Predictors of Multiple Tooth Loss Among Socioculturally Diverse Elderly Subjects

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Purpose: This study identifies clinical factors that predict multiple tooth loss in a socioculturally diverse population of older adults. ***Materials and Methods:*** A total of 193 participants from English-, Chinese-, or Punjabi-speaking communities in Vancouver, British Columbia, with low incomes and irregular use of dental services were followed for 5 years as part of a clinical trial of a 0.12% chlorhexidine mouthrinse. The participants were interviewed and examined clinically, including panoramic radiographs, at baseline and annually for 5 years. Binary logistic regression was used to test the hypothesis that there was no difference between incidence of multiple (≥ 3) tooth loss in older people with various biologic, behavioral, prosthodontic, and cultural variables over 5 years. ***Results:*** Multiple tooth loss, which was distributed similarly among the groups in the trial, occurred in 39 (20%) participants over 5 years. The use of removable prostheses was the best predictor of loss, followed by the number of carious surfaces and number of sites with gingival attachment loss > 6 mm. The pattern of prediction was consistent across the three linguocultural groups. ***Conclusion:*** The use of removable dentures was the dominant predictor of multiple tooth loss in the three communities, but that tooth loss was not significantly associated with the cultural heritage of the participants. *Int J Prosthodont 2013;26:127–134. doi: 10.11607/ijp.2893*

The loss of at least one tooth over time in older subjects has been associated with a wide array of biologic and behavioral factors, such as sex, marital status, education, self-rated oral health, number of teeth and caries lesions, gingival attachment loss (AL), use of dental services, and oral hygiene practices.[1–5] Therefore, the likelihood is high that most people will lose at least one tooth as they age, but with few adverse effects. However, the loss of multiple teeth in old age can be very debilitating,[6,7] and relatively little is known about the factors that predispose people to lose all or most of their natural teeth, other than advanced loss of clinical periodontal attachment and poor oral hygiene[8–11] (Table 1).

Allen and McMillan[12] and Jepson et al[13] demonstrated associations between psychosocial factors and prosthodontic treatment, whereas other authors related prosthodontic treatment to caries and periodontal disease.[14–24] However, there have been very few studies on the associations between prosthodontic treatment and subsequent tooth loss.[4,25,26] Ando et al[4] demonstrated that tooth loss was more common in people with 10 to 27 teeth, caries, symptoms of pain, swelling, or bleeding, dental visits in the previous year, and limited oral hygiene, and was associated with third molars, caries, mobility, artificial crowns, and abutment retainers. Furthermore, Seida et al[25] showed that tooth loss was greater in people with a body mass index ≥ 24, serum immunoglobulin ≥ 1,901 mg/dL, impaired daily activities, 4% or more periodontal sites with AL of 6 mm or more, nine or more crown restorations, and one or more root caries lesions.

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Table 1 Summary of Previous Research on Predictors of Tooth Loss

	Predictors							
Study	Gingival attachment loss	Caries	Hygiene	Age	No. of teeth	Education	Economics	Tobacco use
Locker et al[1]	x	x						
Slade et al[2]			x					x
Warren et al[3]	x							
Ando et al[4]		x			x			
Baelum et al[9]	x	x	x	x				
Shimazaki et al[10]	x	x	x					
Seida et al[25]	x	x	x					
Klein et al[27]				x		x		x
Drake et al[28]	x		x				x	
Gilbert et al[29]	x	x						
Beck et al[30]	x							
Fure and Zickert[38]		x						
Burt et al[39]	x				x	x		
Tezal et al[40]	x							
Copeland et al[41]	x			x	x			x
McGuire and Nunn[42]	x							x

There have been studies about factors associated with tooth loss; however, only a handful have predicted multiple tooth loss from biologic variables,[9–11] a few investigated the relationship between tooth loss and prosthodontic treatments,[4,25–27] and even fewer studied tooth loss and cultural heritage. Drake et al[28] and Gilbert et al[29] found that race in the context of African-American groups in the United States was significantly associated with tooth loss, whereas Beck et al[30] found no association between the two variables. Eklund and Burt[8] analyzed the incidence of total tooth loss over 10 years with data from the NHANES I Epidemiologic Follow-up Study (NHEFS) in the United States but could not associate complete tooth loss (edentulism) with any particular demographic variable. Therefore, it appears that the association between tooth loss and ethnocultural background is inconclusive.

