Relationship between Oral Condition and Bone Density Assessed from Results of Public Health Screening Examinations

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ABSTRACT

Recently, relationships between diseases encountered in the fields of medicine and those in dentistry have been reported in the context of periodontal medicine. In the present study, we examined the relationship between the results on bone density of the calcaneus measured by ultrasonography (echography) and the number of remaining teeth, which studies were performed by local governmental authorities. The subjects were 235 women between 30-70 years of age whose bone density of the calcaneus was examined by echography. Our analysis indicated that subjects with 19 or fewer remaining teeth had an 11-fold greater risk of reduced bone density of the calcaneus, as compared with subjects with 20 or more remaining teeth. (Odds ratio: 10.9, 95% confidence interval: 3.18 for the lower limit, 37.37 for the upper limit). The bone density of the calcaneus in these former subjects was 79% or below the mean value for young adults. These results suggest a direct relationship between tooth loss and osteoporosis, and indicate that for a diagnosis of osteoporosis, an echographic examination would be more pertinent or needful for those women having 20 or more teeth remaining.

Introduction

National Health Promotion in the 21st Century (Healthy Japan 21) was put into action in the year 2000 in Japan, with emphasis on primary, secondary, and tertiary prevention of various diseases. As a result, for early detection and early treatment as secondary prevention when a disorder was detected, as well as for primary prevention, a variety of periodic medical examinations were improved for use by various local authorities.

In addition, using the Healthy Japan 21 campaign, extension of the healthy period when people can live without dementia or being in a bedridden state has been pursued. Recently, it was reported that fractures due to osteoporosis are on the increase in Japan; and osteoporotic fractures ranked second following cerebrovascular disease as the cause for being bedridden. As a result, osteoporosis has attracted much attention;
and many insightful reports on the subject have been published [1,2].

Recently, relationships between medical disease and dental disease (especially periodontal diseases) have been reported in the context of periodontal medicine [3~6]. Furthermore, the relationship between osteoporosis and dental diseases has been investigated [7~12]; however, we know of no study that analyzed the correlation between findings of medical examinations and those of dental examinations performed during widespread public health examinations for various diseases.

Thus, explanations, lifestyle guidance and treatment advice for various diseases are given based on the results of public health screening examinations according to individual criteria for each result. However, correlations among the results obtained in health screening examinations have not been examined.

In the present study, we examined correlations between the results of osteoporosis screening and dental health examinations.

**Subjects and Methods**

In Mitsu-cho, Ibo-gun (now known as Mitsu-cho, Tatsuno-shi, as of October 1, 2005), which is located in the southwest part of Hyogo Prefecture in Japan, various yearly health screening examinations have been conducted in early May as 'whole town checkups' for inhabitants 20 years of age or over. On this occasion, a dental health examination is carried out, along with basic screening for various diseases and cancers. Later, at the end of May, osteoporosis screening examinations intended for the above-mentioned local inhabitants, which screening began in 1997, are performed separately. The subjects of the present study were chosen from those who had undergone the dental health examination at least once during the 5-year period from 1997 to 2001 and at the same time had also been examined in the corresponding osteoporosis screening program. Since osteoporosis is a disease found frequently among women, the examinees for the osteoporosis screening were primarily women. As a result, 235 women served as subjects in the present study. The age distribution of the subjects was as follows: 30-39 years old, 17 subjects (7.2%); 40-49 years old, 37 subjects (15.7%); 50-59 years old, 90 subjects (38.3%); 60-69 years old, 70 subjects (29.8%); 70 years old and older, 21 subjects (8.9%).

Women between 50 and 69 years old thus comprised approximately 70% of all subjects.

For analysis of the dental health examination findings, a data sheet was used; and the number of remaining teeth was utilized as the parameter of the oral condition. As for the results of the osteoporosis screening examination, bone density was determined by using echographic findings on the calcaneus and expressed as the percent of the mean value for young adults (%YAM). The relationship between age and number of remaining teeth and that between age and bone density (%YAM) were analyzed. We also analyzed the relationship between the number of remaining teeth and bone density of the calcaneus (%YAM).

**Statistical Analysis**

Statistical analyses were performed using SPSS for Windows v. 11.0 (SPSS Inc. Chicago, IL). A result was considered statistically significant when \( p < 0.05 \).

**Results**

**Relationship between age and number of remaining teeth (Figs. 1-1, 1-2)**

Figure 1-1 shows a scatter diagram for the relationship between age and number of remaining teeth; and Figure 1-2, the number of remaining teeth in each 5-year age group. For comparison, the results of a survey of the actual condition of dental disease, carried out in 1999 by the Ministry of Health and Welfare, were used; and the comparison revealed that the curves demonstrated similar tendencies.

