Pilot Study of Osteoporosis Screening Using Functional Tooth Evaluation Score Obtained from Oral Cavity Examination

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ABSTRACT

Objectives: To examine the potential of osteoporosis screening using functional tooth evaluation score (FTES).

Methods: In the first study, we examined the relationship between mandibular cortical width (MCW) on panoramic dental radiogram images and FTES in 129 adult female subjects. In the second study, the significance of FTES was determined in 11 subjects with a diagnosis of osteoporosis and 9 subjects without osteoporosis. (Twenty subjects were diagnosed by DXA on Radius 1/3 BMD in orthopedics.)

Results: A statistically significant positive correlation was observed between FTES and MCW. Screening was performed using cutoff levels calculated on the basis of the following relational expression: \( y = -0.307x + 81.78 \), set between age (x) and FTES (y). FTES was shown to be significantly related to osteoporosis.

Conclusions: On the basis of the likelihood ratio obtained, FTES is suggested to be useful for osteoporosis screening.

INTRODUCTION

The relationship between medical and dental diseases has been studied, and referred to as periodontal medicine [1]. It is speculated that oral condition might be a factor that affects the development of medical diseases. We previously studied the relationship between dental checkup and osteoporosis checkup findings obtained in public health mass-screening examination, and found that the number of present teeth...
and functional tooth evaluation score (FTES) [2] had significant correlations with bone density of the calcaneus [3,4]. Moreover, we noted that FTES and bone density values showed similar decreases with age. We also reported that patients with a lower FTES value than their age were diagnosed as osteoporosis following referral to an orthopedic clinic [5]. In addition, Taguchi et al. reported on osteoporosis screening with the use of panoramic dental radiography [6].

Osteoporosis is many disorders to a female predominantly. In the first study, we studied the relationship between FTES and mandibular cortical width (MCW) on panoramic radiograms of females. In the second study, we also discuss the potential of FTES for use in osteoporosis screening for females.

SUBJECTS and METHODS

Subjects
The subjects in the first study were 129 adult females (age: 20~81 years old, 49.2±16.7 years old) who underwent panoramic dental radiography examinations at Yamamoto Dental Clinic (Mitsu-cho, Tatsuno City, Japan) in the period from September to December 2006.

In the second study, we analyzed 11 subjects diagnosed with osteoporosis after a follow-up examination at an orthopedic clinic and given medication (osteoporosis group), and 9 subjects with no suspicion of osteoporosis (no osteoporosis group). Twenty subjects in the second study were diagnosed by DXA on Radius 1/3 BMD in orthopedics.

Methods
1. Calculation of functional tooth evaluation score (FTES)
The condition of each type of teeth (dental formula) was recorded during an examination of the oral cavity. Then, FTES was calculated according to the following formula using the total score set in accordance with the dental condition (Table 1).

\[ \text{FTES} = \frac{\text{Total points} + 280 \times 100}{100} \]

For the calculation, the third molar teeth were not included.

2. Measurement of mandibular cortical width (MCW)
The MCW was measured according the method reported by Taguchi et al. [6] on each panoramic dental radiogram (Fig. 1). We measured the width where the line segment passed through mental foramen and contacted the inferior margin of the mandible, as cut across the cortical bone. The measurements were carried out for both the right and left sides. The mean was regarded as the MCW for the subject.

3. Statistical analysis
In the first study, the correlation between FTES and MCW as well as the factor of age were studied in 129 subjects.

In the second study, indices related to osteoporosis were created for both the osteoporosis and no osteoporosis groups. Furthermore, the correlation between age and FTES was examined in both groups.

Statistical analyses were performed using ystat 2006 [7], a statistical calculation program based on Excel (Microsoft). For multiple regression analysis and discriminant analysis, SPBS V9.4 (statistical package for bioscience) [8] was used. Results of p<0.05 were regarded as statistically significant.

