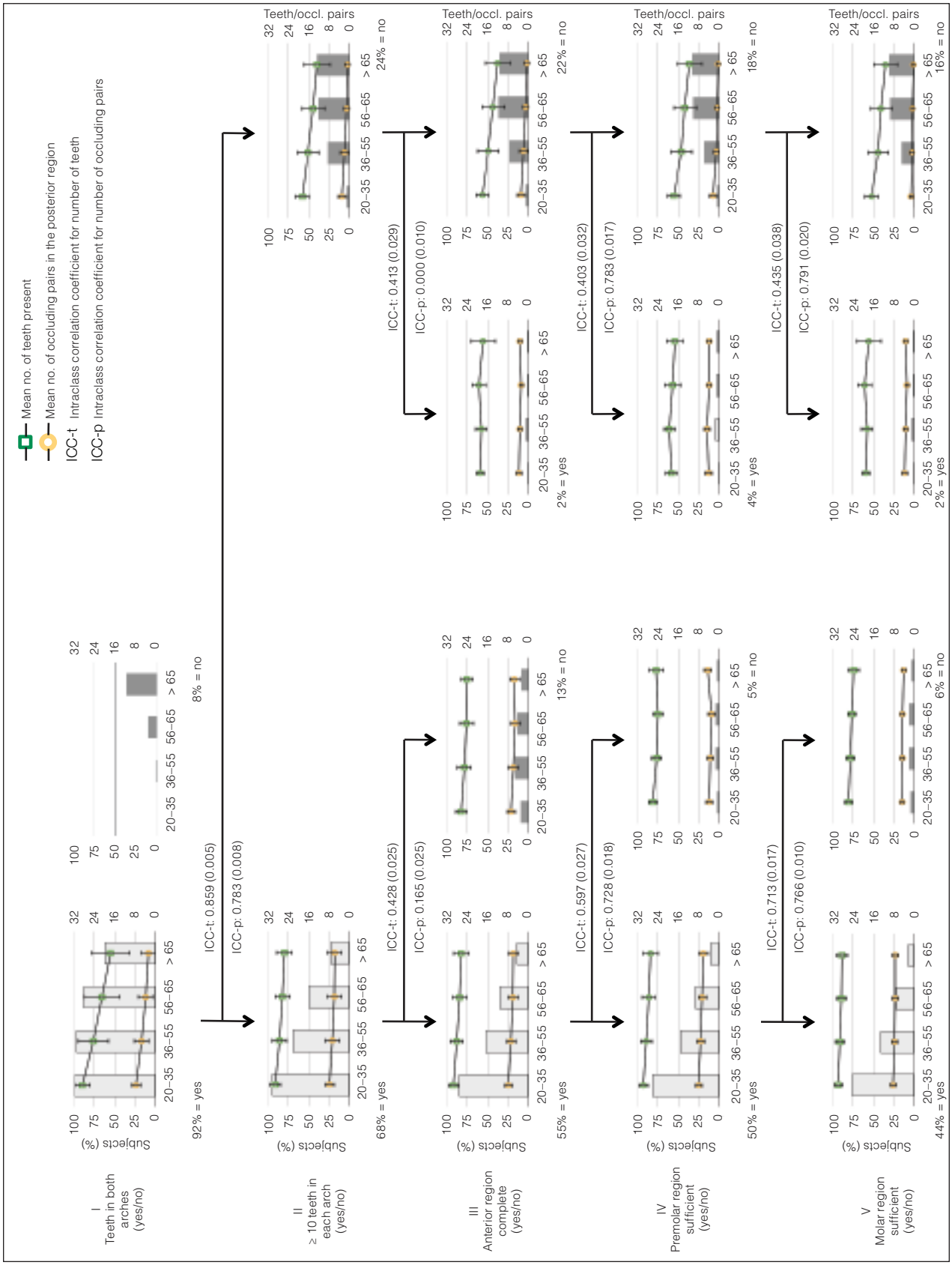

Fig 2 Distribution of subjects according to the step-by-step branching hierarchy dichotomized at 5 levels: level I = dentate in both arches, level II = ≥ 10 natural teeth in each arch, level III = anterior region complete, level IV = premolar region sufficient, and level V = molar region sufficient. Dark columns indicate status of not meeting criterion.

