Tooth loss patterns in older adults with special needs: a Minnesota cohort

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This study was conducted to detail tooth loss patterns in older adults with special needs. A total of 491 elderly subjects with special needs were retrospectively selected and followed during 10/1999-12/2006. Medical, dental, cognitive, and functional assessments were abstracted from dental records and used to predict risk of tooth loss. Tooth loss events were recorded for subjects during follow-up. Chi-squared tests were used to study the association between tooth loss and the selected risk factors. Logistic, poisson, and negative binomial regressions were developed to study tooth loss patterns. Overall, 27% of the subjects lost at least one tooth during follow-up. Fourteen subjects had tooth loss events per 100 person-years. Tooth loss pattern did not differ significantly among different special-needs subgroups (i.e. community-dwelling vs. long-term care, physically disabled vs. functionally independent). Special-needs subjects with three or more active dental conditions at arrival had more than twice the risk of losing teeth than those without any existing conditions. After adjusting other factors, the number of carious teeth or retained roots at arrival was a significant predictor of tooth loss for older adults with special needs ($P=0.001$). These findings indicate that appropriately managing active caries and associated conditions is important to prevent tooth loss for older adults with special needs.

Keywords: tooth loss; elderly; special needs

Introduction

“Older adults with special needs” refer to medically compromised, physically disabled, or cognitively impaired elders, and those for whom oral health and oral health care are complicated by financial, and/or access factors. Due to loss of cognitive skills, physical disability, self-neglect, and lack of social support and resources for regular dental care, special-needs elders experience more oral disease and conditions compared to healthy, independent elders [1-3]. Compared to age- and gender-matched elders, demented patients may have poorer oral hygiene, and experience a high incidence of caries, periodontal disease, soft tissue pathology, and denture-related problems [1-8]. Research shows that oral health is poor in long-term care (LTC) residents. Coronal and root caries are highly prevalent in LTC residents, especially those with severe cognitive impairment [9]. An Australian study found that 72.1% of nursing home (NH) residents developed new coronal and/or root caries in a one-year follow-up period. The coronal and root caries increments among NH subjects were many times greater than that of community-dwelling older adults [10]. Dental plaque accumulation and prevalence of gingivitis are increased among institutionalized elderly [9, 11]. These findings indicate that older adults with special needs have an increased risk of dental caries and periodontal disease, the common cause of tooth loss.

Given the differences in oral disease patterns, general health, cognitive and physical function, and socioeconomics, the pattern of tooth loss in special-needs elders...
may differ from that in general elderly population. The
limited evidence also shows that demented elders tend
to have a slightly increased risk of tooth loss compared
to non-demented elders [3, 5]. Although the difference is
not statistically significant, demented patients lost on
average 1.2 teeth in 5 years, slightly more than 1.0 tooth
in non-demented elders [12]. Similar findings can also
be found in LTC residents. Tramini and colleagues found
that among 321 long-term care residents, more than 50%
had lost 21 or more teeth at the time of examination [13].
A recent study also found that among 260 NH residents,
the mean number of functioning teeth was only 10.6,
indicating remarkable oral function loss in these individ-
uals [11]. Another national survey also showed nearly
50% of nursing home residents had lost their natural
teeth completely, and more than 40% of the residents
reported difficulty biting or chewing [14], remarkably
higher than the national average edentulous rate in people
aged 65 and above [15]. These evidences suggest that
tooth loss is a serious issue in special-needs elders.
However, most of the evidence has been based on cross
sectional studies [11, 13-14, 16-17]. Therefore, the detailed
tooth loss pattern in older adults with special needs
remains unclear. Although multiple factors, such as old
age [13-14, 16, 18], sociodemographic characteristics
[18], poor oral health condition [13, 18], cognitive
impairment [17], physical disability [14, 18-19], systemic
health and so on [13, 17], are considered to be associated
with tooth loss in special-needs individuals, how these
risk factors interactively and synergistically affect tooth
loss in these individuals remains unknown. The lack of
understanding on these issues not only increases diffi-
culty for dental professionals in managing tooth loss and
associated oral dysfunction for older adults with special
needs, but also affects quality of care for these vul-
nerable individuals.