Low-income elderly subjects aged 60 to 75 years were recruited for a 5-year double-blind clinical trial in Seattle, Washington, and Vancouver, British Columbia.[31] The Trial to Enhance Elders' Teeth Health (TEETH) tested the influence of a chlorhexidine (CHX) mouthrinse regimen compared with a placebo. At baseline and annually for 5 years, all of the participants were interviewed about their oral health–related behaviors, values, and concerns and examined clinically for caries, periodontal bone loss, and tooth loss.[32] A dental hygienist cleaned all teeth before the examinations, and panoramic radiographs were taken at baseline and at the end of the trial. Participants received no dental treatment as part of the trial, but they were advised to attend a dentist if the examiner found a problem. The results of the trial found no significant differences in the oral health status of participants using CHX or the placebo at baseline or after 5 years.[31] Consequently, the combined clinical and radiographic data from the 193 participants in Vancouver over 5 years were used to identify the characteristics of participants who lost three or more teeth. The hypothesis was that there was no difference between the incidence of multiple (≥ 3) tooth loss in older people with various biologic, behavioral, prosthodontic, and cultural variables over 5 years.

Materials and Methods

Participants

Letters were sent to administrators in local community centers, notices were posted in the centers, and advertisements were placed in local English, Chinese, and Punjabi newspapers around Vancouver, British Columbia. Participants were enrolled in the

Predictors	
Sex	Other
x	Marital status; self-rated oral health
x	Recent extractions; immigration
	Visits to dentist
	Body mass index ≥ 24; immunoglobulin ≥ 1,901 mg/dL; impaired physical activity
	Alcohol abuse; diabetes
	Symptoms such as oral pain and tooth sensitivity; psychosocial factors
	Mobile teeth
x	Number of teeth with restorations; alcohol abuse
	Bruxism

trial if *(1)* their age was between 60 and 75 years; *(2)* they had a minimum of four natural teeth; *(3)* they had no preventive dental care in the preceding 2 years; *(4)* they achieved a self-efficacy score of at least 60 (with responses ranging from 0 to 100) on a measure of health self-efficacy adapted from Bandura[33]; and *(5)* they were willing to remain in the trial for 5 years. Details of the recruitment strategy have been described elsewhere.[34] The trial, which was part of a larger two-center trial, was approved by the Clinical Trials Ethics Board of the University of British Columbia, and data collection and participant safety were monitored by a Data and Safety Managing Board operating with guidelines from the U S National Institutes of Health.[31,34]

There were 335 participants at baseline with a dropout rate of 42% over 5 years from the Vancouver recruitment, leaving 193 participants (107 men, 86 women) after 5 years with a mean age at baseline of 67 ± 4 years for interviews and clinical examinations (Table 2).

Outcome Measurements

The dependent variable was loss of 3 or more teeth during the 5 years, with independent variables relating to various biologic, prosthodontic, and cultural

Table 2 Sample Characteristics at Baseline

Characteristic	No. of subjects (%)
Sex	
Male	107 (55.4)
Female	86 (44.6)
Age (y)	
< 65	78 (40.4)
≥ 65	115 (59.6)
Linguocultural group	
English	93 (48.2)
Chinese	34 (17.6)
Punjabi	58 (30.1)
Other	8 (4.1)
Income group	
< $5,000	27 (14.0)
$5,000–$9,999	25 (13.0)
$10,000–$14,999	19 (9.8)
$15,000–$19,999	27 (14.0)
$20,000–$24,999	21 (10.9)
≥ $25,000	48 (24.9)
Unknown	26 (13.5)
Formal education (y)	
0–11	83 (43.0)
12 or more	99 (51.3)
Unknown	11 (5.7)
Current tobacco use	
Yes	78 (40.4)
No	97 (50.3)
Unknown	18 (9.3)
No. of teeth at baseline	
1–19	44 (22.8)
20 or more	149 (77.2)
No. of teeth with caries lesions	
0	86 (44.6)
1 or more	107 (55.4)
No. of teeth with AL ≥ 6 mm	
0 or 1	96 (49.7)
2 or more	97 (50.3)
No. of crowned teeth	
0	110 (57.0)
1 or more	83 (43.0)
No. of endodontic fillings	
0	108 (56.0)
1 or more	85 (44.0)
Abutments for fixed partial dentures	
0	146 (75.6)
1 or more	47 (24.4)
Removable denture use	
Yes	20 (10.4)
No	173 (89.6)

AL = gingival attachment loss.