Table 3 Homogeneity of Groups as Expressed by ICCs (SE) for Number of Teeth (ICC-t) and Number of POPs (ICC-p) and the Percentage of Subjects Meeting the Criterion After Dichotomization at Different Levels for Different Cut-offs in the Main Step

	Cut-off		
	10 teeth in each arch	20 teeth	21 teeth
Dentate subjects meeting the main cut-off	74%	80%	77%
Cut-off level			
ICC-t			
Main	0.859 (0.005)	0.882 (0.003)	0.880 (0.003)
Anterior region complete	0.428 (0.025)	0.487 (0.023)	0.457 (0.024)
Premolar region sufficient	0.597 (0.027)	0.652 (0.022)	0.630 (0.023)
Molar region sufficient	0.713 (0.017)	0.719 (0.016)	0.712 (0.017)
ICC-p			
Main	0.783 (0.008)	0.778 (0.008)	0.787 (0.007)
Anterior region complete	0.165 (0.025)	0.218 (0.259)	0.186 (0.024)
Premolar region sufficient	0.728 (0.018)	0.756 (0.014)	0.744 (0.015)
Molar region sufficient	0.766 (0.010)	0.769 (0.009)	0.767 (0.020)
Subjects meeting the main cut-off			
Anterior region complete	81%	76%	80%
Premolar region sufficient	74%	70%	72%
Molar region sufficient	65%	61%	63%

Subjects having 20 teeth showed on average 3 POPs (Fig 3). The mean number of POPs increased almost linearly starting from 0.41 for 12 teeth present to 10 when all teeth were present, indicating a strong relationship between the number of teeth and the number of POPs in this range. Twenty-two to 23 teeth present were accompanied with 4 POPs on average. It should be noted that the number of POPs does not disclose the position of the POPs. Fig 3 also shows that in the present study, only 14% of the population with 20 teeth present had a dentition with 10 teeth in each arch. Thus, 86% of subjects with 20 teeth did not present with 10 teeth in each arch, which was the stated condition for homogeneity with respect to tooth distribution (ie, 20 well-distributed teeth). However, this percentage drops rapidly with an increasing number of teeth present. With 21 teeth present, the percentage of the population not meeting the criterion "≥ 10 teeth in each arch" is slightly less than 50%.

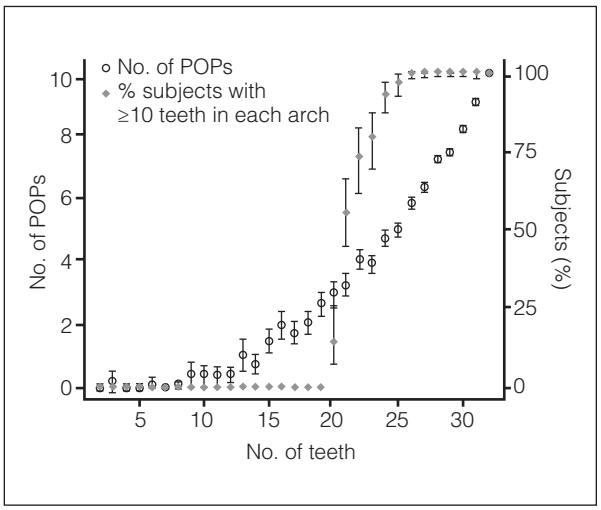

Fig 3 Mean number of POPs and percentage of subjects with 10 or more teeth present in each arch as functions of the number of teeth. Vertical bars indicate 95% confidence intervals.

Discussion

This study aimed to explore the dental functional status of a Southern Vietnamese adult population. Since this study is part of a larger epidemiologic study,

sample construction aimed for an equal distribution of subjects according to residence, province, sex, and age.[1] In comparison to the age group distribution in the population, older subjects were overrepresented in the sample. The sample's socioeconomic status structure is comparable with governmental data.[30] The significant strengths of this study include a large sample size, which provided ample power to evaluate effect modification. Although the structure of the study sample is not a direct reflection of the structure of the population, the outcomes are considered representative for Southern Vietnam.