To address this issue, we conducted a longitudinal
study to detail the pattern of tooth loss in a Minnesota
elderly cohort with special-needs.

Materials and Methods

A detailed description regarding study subjects, sample
selection and data collection has been reported pre-
viously [18]. To facilitate discussion, the materials and
methods are briefly described below.

This study was a retrospective longitudinal study
approved by University of North Carolina Institutional
Review Boards (Study #: 10-0406), ranging from 10/
1999 to 12/2006. During the study period, 1626 older
adults, including both community-dwelling elderly (38%) and
LTC residents (62%), presented as new patients at
the study site, a community-based geriatric dental clinic
in Minnesota, USA. Among of them, 491 met the selec-
tion criteria, 1) presented as a new patient during the
observation period and 2) remained dentate after fini-
shing their initial treatment plans and returned for care at
least once thereafter, and were retrospectively selected
as study subjects. Subjects were treated and brought to a
state of oral health before enrollment. The follow-up
started when the first treatment plan was completed.
Comprehensive dental care was continually provided to
the subjects during follow-up.

The study data was abstracted from two sources:
dental records and the dental office management system
used in the study clinic, and classified into four cate-
gories: 1) demographic and socioeconomic factors; 2) oral
assessment at arrival; 3) medical assessment at
arrival; 4) and functional and cognitive assessment at
arrival. Given that there were multiple dental providers
involved in caring for the subjects during the study
period and calibration between examiners was impossi-
bile to be implemented, potential variations might be
present in recording the existing conditions (i.e. exten-
sive caries vs. retained root). To overcome this limitation,
the existing conditions on dental hard tissue were verified
by the radiographs of the subjects and grouped together
using one variable, number of teeth being carious or
retained roots. Similarly, number of teeth with restorations
was used to record all the teeth with any type of
restorations, including amalgam restoration, composite
restoration, gold inlay/onlay, metal or porcelain-fused-
to-metal crown, and so on.

The study sample was a dynamic population and the
subjects entered the study and dropped out at different
points of time during the study period. Therefore, person-
year was used as an offset to standardize the data for
calculating frequency and rate of tooth loss.

Student’s t-test, Chi-squared test and Analysis of
Variance (ANOVA) were used to study the association
between tooth loss and the selected risk factors. An
unadjusted relative risk along with a corresponding 95%
confidence interval was calculated for the categories
within each risk factor. A poisson regression and a
negative-binomial regression were adapted to estimate
the incident rate of tooth loss and number of teeth lost
per person-year in this special-needs population. A
logistic regression was developed to study probability of
tooth loss. A candidate multivariate regression was first
developed using all the selected variables. Variables with
high P-values (P>0.05) were then removed using a
backward stepwise technique, with each variable’s P-value
reassessed at each step. The final reduced model included
only variables that were significant at the 0.05 level.
SAS 9.2 was used for the data analysis.

**Results**

**Pattern of tooth loss**

Overall, 134 (27%) subjects lost 328 teeth during the follow-up, which accounted for 3.7% of the total teeth presented at the beginning of follow-up. The proportion of subjects losing one or more teeth was slightly higher in LTC residents, but the difference was non-significant ($P=0.86$, Table 1). The overall incident rate of tooth loss in this special-needs population was 14 cases per 100 person years with no difference among different special-needs subgroups (i.e. community-dwelling vs. long-term care, physically disabled vs. functionally independent, data not shown). On average, a special-needs subject lost about one tooth per five person years, with disabled subjects losing slightly more teeth than functionally independent subjects (1.3 vs. 0.8, Rate ratio=1.7, 95% CI=1.1, 2.5).