<table>
<thead>
<tr>
<th>Tooth condition</th>
<th>Score (Point)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact tooth (Caries Free)</td>
<td>10</td>
</tr>
<tr>
<td>Questionable Caries</td>
<td>9</td>
</tr>
<tr>
<td>Filling with Resin or Inlay etc</td>
<td>8</td>
</tr>
<tr>
<td>Crown or Abutment of Bridge</td>
<td>7</td>
</tr>
<tr>
<td>Secondary Caries</td>
<td>6</td>
</tr>
<tr>
<td>Caries</td>
<td>5</td>
</tr>
<tr>
<td>Mobility Tooth (Medium)</td>
<td>4</td>
</tr>
<tr>
<td>Pontic of Bridge</td>
<td>3</td>
</tr>
<tr>
<td>Artificial Tooth of Denture</td>
<td>2</td>
</tr>
<tr>
<td>Remaining Roots</td>
<td>1</td>
</tr>
<tr>
<td>Missing Tooth or Mobility Tooth (Severe)</td>
<td>0</td>
</tr>
</tbody>
</table>

Fig. 1 MCW Measurement
RESULTS

1. Correlation between FTES and MCW.
Spearman’s correlation analysis revealed a statistically significant positive correlation (p<0.01) between FTES and MCW in the 129 subjects. Furthermore, MCW became significantly larger as FTES became higher (Fig. 2). To review influence of age, we performed multiple regression analysis using an independent variable in age and FTES related to MCW. Each T-value significance of age and FTES showed p=0.152 and p<0.001 (Table 2). The results showed that MCW increased with the increase in FTES regardless of age.

2. Comparison between osteoporosis and no osteoporosis groups.
As shown in Table 3, the groups were examined using a Mann-Whitney U-test. There was no significant difference between the osteoporosis (67.2±7.5

Table 2 Results of multiple regression analysis

**SPBS - MULTIPLE REGRESSION ANALYSIS**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Independent variable</th>
<th>M.C.W</th>
<th>Age</th>
<th>Functional Tooth Evaluation Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analysis of variance</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Sum of squares</th>
<th>Degree of freedom</th>
<th>Unbiased variance</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>32.8134</td>
<td>2</td>
<td>16.40967</td>
</tr>
<tr>
<td>Residual error</td>
<td>32.90962</td>
<td>126</td>
<td>0.26119</td>
</tr>
<tr>
<td>Whole</td>
<td>65.72895</td>
<td>128</td>
<td>0.51351</td>
</tr>
</tbody>
</table>

Multiple correlation coefficient (R) 0.70662
Multiple correlation coefficient finished with degree of freedom adjustment (R^*) 0.70097

Contribution ratio 0.49931

Regression equation Y =+0.00574835 * X(1) +0.0307218 * X(2) +1.73760

Standard regression coefficient 0.13387 0.79898

T value 1.443 8.611 P=0.152 P<0.001
Table 3 Results of Mann-Whitney U-test

<table>
<thead>
<tr>
<th></th>
<th>Osteoporosis group</th>
<th>No osteoporosis group</th>
<th>Statistical Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>67.2±7.5</td>
<td>59.3±11.1</td>
<td>NS</td>
</tr>
<tr>
<td>FTES (Point)</td>
<td>43.7±9.9</td>
<td>79.3±9.7</td>
<td>**</td>
</tr>
<tr>
<td>Number of Present Teeth</td>
<td>12.8±4.8</td>
<td>25.3±2.9</td>
<td>**</td>
</tr>
<tr>
<td>MCW (mm)</td>
<td>3.3±0.9</td>
<td>4.4±0.6</td>
<td>*</td>
</tr>
</tbody>
</table>

NS: not significant    ** : p<0.01    * : p<0.05

Table 4 Results of discriminant analysis

**SPBS – DISCRIMINANT FUNCTION**

- Variables
  1: Age
  2: FTES
  3: Number of teeth present
  4: MCW
- Linear discriminant function

\[
Z = +0.012424 \times X(1) -0.606984 \times X(2) +0.473264 \times X(3) +1.26340 \times X(4) +22.6603
\]

D^2 of each coefficient

\[
D^2 = 14.365\quad 9.830\quad 13.928\quad 13.738\quad 22.6603
\]

T value

\[
0.094\quad 2.250\quad 0.618\quad 0.741\quad 1.727
\]

Significance

\[
P=0.927\quad P=0.040\quad P=0.546\quad P=0.470\quad P=0.001
\]

Squared distance (D^2) of Mahalanobis

\[
D^2 = 14.375\quad F(4,15) = 14.824\quad P<0.001
\]

years old) and no osteoporosis (59.3±11.1 years old) groups in regard to age. In contrast, FTES for the osteoporosis group (43.7±9.9 points) was significantly lower than that for the no osteoporosis group (79.3±9.7 points) (p<0.01). Furthermore, statistically significant differences were observed for the number of present teeth and MCW (p<0.01 and p<0.05, respectively) between the groups. As shown in Table 4, discriminant analyses were performed using the oral indices related to osteoporosis, with age, FTES, number of present teeth, and MCW employed as independent variables. As a result, a significant discriminant function (p<0.001) was obtained, which demonstrated that FTES was significantly related to osteoporosis (p=0.040). Based on the results of Spearman’s correlation analysis for age and FTES between the osteoporosis and no osteoporosis groups, a line for calculating the cutoff level of FTES (y) according to age (x), y = -0.307x + 81.97 was set in the middle of the lines to show the correlation (Fig. 3).