For investigating the sequels of tooth loss in terms of impact of functionality on the remaining dentition, the present study attempted to develop a classification system for describing dental functional status. In epidemiologic studies, reduced dentitions are mainly described by the number of teeth present or by the missing component of decayed, missing, or filled teeth scores, ignoring the functionality of teeth in different dental regions. Focusing on numbers, the WHO set a goal for oral health care to retain 20 or more natural teeth throughout life. This number alone, however, does not guarantee sufficient POPs for adequate function. The 20-tooth requirement allows a large variety in functionality; from a purely mathematic point of view, there are more than 231 million possible configurations comprising 20 or more teeth. In contrast, a requirement for at least 10 teeth in both the mandible and maxilla allows 55 million possible configurations. This is, of course, only part of the story, since in reality, different teeth have different risks for tooth loss. For instance, in this sample, molars were statistically significantly more often affected by caries, more often missing, and less sound than premolars and anterior teeth.[1]

The classification system described in this study is based on the assumption of different qualities for different tooth types, as well as their role in a functional dentition. Although high-level evidence is not available and difficult to retrieve, there is ample circumstantial evidence that the cut-offs chosen for this classification system reflect functionality of a dentition for different populations.[5–11,14–18,20,23,25–28]

Subjects in this study showed on average 7.7 POPs for young adults (20 to 35 years) and 2.8 POPs for elderly subjects (> 65 years). These numbers are comparable with data from other epidemiologic studies; however, no conclusion can be drawn with respect to the comparability of the actual functionality. For instance, in a recent adult study in Japan (40 to 75 years), dentitions with 20 natural teeth had a mean number of 3.58 natural POPs.[23] However, this figure of 3.58 neither discloses the position of the teeth nor the number of occluding premolar or molars, because a pair of opposing molars was defined as 2 opposing posterior pairs, while premolars were recorded as 1 opposing posterior pair.

To present 20 well-distributed teeth (which in this classification system is delineated at level II), a majority of the population needed 21 or more teeth (Fig 3). This distribution, based on the "10 teeth in each arch" cut-off, led to high percentages of intact anterior regions and relatively high percentages of sufficient premolar and molar regions (Table 3). With the cut-offs of 20 and 21 teeth for the entire dentition, these percentages were slightly lower. Regardless of the cut-off for the main criterion, approximately 70% of the population that met the cut-off had a dentition comprising complete anterior regions and sufficient premolar regions with three or four POPs. Of the 207 subjects with three POPs in the premolar region, 75 (36%) were missing a first premolar POP and 132 (64%) were missing a second premolar POP.

Having 20 or more teeth was accompanied with at least 3.4 POPs (Fig 3). However, as in other studies, this number alone neither reveals the position nor reflects the functional quality of the teeth or dentition, since incomplete anterior regions may be included in this category. Therefore, it is considered appropriate to accept the hypothesis that dentitions with 20 or more teeth do not provide 3 to 4 POPs. The cut-offs of 20 and 21 teeth present in the entire dentition or "10 teeth in each arch" hardly influenced the outcomes on functionality. Independent from the cut-offs chosen for the main dichotomy, the next levels in the branching hierarchy are proposed to describe qualitative essentials.

Conclusion

The present classification system is a useful framework for mapping the large variety seen in the configuration of dentitions. The WHO goal of retaining at least 20 teeth is being met in some European countries.[31] The outcomes of the present study, however, show that this is not the case in Southern Vietnam; above the age of 44, less than 75% of the population presented with 20 or more teeth. Surveys in other populations using the presented classification system might provide clarity regarding the best discriminative cut-off points for numbers of teeth to predict functionality.