More than seventy percent of the subjects with tooth loss events during the follow-up lost one or two teeth (Table 2). About twelve percent of the subjects lost 3 or 4 teeth and more than 14% lost 5-9 teeth. The incidence of edentulism was low. Overall, only 0.6% of subjects (2.2% among those with tooth loss) became edentulous during the follow-up. The subjects with physical limitations tended to lose more teeth than those functionally independent subjects, but the difference was non-significant ($P=0.70$, Table 2). Similarly, there was no difference in number of teeth lost between community-dwelling and LTC subjects (data not shown).

| Table 1 Percent of subjects losing one or more teeth by residency |
|---------------------------------------------------------------|
| Residency | Percent of subjects losing one or more teeth | Relative risk & 95% CI | $P$-value** |
| Community subjects ($n=256$) | 27.0 | Ref* | 0.86 |
| LTC subjects* ($n=235$) | 27.7 | 1.03 (0.77, 1.37) | |

*LTC: Long-term care, including nursing homes and assisted programs. **: Chi-square test.

| Table 2 Number of teeth lost by physical limitation |
|---------------------------------------------------|
| Number of teeth lost | All subjects (%) ($n=487$) | Subjects losing one or more teeth (%) ($n=134$) | Physical limitation* | $P$-value** (Yes vs. No) |
|----------------------|--------------------------|---------------------------|-----------------|---------------------|
| 0                    | 72.9                     | --                        | 74.8            | 70.0                | 0.70 |
| 1                    | 15.1                     | 55.2                      | 14.3            | 16.4                | |
| 2                    | 4.7                      | 17.2                      | 4.5             | 5.0                 | |
| 3–4                  | 3.3                      | 11.9                      | 3.0             | 3.6                 | |
| 5–9                  | 3.9                      | 14.2                      | 3.0             | 5.0                 | |
| 10+                  | 0.1                      | 1.5                       | 0.4             | 0.0                 | |

*: measured by transferability, an important component of activities of daily living (ADL). Subjects walk and transfer themselves into dental chair independently was considered having no physical limitation. **: Chi-square test. Due to missing data, some subjects were excluded from data analysis. Therefore, $n$ may vary from the total number of subjects in difference analysis.

**Type of teeth lost**

Overall, maxillary molars had the greatest risk of being lost during the follow-up, followed by mandibular incisors. Compared to other tooth types, canines, especially mandibular canines, were less likely to be lost. Types of teeth lost differed between demented and non-demented subjects. While there was no difference in the lost mandibular teeth between two groups, demented subjects were more likely to lose maxillary posterior teeth ($P=0.04$). More specifically, maxillary incisors were least likely to be lost in demented subjects, and mandibular incisors were lost most frequently among these subjects. Among non-demented subjects, maxillary incisors were lost most frequently and mandibular canines were least likely to be lost (data not shown).

**Factors associated with tooth loss**

A bivariate analysis shows that tooth loss was asso-
associated with two dental factors, number of teeth at arrival and number of teeth being carious or retained root at arrival. Elderly subjects with moderate to severe cognitive impairment, with physical limitation, or required supervision/help to perform oral hygiene care tended to have increased risk of tooth loss, but the associations were non-significant (data not shown).

Further analysis indicated that dental characteristics at arrival differed in subjects with and without tooth loss during the follow-up (Table 3). On average, subjects losing at least one tooth presented with fewer teeth and more caries/retained roots than those without tooth loss, and a higher proportion of these remaining teeth were either carious or retained roots ($P=0.002$).

### Table 3 Selected dental characteristics at arrival between groups with and without tooth loss ($n=491$)

| Characteristics at arrival       | Persons losing no teeth | Person losing one or more teeth | $P$-value* |
|----------------------------------|-------------------------|---------------------------------|------------|
|                                  | Mean (SD)               | Mean (SD)                       |            |
| Number of remaining teeth at arrival | 18.31 (8.41)           | 14.47 (7.57)                    | $<0.001$   |
| Number of teeth being carious or retained roots at arrival | 2.99 (4.00)           | 4.26 (3.88)                     | 0.002      |
| Number of teeth with restorations at arrival | 11.34 (6.26)           | 10.65 (5.73)                    | 0.27       |
| Percent of teeth being carious or retained roots at arrival / % | 18.48 (24.57)         | 26.37 (24.56)                   | 0.002      |
| Percent of teeth with restorations at arrival / % | 57.13 (23.57)         | 57.40 (23.33)                   | 0.91       |

*: Student’s $t$-test.