**Age and bone density (%YAM) (Figs. 2-1, 2-2, 2-3, and Table 1)**

Figures 2-1, -2, and -3, and Table 1 show the relationship between age and bone density of the calcaneus (%YAM). The results in Fig. 2-1 are depicted as a scatter diagram for age and bone density of the calcaneus (%YAM), drawn as a curve (quadratic function) and a line (direct function). In Table 1, the distribution of bone density of the calcaneus (%YAM) by 10-year age group is shown; and Figs. 2-2 and -3 are graphs of the distribution of bone density by age group.
Oral condition and bone density

Fig.1-1 Number of remaining teeth is reduced with aging.

Fig.1-2 Two curves showing decrease in the number of remaining teeth with aging.

Fig.2-1 Upper and lower lines showing reduction in bone density with aging.

Bone density suddenly decreased between 40-60 years old and was relatively stable afterwards.

A negative correlation of $r=-0.486$ was found between bone density and age.
Fig. 2-2 Approximately 50% of the subjects in their 50s show a bone density (%YAM) of 79% or below, which is comparable to that of patients with osteopenia.

Fig. 2-3 Subjects 60 years of age or older comprise 80% of those who could be categorized as having osteoporosis, i.e. as indicated by a bone density (%YAM) of 69% or below.

<table>
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<tr>
<th>Age range (years old)</th>
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<td>21</td>
<td>6</td>
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<tr>
<td></td>
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<td>235</td>
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Table 1. Distribution of bone density according to age group.
Number of remaining teeth and bone density of the calcaneus (%YAM) (Groups 1-4) (Figs. 3-1, 3-2)

Group 1 consisted of subjects with 20 or more remaining teeth and a bone density of the calcaneus (%YAM) of 80% or over; group 2 of those with 20 or more remaining teeth and a bone density of 79% or lower; group 3 of those with 19 or fewer remaining teeth and bone density of 80% or over; and group 4 of those with 19 or fewer remaining teeth and a bone density of 79% or lower. According to this classification, the number of subjects, mean number of remaining teeth, and mean bone density of the calcaneus (%YAM) were 120 subjects, 25.9 teeth, and 94.4%YAM in group 1; 88 subjects, 25.8 teeth, and 70.3%YAM in group 2; 3 subjects, 15.3 teeth, and 96.7%YAM in group 3; and 24 subjects, 11.6 teeth, and 68.9%YAM in group 4.

Odds ratio (Table 2)

The odds ratio between the number of remaining teeth and bone density of the calcaneus (%YAM) was 10.9, with a 95% confidence interval

Fig.3-1 Scatter diagram showing the relationship between number of remaining teeth and bone density of the calcaneus (%YAM). A positive correlation is indicated between bone density and number of remaining teeth.

Fig.3-2 Subjects categorized into 4 groups based on the number of remaining teeth and bone density.
of 3.18 for the lower limit and 37.37 for the upper limit. Furthermore, the result of the chi-square test was 18.96. These results indicate a significant difference between the number of remaining teeth and bone density of the calcaneus (%YAM), with the percentage of risk being 0.1% (p<0.001).

Accordingly, we concluded that subjects with 19 or fewer remaining teeth had an 11-fold greater risk of reduced bone density of the calcaneus, as compared with those with 20 or more remaining teeth. The bone density of the calcaneus in these former subjects was 79% or below the mean value for young adults.

**Bone density (%YAM) in the calcaneus compared with the number of remaining teeth (Fig. 4)**

In the group with 19 or fewer remaining teeth, the mean bone density (%YAM) was 72%, whereas the other 3 groups of subjects with 20 or more remaining teeth showed nearly the same bone density (approximately 84%) and no significant differences.

**Age and bone density of the calcaneus (%YAM) in subjects with 20 or more remaining teeth (Fig. 5)**

As seen in Fig. 5, the straight line of Y=-0.7733X+126.5, where age is expressed as X and bone density (%YAM) as Y, shows a significant negative correlation, with a risk rate of p<0.01 and a correlation coefficient of r=-0.4576(n=208). Furthermore, using this formula, we found 60.1 years to be the age at which the bone density would be 80%YAM or lower.
Oral condition and bone density

**Bone density (%YAM) and number of remaining teeth by age (Figs. 6-1, 6-2)**

The mean bone density of the calcaneus (%YAM) was 79%YAM or lower in subjects 60-69 years of age, and the mean number of remaining teeth dropped to 19 or fewer in those 70 years old and older.

The numerical decrease in the total number of remaining teeth in subjects 70 years old and older particularly depended on the decrease in the number of remaining molar teeth.

**Discussion**

**Age distribution of the subjects**

The subjects from 50 to 70 years of age constituted approximately 70% of the total; and those from 40 to 70, 83.8%. These ratios are similar to the 79.5% reported in a similar survey carried out in 16 cities of Saitama Prefecture, Japan. This tendency shows that women in their 50s and 60s are susceptible to osteoporosis [2].
Relationship between age and number of remaining teeth

As shown in Fig. 1-1 and 1-2, our results showed a tendency similar to that revealed in the Actual Condition Survey on Dental Diseases in 1999, which was part of a survey carried out once every 6 years by the Health Policy Bureau of the Health, Labor, and Welfare Ministry of Japan [10]. The subjects in the present study tended to have a slightly greater number of remaining teeth [13, 14]. We suspect that people with few or no teeth might not be willing to attend a public dental health examination screening. Similar results were found in a study of periodontal diseases and bone density in postmenopausal women [11].