Table 3 Associations Between Multiple Tooth Loss and Various Demographic and Clinical Characteristics

Characteristic	No. of subjects	Subjects who lost teeth (%) ≤ 2 teeth	Subjects who lost teeth (%) ≥ 3 teeth	Chi-square	*P*
Sex					
Male	107	74.8	25.2	3.76	.05
Female	86	86.0	14.0		
Age (y)					
> 65	78	82.1	17.9	0.41	.5
< 65	115	78.3	21.7		
Linguocultural group					
English	93	90.3	9.7	12.34	.001**
Other	100	70.0	30.0		
Punjabi	58	65.5	34.5	10.48	.001**
Other	135	85.9	14.1		
Chinese	34	73.5	26.5	1.00	.32
Other	159	81.1	18.9		
Income†					
≤ $25,000	118	72.9	27.1	9.21	.002**
> $25,000	49	93.9	6.1		
Education (y)					
≤ 10	79	70.9	29.1	6.65	.01*
> 10	103	86.4	13.6		
No. of teeth with caries lesions					
0	86	90.7	9.3	11.44	.001**
≥ 1	107	71.0	29.0		
No. of teeth with AL ≥ 6 mm					
0	71	94.4	5.6	14.80	.001**
≥ 1	122	71.3	28.7		
No. of crowned teeth					
0	110	73.6	26.4	6.01	.01*
≥ 1	83	88.0	12.0		
No. of fixed partial dentures					
0	146	78.8	21.2	0.39	.53
≥ 1	47	83.0	17.0		
No. of endodontic fillings					
0	108	73.1	26.9	6.72	.01*
≥ 1	85	88.2	11.8		
Removable denture use					
Yes	20	60.0	40.0	5.42	.02*
No	173	82.1	17.9		
CHX mouthrinse use					
Yes	95	82.1	17.9	0.62	.43
No	98	77.6	22.4		
Tobacco use					
Nonsmoker	89	77.5	22.5	0.09	.76
Smoker	78	79.5	20.5		

†Canadian dollars.
AL = gingival attachment loss; CHX = chlorhexidine.

characteristics at baseline. All participants completed a demographic and health questionnaire and were examined clinically at baseline and every year during the trial. Professional interpreters were used for any participants who did not understand English to help interpret questions relating to linguocultural group, age, sex, tobacco use, and self-assessed risk of disease, and a self-determined score was obtained for the Geriatric Oral Health Assessment Index (GOHAI).[35] Changes in health status, health behaviors, and GOHAI scores were assessed at the intermediate and final interviews. Three calibrated dentists performed the clinical examinations, including assessments of probing depths, AL, numbers of teeth, teeth with caries, and filled surfaces.[31] Periodontal probing depths and AL were measured with a millimeter-graded University of North Carolina probe (UNC, Hu-Friedy), and caries lesions were diagnosed using well-established criteria described elsewhere.[31,36,37] Panoramic radiographs were obtained for each participant at baseline and after 5 years to provide information on endodontic fillings and periodontal bone levels.

Statistical Analyses

The SPSS program (version 15.0, IBM) was used to analyze the data with a threshold for significance at $P < .05$ for bivariate and multivariate analyses. Chi-square tests were used to identify associations between loss of ≥ 3 teeth during the 5 years and 13 demographic or clinical variables, whereas binary logistic multiple regression (BLMR) with the likelihood ratio was used to quantify the risk of losing teeth. The independent variables were introduced into each regression model and analyzed to compare the characteristics and measurements from participants who live in communities whose dominant language is English, Cantonese, or Punjabi, and to test the effects of socioeconomic status and cultural influences on tooth loss. The BLMRs were analyzed within all subjects and for the three dominant languages.