### Table 4 Factors associated with tooth loss in older adults with special needs

| Number of teeth | % Losing one or more teeth | Relative risk & 95% CI | $P$-value* | Mean number of teeth lost | $P$-value** |
|-----------------|----------------------------|-------------------------|------------|---------------------------|-------------|
| at arrival      |                           |                         |            |                           |             |
| 1–6 ($n=39$)    | 18.0                      | 1.00                    | 0.01       | 0.33 (0.93)               | 0.04        |
| 7–12 ($n=71$)   | 31.0                      | 1.73 (0.81, 3.67)       | 0.01       | 1.00 (2.19)               |             |
| 13–18 ($n=87$)  | 39.1                      | 2.18 (1.06, 4.48)       | 0.01       | 0.98 (1.84)               |             |
| 19–24 ($n=144$) | 29.2                      | 1.63 (0.79, 3.33)       | 0.01       | 0.63 (1.68)               |             |
| 25–32 ($n=150$) | 19.3                      | 1.08 (0.51, 2.27)       | 0.01       | 0.46 (1.35)               |             |
| 0 ($n=146$)     | 18.7                      | 1.00                    | 0.01       | 0.36 (1.08)               | 0.005       |
| being carious or retaining roots at | 21.6                      | 1.30 (0.81, 2.11)       | 0.002      | 0.54 (1.45)               |             |
| arrival 3–4 ($n=76$) | 20.2                      | 2.08 (1.30, 3.31)       | 0.002      | 0.84 (1.71)               |             |
| ≥5 ($n=139$)    | 39.6                      | 2.23 (1.47, 3.37)       | 0.002      | 1.02 (2.20)               |             |

*: Chi-square test. **: ANOVA.

Compared to those with only a few teeth remaining at arrival, subjects presenting with more teeth tended to have an increased risk to losing teeth during the follow-up, especially those with 13–18 teeth at arrival (RR=2.2, 95% CI 1.06–4.48). The number of teeth lost also followed a similar pattern. The mean number of teeth lost in subjects with 1–6 teeth at arrival was 0.33, significantly lower than 1.0 and 0.98 in those with 7–12 and 13–18 teeth at arrival, respectively (Table 4). The number of teeth being carious or retained root at arrival also played an important role in the risk of tooth loss in this population. Subjects presenting with three or more existing dental conditions had more than twice the risk of losing at least one tooth compared to those without any existing condition on dental hard tissue. The mean number of teeth lost in subjects with five or more teeth being carious or retaining roots at arrival was about three times that in those without any caries or related dental conditions ($P=0.005$, Table 4).

### Multivariate analysis

A multivariate logistic regression was developed to identify predictors of tooth loss. After adjusting other factors, number of teeth being carious or retained root at arrival was the only risk factor significantly associated with tooth loss ($P=0.001$, Table 5). Holding all other
oral diseases and lack of access to regular dental care for unrestorable teeth are the cumulative results of different etiologies. In our opinion, these infected or unrestorable teeth frequently, these individuals usually presented to the study their healthy, independent counterparts [20-24]. Consequently, these infected or unrestorable teeth at arrival means the likelihood of tooth loss will increase by 1.1 times. These results provide useful information for dental professionals to appropriately prevent and manage tooth loss for special-needs elders.

The subjects were treated and brought to a state of oral health before enrollment. The follow-up started when the first treatment plan was completed. At this point, subjects were considered disease-free and their oral function was deemed relatively stable. The selection of the study’s time origin was appropriate given the oral function was deemed relatively stable. The selection of the study’s time origin was appropriate given the purpose of the study was to detail patterns of tooth loss for older adults with special needs. Among 491 subjects, 27% of the subjects lost at least one tooth during the follow-up (mean=39). The incident rate of tooth loss was 14 cases per 100 person-years. On average, special-needs subjects lost about one tooth every five person-years, with disabled subjects losing slightly more teeth per person-year than non-disabled subjects. Tooth loss pattern did not differ significantly among different special-needs subgroups (i.e. community-dwelling vs. LTC, physically disabled vs. functionally independent). Tooth loss was significantly associated with dental caries and related conditions. A one unit increase in number of teeth being carious or retaining roots at arrival means the likelihood of tooth loss will increase by 1.1 times. These results provide useful information for dental professionals to appropriately prevent and manage tooth loss for special-needs elders.