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References

1. Nguyen TC, Witter DJ, Bronkhorst EM, Truong NB, Creugers NHJ. Oral health status of adults in Southern Vietnam—A cross-sectional epidemiological study. BMC Oral Health 2010;10:2.
2. World Health Organization. A Review of Current Recommendations for the Organization and Administration of Community Oral Health Services in Northern and Western Europe. Oslo: World Health Organization, 1982.
3. Petersen PE. Challenges to improvement of oral health in the 21st century—The approach of the WHO Global Oral Health Programme. Int Dent J 2004;54(suppl 1):329–343.
4. Global goals for oral health in the year 2000. Fédération Dentaire Internationale. Int Dent J 1982;32:74–77.
5. Locker D, Slade G. Association between clinical and subjective indicators of oral health status in an older adult population. Gerodontology 1994;11:108–114.
6. Hugo FN, Hilgert JB, de Sousa MdaLR, da Silva DD, Pucca GA Jr. Correlates of partial tooth loss and edentulism in the Brazilian elderly. Community Dent Oral Epidemiol 2007;35:224–232.
7. Swoboda J, Kiyak HA, Persson RE, et al. Predictors of oral health quality of life in older adults. Spec Care Dentist 2006; 26:137–144.
8. Steele JG, Sanders AE, Slade GD, et al. How do age and tooth loss affect oral health implants and quality of life? A study comparing two national samples. Community Dent Oral Epidemiol 2004;32:107–114.
9. Elias AC, Sheiham A. The relationship between satisfaction with mouth and number and position of teeth. J Oral Rehabil 1998;25:649–661.
10. Helkimo E, Carlsson GE, Helkimo M. Chewing efficiency and state of dentition. A methodologic study. Acta Odontol Scand 1978;36:33–41.
11. Sarita PTN, Witter DJ, Kreulen CM, van't Hof MA, Creugers NHJ. Chewing ability of subjects with shortened dental arches. Community Dent Oral Epidemiol 2003;31:328–334.
12. Eichner K. Über eine Gruppeneinteilung der Lückengebisse für die Prothetik. Dtsch Zahnärtzl Z 1955;10:1831–1834.
13. Carlsson GE. Dental occlusion: Modern concepts and their application in implant prosthodontics. Odontology 2009;97:8–17.
14. Gordon PH, Murray JJ, Todd JE. The shortened dental arch: Supplementary analyses from the 1988 adult dental health survey. Community Dent Health 1994;11:87–90.
15. Gotfredsen K, Walls AWG. What dentition assures oral function? Clin Oral Implants Res 2007;18(suppl 3):34–45 [erratum 2008;19:326–328].
16. Steele JG, Ayatollahi SMT, Walls AWG, Murray JJ. Clinical factors related to reported satisfaction with oral function amongst dentate older adults in England. Community Dent Oral Epidemiol 1997;25:143–149.
17. Trovik TA, Klock KS, Haugejorden O. Level and predictors of agreement between patients and their dentists concerning need for replacement of teeth at the time of extraction. Acta Odontol Scand 2002;60:186–192.
18. Leake JL. An index of chewing ability. J Public Health Dent 1990;50:262–267.
19. Armellini DB, Heydecke G, Witter DJ, Creugers NHJ. Effect of removable partial dentures on oral health-related quality of life in subjects with shortened dental arches: A 2-center cross-sectional study. Int J Prosthodont 2008;21:524–530.
20. Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Masticatory ability and functional tooth units in Japanese adults. J Oral Rehabil 2008;35:337–344.
21. Zhang Q, Kreulen CM, Witter DJ, Creugers NHJ. Oral health status and prosthodontic conditions of Chinese adults: A systematic review. Int J Prosthodont 2007;20:567–572.
22. Morita M, Nishi K, Kimura T, et al. Correlation between periodontal status and biting ability in Chinese adult population. J Oral Rehabil 2003;30:260–264.
23. Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Category of functional tooth units in relation to the number of teeth and masticatory ability in Japanese adults. Clin Oral Investig 2010;14:113–119.
24. Leake JL, Hawkins R, Locker D. Social and functional impact of reduced posterior dental units in older adults. J Oral Rehabil 1994;21:1–10.
25. Kanno T, Carlsson GE. A review of the shortened dental arch concept focusing on the work by the Käyser/Nijmegen group. J Oral Rehabil 2006;33:850–862.
26. Witter DJ, van Palenstein Helderman WH, Creugers NHJ, Käyser AF. The shortened dental arch concept and its implications for oral health care. Community Dent Oral Epidemiol 1999; 27:249–258.
27. Rosenoer LM, Sheiham A. Dental impacts on daily life and satisfaction with teeth in relation to dental status in adults. J Oral Rehabil 1995;22:469–480.
28. Baba K, Igarashi Y, Nishiyama A, et al. Patterns of missing occlusal units and oral health-related quality of life in SDA patients. J Oral Rehabil 2008;35:621–628
29. Fleiss JL. The Design and Analysis of Clinical Experiment. New York: Wiley, 1986.
30. General statistics office of Vietnam. Living Standard Survey 2004. www.gso.gov.vn. Accessed 18 March 2010.
31. Müller F, Naharro M, Carlsson GE. What are the prevalence and incidence of tooth loss in the adult and elderly population in Europe? Clin Oral Implants Res 2007;18(suppl 3):2–14 [erratum 2008;19:326–328].