Results

Baseline Distributions

More than three-quarters (77%) of the 193 participants had ≥ 20 teeth at baseline, while more than half (55%) had at least one caries lesion and more than two teeth with AL ≥ 6 mm. Nearly half (40%) of participants had crowned teeth and teeth with endodontic treatment; 20 had one or more removable dentures (including 17 partial and 11 complete dentures), with

Table 4 Significant Predictors of Losing 3 or More Teeth Over 5 Years Based on Binary Logistic Multiple Regression Analysis with Forced Entry

Predictors	Beta	OR	*P*	95% CI
Use of removable denture	1.84	6.32	.022	1.30–30.7
Caries lesions	0.32	1.38	.003	1.12–1.71
AL	0.22	1.25	.000	1.11–1.42

AL = gingival attachment loss; OR = odds ratio; CI = confidence interval.

Table 5 Significant Predictors of Losing 3 or More Teeth Within Each Group Based on Binary Logistic Multiple Regression

Linguocultural group	Predictors	OR	*P*	95% CI
All languages	Caries lesions	1.26	.001	1.10–1.45
	Gingival attachment loss	1.25	.000	1.15–1.36
	Use of removable denture	4.89	.007	1.55–15.4
English	Caries lesions	1.21	.498	0.70–2.11
	Gingival attachment loss	1.24	1.027	1.03–1.52
	Use of removable denture	2.72	.313	0.39–19.0
Chinese	Caries lesions	1.32	.035	0.73–2.41
	Gingival attachment loss	2.58	.014	1.21–5.49
	Use of removable denture	8.88	.199	0.32–248.5
Punjabi	Caries lesions	1.23	.014	1.04–1.46
	Gingival attachment loss	1.17	.005	1.05–1.31
	Use of removable denture	6.40	.056	0.95–43.0

OR = odds ratio (result of likelihood-ratio test is probability = .08); CI = confidence interval.

18 maxillary dentures and 10 mandibular dentures (Table 2). About half (51%) of the participants lost one or more teeth and one-fifth lost three or more teeth during the 5 years for a total of 300 (6.8%) of the 4,438 teeth at baseline.

Bivariate and Multivariate Analyses

Multiple tooth loss over 5 years was significantly associated with the English and Punjabi groups and participants with low incomes, limited education, caries, attachment loss, crowned teeth, endodontic fillings, and removable dentures at baseline (Table 3). The BLMR with forced entry demonstrated significant associations between tooth loss and the use of a removable denture, caries, and AL (Table 4), but not with linguocultural background (likelihood-ratio test, $P = .08$) (Table 5). The "number of teeth at baseline" was excluded from the regression analysis to avoid multicollinearity because it was significantly associated with use of removable dentures.

Discussion

The present results are consistent with previous studies showing that between 7% and 16% of older people lose natural teeth over a 5-year period. Others also identified the number of caries lesions[1,4,9,25,29,38] and AL[1,3,9,25,28–30,39,40] as significant predictors of tooth loss; however, they also identified men,[1,2,41] tobacco users,[2,27,41,42] older age,[9,27,41,43] and limited education[27,39] as predictors. The present convenience sample of participants was intentionally selected from elderly populations with low incomes, minimal education, and a preference for non-English speakers to provide participants for the trial who might be at particular risk of tooth loss. These characteristics, particularly the preference for non-English speakers, distinguish the present participants from other population samples used to study tooth loss. Moreover, this was an efficacy trial. Consequently, the participants were monitored by telephone at least once each month during the 5 years to monitor compliance with

the protocol of the trial, and participants were examined clinically without charge every year. It is likely that this frequent contact helped motivate many of them to maintain their oral hygiene. Nonetheless, as others have shown among institutionalized elders,[44] low income and minimal formal education predisposes older people to tooth loss.

The authors initially struggled when designing this study to find a variable that might reflect the particular characteristics of the participants. Ethnicity came to mind, but it was recognized that this is a complicated concept and inappropriate for people who had emigrated from one society to another. Similarly, the authors considered the variable culture but recognized that it too is a vague phenomenon that crosses geographic boundaries and is unlikely to remain stable in an immigrant population. The concepts of acculturation and enculturation suggest that the original culture of an immigrant group can be maintained for several generations after migration.[45–47] The concept of language, on the other hand, appears to be more stable, at least among older people, and offers a strong focus of identity.[48] Consequently, language was selected as the variable to distinguish between the groups of participants. The authors believe it is important to explore the relevance of linguistic identity to tooth loss because there is evidence that oral health and related behaviors of some immigrant communities are less robust compared with the mainstream of society.[49] The results of the current study demonstrate that tooth loss was not influenced by the linguistic identity of the participants and support the view that tooth loss is indeed a complicated process that defies the usual stereotypes of race, ethnicity, and culture.