Table 5: The logistic regression model to predict risk of tooth loss

| Covariate                              | Parameter estimate | Standard error | P-value | Odds ratio and 95% CI |
|----------------------------------------|--------------------|----------------|---------|-----------------------|
| Intercept                              | -1.28              | 0.15           | <0.000 1| –                     |
| Number of teeth being carious or retaining roots at arrival | 0.08               | 0.03           | 0.001   | 1.09 (1.03, 1.14)     |

predictors constant, a one unit increase in the number of teeth being carious or retained roots at arrival corresponds to an increased likelihood of 1.1 (95% CI=1.03, 1.14) for tooth loss.

Discussion

This study detailed patterns of tooth loss for older adults with special needs. Among 491 subjects, 27% of the subjects lost at least one tooth during the follow-up (mean=39). The incident rate of tooth loss was 14 cases per 100 person-years. On average, special-needs subjects lost about one tooth every five person-years, with disabled subjects losing slightly more teeth per person-year than non-disabled subjects. Tooth loss pattern did not differ significantly among different special-needs subgroups (i.e. community-dwelling vs. LTC, physically disabled vs. functionally independent). Tooth loss was significantly associated with dental caries and related conditions. A one unit increase in number of teeth being carious or retaining roots at arrival means the likelihood of tooth loss will increase by 1.1 times. These results provide useful information for dental professionals to appropriately prevent and manage tooth loss for special-needs elders.

The subjects were treated and brought to a state of oral health before enrollment. The follow-up started when the first treatment plan was completed. At this point, subjects were considered disease-free and their oral function was deemed relatively stable. The selection of the study’s time origin was appropriate given the unique characteristics of the study population. The study clinic was a not-for-profit geriatric dental clinic. A great majority of the patients who received care in this clinic were low-income elderly and those with special-needs. Due to lack of resources for dental care, physical/mental disability, lack of social support and transportation, neglect and other reasons, special-needs elders experience more difficulties in accessing necessary dental care than their healthy, independent counterparts [20-24]. Consequently, these individuals usually presented to the study clinic with poor oral health, including multiple infected or unrestorable teeth. In our opinion, these infected or unrestorable teeth are the cumulative results of different oral diseases and lack of access to regular dental care for long periods of time. Therefore, including the teeth that were extracted during the initial treatment into the analysis would inflate the tooth loss rate and might not truly reflect the risk of tooth loss in this population, especially for those who had not had dental care for a long-period time (i.e. those who intentionally held off dental care until being eligible for Minnesota Medicaid program).

Out of 487 subjects, 15.1% of the subjects lost one tooth during the follow-up; 4.7% lost two teeth, 3.3% lost three to four teeth and 3.9% lost five or more teeth. This pattern is similar with that in the Florida Dental Care Study [25]. However, given the fact that all subjects were disease-free at enrollment and routine dental care was continually provided to subjects during follow-up, the severity of tooth loss in this special-needs cohort may be more considerable than those reported in the previous studies [25-26] in which many study subjects might enroll with active dental diseases and conditions. Also, although more than one-fourth of the subjects had tooth loss events during the follow-up, only 3.7% of the teeth presented at the beginning of the follow-up were lost. Among them, maxillary molars were most likely to be lost, followed by mandibular incisors. Compared with other types of teeth, mandibular canines were least likely to be lost. A similar pattern has been reported in the studies in Iowa [27] and China [28].