Fig. 3 Setting of cutoff level (broken line).

Calculated by the relational expression:

\[
FTES = -0.307 \times \text{Age} + 81.78
\]

Horizontal axis = Age(year), Vertical axis = FTES (point)
Table 5 Results of osteoporosis screening using FTES (20 subjects)

<table>
<thead>
<tr>
<th></th>
<th>With osteoporosis</th>
<th>Without osteoporosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTES Results (positive +)</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>FTES Results (negative -)</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

Sensitivity = 0.91, Specificity = 0.889, Likelihood- positive ratio = 8.18, Likelihood- negative ratio = 0.102

The usefulness of osteoporosis screening on the basis of the FTES obtained from the line was investigated. As shown in Table 5, sensitivity was 0.91, specificity 0.889, likelihood- positive ratio 8.18, and likelihood- negative ratio 0.102.

DISCUSSION

1. Panoramic dental radiography

When utilizing panoramic dental radiography, it is considered that the horizontal deformation (dispersion in scale of enlargement) is large, while the vertical deformation (dispersion in the scale of enlargement) is small, depending on the head and tomography instrument positioning [9]. MCW values obtained in the first study seemed to be appropriate for comparisons among the subjects, as they provided data in regard to vertical direction. Moreover, it is considered that enlargement is likely to vary between the right and left sides in panoramic radiographic images, as fixation of the head can fluctuate horizontally during the procedure. In the first study, we measured MCW on both sides and calculated the average, which was considered to correct the fluctuation between the sides. Taguchi et al. reported that errors (dispersion) of measurement of the MCW were dependent on the site and individual performing the measurements, though they were 2% or lower [6] and that such measurements were nearly as effective for osteoporosis screening as questionnaires [10]. In the first study, we examined the relationship between FTES and MCW to determine the possibility of using FTES for osteoporosis screening.

2. Significance of osteoporosis screening with FTES

In the field of dentistry, the condition of teeth in the oral cavity is recorded at public health mass-screening examinations and when starting treatment.

Accordingly, FTES calculated on the basis of dental formula is used as an index to evaluate the oral condition in a simple and easy to perform manner [2]. In the first study, a statistically significant positive correlation was observed between FTES and MCW, indicating that FTES could be used in osteoporosis screening in a manner similar to panoramic dental radiography, which utilizes MCW. Furthermore, in the second study, discriminant analysis of 20 subjects divided between those with and without osteoporosis showed that FTES was significantly correlated with osteoporosis. When the screening results of 20 subjects, in whom FTES was calculated for each age bracket, were used as a cutoff level, the likelihood- positive ratio was 8.18 and the likelihood- negative ratio was 0.102. Since the former was greater than 5 and the latter less than 0.2, we concluded that FTES was useful for osteoporosis screening [11].

Osteoporosis is considered to be a 'silent disease,' as the symptoms are rarely noticed in the early stage. However, the symptoms become considerably worse following bone fracture. Therefore, early detection and rapid curing are important. Yamauchi et al. [12] found the consultation rate for osteoporosis checkups to be as low as 4.59%, whereas the Statistics of National Health 2008 [13] noted that the consultation rate categorized by kind of disease was the highest for alimentary diseases, of which a large portion are dental diseases. In light of this background, we considered that FTES obtained from the dental formula recorded at the time of health mass screening without the use of dental panoramic radiography or consultation at a dental clinic would be useful for screening subjects with suspected osteoporosis, who could then be referred to an orthopedic clinic. In the future, it will be important to improve the precision of this screening method by closely comparing its results with confirmed cases.
CONCLUSION

FTES was significantly related to osteoporosis when using a cutoff level calculated by the following formula set between age (x) and FTES (y): y = -0.307x + 81.78.

We concluded that FTES is useful for osteoporosis screening during public health mass-screening examinations.

REFERENCES


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