The present findings do not agree with the conclusions from two studies in the United States where investigators failed to find a significant association between tooth loss and use of dentures,[4,27] possibly because they assigned anyone who had lost one or more teeth to the tooth loss group, whereas the present participants were only assigned to this category if they had lost 3 or more teeth. The present designation was based on the view that the loss of one or two teeth in a lifetime might not be disturbing, whereas the loss of 3 or more is more likely to cause concern and motivate participants to seek dentures.

The absence of associations between tooth loss and cultural heritage disagrees with the findings of several studies of older people in the United States where African-Americans were more likely than Euro-Americans to lose teeth.[28,29] Many of the present participants were older immigrants to Canada or the United States from Punjab and Southern China with distinctly different cultural backgrounds than the African-Americans in the southeastern United States, where the previous studies on tooth loss were conducted. Immigrants from Punjab and China probably had relatively limited access to dental services in their youth,[49] in contrast to African-Americans who resided their entire lives in the United States.

It was no surprise that the use of removable dentures predicted further tooth loss, and again highlights the need for additional efforts to prevent the loss of remaining natural teeth.[50,51] Apparently, the CHX rinse did not influence the loss of teeth, contradicting what others have reported,[31,37] possibly because bacteria alone are not major contributors to tooth loss in a population of elderly people with teeth weakened structurally and periodontally by many interacting factors. Rinsing with CHX is primarily a preventive measure to reduce the risk of gingivitis and reduce Gram-positive bacteria associated with tooth decay. The rationale for tooth extraction in elderly people is often a teeth that are unhealthy or untreatable and conditions beyond repair. It is, therefore, logical that rinsing with CHX in the present study did not prevent or alter the risk for tooth loss. The clinical trial indicated in general that CHX did not inhibit the loss of teeth, so the search continues for more effective medications and protocols to help elderly patients retain their natural teeth. The present analysis of the factors contributing to tooth loss offers guidance as to where prevention planning should be focused.

Surprisingly, a number of participants who had several teeth with little periodontal support at baseline did not appear to deteriorate further over the 5 years, again, probably because of the close surveillance of the trial. For instance, one participant had 10 teeth and another had 4 teeth with ≥ 8 mm attachment loss at baseline, but neither lost teeth during the trial. Therefore, as Nyman and Ericsson[52] demonstrated, there appears to be hope for people who want to retain their natural teeth even in the presence of advanced periodontal bone loss.

Conclusion

The use of removable dentures was the dominant predictor of multiple tooth loss in the three communities, but that tooth loss was not significantly associated with the cultural heritage of the participants.

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Literature Abstract

Computer-aided measurement of mandibular cortical width on dental panoramic radiographs for identifying osteoporosis

Many investigators have used the mandibular inferior cortical width (MCW) below the mental foramen obtained from panoramic radiographs to identify postmenopausal women with low skeletal bone mineral density or those at risk of osteoporotic fractures. The aim of this study was to develop a computer-aided diagnostic system that could continuously measure the MCW on panoramic radiographs and to evaluate the system's efficacy in identifying postmenopausal women with low skeletal bone mineral density. Panoramic radiographs from 100 postmenopausal women were obtained; 50 were allocated to the development of the tool and 50 to its validation. The radiographs were digitized and the images were then digitally enhanced to provide better input to the automated image-processing. The distance between the upper and lower boundaries of the cortical bone was continuously measured in the area of interest. All 100 women also underwent bone mineral density scans and were classified as normal, osteopenic, or osteoporotic. The system's efficacy in identifying osteoporosis in the lumbar spine and femoral neck was evaluated. From the data gathered, the sensitivity and specificity of identifying patients with low bone mineral density was around 90% and 75% overall, respectively. However, there appeared to be large intersubject variations. Previously, the overlap of the hyoid bone could result in measurement errors; however, continuous measuring of the MCW, as was done in this study, appeared to reduce these errors. Continuous measuring of the MCW also appeared to improve the efficacy of the system compared to one point measurements. This new computer-aided diagnosis system may provide a useful means of identifying patients at risk for osteoporosis.

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