A bivariate analysis found that, except for those with only 1–6 teeth remaining, subjects presenting with fewer teeth at arrival had a higher risk of losing teeth during the follow-up, especially those with 13–18 teeth at arrival. These findings, together with the results of previous studies [26-27], indicate that past history of tooth loss is an important predictor for future tooth loss in this special-needs cohort. Compared with other groups, subjects with 1–6 remaining teeth had a lower risk to lose teeth. This may be associated with the current model of dental care in which tooth loss not only results from clinical pathology, but is also associated with the treatment planning judgments of the dental professionals involved in care [29], and the preferences, values and available resources for dental care of patients or their responsible parties [27, 29]. Loss of one tooth could potentially have a significant impact on the oral function of those with only 1–6 teeth remaining at enrollment, depending on
the location of the tooth in the dentition and if this tooth is supporting a dental prosthesis. Under this circumstance, patients and/or their responsible parties might be hesitant to have any teeth extracted. The dentists involved in care might also be more conservative during treatment planning and be reluctant to extract the remaining teeth. As a result, risk of tooth loss was lowered in these patients.

Number of teeth being carious or retained roots at arrival, an indicator of existing dental conditions, is an important risk factor associated with tooth loss in special-needs elders. Subjects who lost at least one tooth not only presented with more caries or retained roots, but the proportion of the remaining teeth being carious or retained roots was also higher. Compared to those without active dental conditions at arrival, subjects who presented with three or more teeth being carious or retained roots had more than twice the risk to lose teeth during follow-up. Multivariate logistic analysis also revealed that number of teeth being carious or retained roots was the only risk factor associated with subsequent tooth loss in this cohort. This result corroborates the findings of the previous studies [25-26, 28, 30] and indicates that dental caries and/or its associated conditions is an important predictor for tooth loss, not only in general elderly population but also in older adults with special needs. Although a one unit increase in number of teeth being carious or retained roots at arrival only results in a 1.1 times increase in risk of subsequent tooth loss, which seems clinically insignificant, given that nearly 30% of the subjects presented with 5 or more decayed/broken teeth, risk for subsequent tooth loss will increase at least 1.6 times in these individuals. Therefore, for elderly patients presenting with multiple existing dental caries, thorough risk assessment and adequate preventive care plans need to be established to prevent tooth loss. This is particularly important for those with cognitive and/or functional impairment.

Previous studies found that physical disability is associated with tooth loss in special-needs individuals [14, 19, 31]. However, functional assessment based on standard instruments, such as activity of daily living (ADL), were not available in the dental records. We were therefore unable to assess the impact of physical function impairment on tooth survival in the elderly subjects using the standard functional assessment instruments. Given that more than 40% of the subjects presented with some sort of physical limitation, we used transferability, an important component of ADL, together with capacity to perform oral hygiene care to assess the impact of functional impairment on tooth loss. We found no significant association between tooth loss and these two variables. However, given these variables cannot fully represent physical functional status of study subjects, further efforts are necessary to better understand the association between physical function impairment and tooth loss. Cognitive impairment is also associated with increased tooth loss in dementia patients [9, 31-32]. However, since cognitive assessment based on standard instruments (e.g. Mini Mental Status Examination) is not widely available in clinical dental settings, including in the study clinic, we were unable to precisely measure the association between cognitive impairment and tooth loss in this study. Moreover, potentially important risk factors, including periodontal health, salivary flow, use of preventive care, and baseline oral hygiene status, were either not available or not available electronically and were not included in the analysis. Finally, this study was conducted based on a community-based geriatric dental clinic in which a large proportion of the subjects had special-needs and dental coverage through the Medicaid program. This study sample could have different characteristics and disease patterns when compared to the general elderly population [33]. Additionally, the specific practice pattern and treatment philosophy employed in this clinical setting might also differ from other general dental practices, which therefore affects tooth survival in the study population. While the findings of this study may be applicable to the elderly patients who are older, medically compromised or with special-needs, further work is needed to generalize the results of this study to the general elderly population.

Conclusion

Tooth loss did not differ significantly among different special-needs subgroups (i.e. community-dwelling vs. LTC, physical disable vs. functionally independent). The incident rate of tooth loss in older adults with special needs was fourteen cases per 100 person-years. The elderly subject lost one tooth per 5 person years. The special-needs subjects with three or more active dental conditions had more than twice the risk to lose teeth compared to those without any existing condition at arrival. After adjusting other factors, the number of active dental caries and associated conditions is an important risk factor to predict tooth loss. These findings indicate that appropriate management of dental caries is important to prevent tooth and oral function loss in older adults with special needs.

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