Age and bone density (%YAM) of the calcaneus

The left chart in Fig. 2-1 shows a scatter diagram with a quadratic curve derived from the data. Bone density (%YAM) was markedly reduced in subjects 40 to 60 of age and then became relatively stabilized in older individuals. These findings are similar to the tendency for an age-related decrease in bone density shown in previous reports [1, 2]. Further, the right chart in Fig. 2-1 shows a scatter diagram in which the data were approximated by using a straight line, which resulted in $r=-0.486$. This finding is comparable to that reported by osteoporosis foundation et al. [15, 16], which showed a negative correlation of $r=-0.44$ between stiffness level and age. We further analyzed the relationship between changes in age and bone density (%YAM), and also referred to the results of osteoporosis screening examinations carried out by Tomomitsu [17], which used an A-1000 (Lunar CO.) to measure the stiffness level in the calcaneus, as well as of the subjects in the present study. Our results agreed well with those reported by Tomomitsu. In addition, Table 2 and Fig. 2-2 show bone density (%YAM) by age. Approximately 50% of women between the ages of 50 to 60 years are thought to be affected by osteopenia, and our findings suggested the same tendency. Subjects with a bone density (%YAM) of 69% or lower, which is equivalent to the levels found in osteoporosis, constituted 16.6% of those aged 50 to 59, 44.5% of those aged 60 to 69, and 35.6% of those 70 years old or older. These results coincide well with the incidence of osteoporosis.

Cut-off levels have not been set by the governmental agency in charge of the screening examinations. However, based on the findings shown in Figs. 2-1 and 2-2, appropriate cut-off levels for bone density of the calcaneus (%YAM) should be set. Judging from the relationship between age and number of remaining teeth and that between age and bone density, we consider that the 235 subjects in the present study were a reasonable representation of all the examinees who attended the mass screening examinations, without specific bias.

Number of remaining teeth and bone density of the calcaneus (%YAM)

Results regarding the number of remaining teeth and bone density of the calcaneus (%YAM) were shown in Figs. 3-1 and 3-2. The Japan Dental Association has endorsed the so-called "8020" campaign, which promotes the goal of 20 or more teeth left in the oral cavity by 80 years of age, as nearly all types of food can be consumed with at least 20 teeth. Furthermore, according to the diagnostic criteria for primary osteoporosis set by the Japanese Society for Bone and Mineral Research, bone density lower than 80% of the mean for young adults is diagnosed as osteopenia, which can lead to osteoporosis. At present, no clear-cut cut-off levels have been established for bone density (%YAM) determined by echography, though studies continue to obtain standard values and examine their usefulness.

In the present study, we set the cut-off line for remaining teeth between 19 and 20, and that for bone density (%YAM) between 79% and 80%, for the purpose of dividing the subjects into 4 groups. As shown in Table 2, the results were examined by determining the odds ratio, which is useful for obtaining the magnitude of the influence of a factor on disease development. Furthermore, the odds ratio is an index of the probability that a certain risk factor will cause susceptibility to a disease as compared to the susceptibility of subjects without the risk factor. It can also be used to determine how many times greater the risk is for those with the factor, when those without the risk factor are rated as 1. Our odds ratio findings suggest that 19 or fewer remaining teeth might be a factor for osteopenia or osteoporosis, but not the cause. As a result, we recommend that cut-off levels for the number of teeth be re-examined in a future study.

The subjects were divided into 4 groups on the basis of the number of remaining teeth and mean
bone density (%YAM), as was shown in Fig. 4. In the groups with 20 or more remaining teeth, bone density was approximately 84%YAM, and was not significantly different between the groups. Fig. 5 indicated that the bone density was reduced to 80%YAM or lower at around 60 years of age, which suggests the usefulness and necessity for osteoporosis screening examinations for women above the age of 55 years.

**Bone density of the calcaneus (%YAM) and number of remaining teeth by age**

Fig. 6-1 showed the relationship between the mean bone density (%YAM) and mean number of remaining teeth in each age group. The mean bone density dropped to below 79%YAM, which is comparable to the level in osteopenia [12], and the mean number of remaining teeth was lower than 19, in women 70 years of age or older. As the decrease in bone density appeared to start prior to that in tooth number, it is possible that the former contributed to the latter.

Furthermore, in the field of dentistry, osteoporosis in the jaw has drawn attention and study [18~21]. It has been suggested that a reduction in tooth number and occlusion are participating factors in osteoporosis in the jaw [12, 18, 19].

We consider that the result shown in Fig.6-2, namely, that the reduction in the number of remaining molar teeth particularly occurred in subjects 70 years old and older, supports this notion.

**Acknowledgments**

A summary of this study was given at the 14th Scientific Meeting of the Japanese Society of Gerodontology held in Nagoya, Japan, June 2003.

**References**

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Received April 17, 2006
Accepted August 8, 2006