

## **Clinical significance and variation of the advanced calcified stylohyoid complex detected by panoramic radiographs among 80-year-old subjects**

Sachiko Okabe, DDS <sup>a)</sup>, Yasuhiro Morimoto DDS PhD <sup>b)</sup>, Toshihiro Ansai, DDS, PhD <sup>c)</sup>, Kazuhiro Yamada DDS PhD <sup>d)</sup>, Taturou Tanaka, DDS, PhD <sup>e)</sup>, Shuji Awano, DDS, PhD <sup>f)</sup>, Shinji Kito, DDS, PhD <sup>g)</sup>, Yutaka Takata, MD PhD <sup>h)</sup>, and Tadamichi Takehara, DDS, PhD <sup>i)</sup> and Takeshi Ohba DDS DMSc <sup>j)</sup>

<sup>a)</sup> Instructor, Department of Oral Diagnostic Science, Kyushu Dental College, Kitakyushu, Japan. <sup>b)</sup> Associate Professor, Department of Oral Diagnostic Science, Kyushu Dental College, Kitakyushu, Japan. <sup>c)</sup> Associate Professor, Department of Preventive Dentistry, Kyushu Dental College, Kitakyushu, Japan. <sup>d)</sup> Assistant Professor, Department of orthodontics, Niigata University, Niigata, Japan. <sup>e)</sup> Assistant Professor, Department of Oral Diagnostic Science, Kyushu Dental College, Kitakyushu, Japan. <sup>f)</sup> Assistant Professor, Department of Preventive Dentistry, Kyushu Dental College, Kitakyushu, Japan. <sup>g)</sup> Assistant Professor, Department of Oral Diagnostic Science, Kyushu Dental College, Kitakyushu, Japan. <sup>h)</sup> Professor and chairman, Department of Internal Medicine, Kyushu Dental College, Kitakyushu, Japan. <sup>i)</sup> Professor and chairman, Department of Preventive Dentistry, Kyushu Dental College, Kitakyushu, Japan. <sup>j)</sup> Professor and chairman, Department of Oral Diagnostic Science, Kyushu Dental College, Kitakyushu, Japan.

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### **Send all correspondence to:**

Yasuhiro Morimoto DDS PhD,  
Division of Diagnostic Radiology,  
Department of Oral Diagnostic Science,  
Kyushu Dental College,  
2-6-1 Manazuru, Kokurakita-ku,  
Kitakyushu 803-8580, JAPAN  
TEL: 81-93-582-1131 (Ext. 2116)  
FAX: 81-93-581-2152  
E-mail: rad-mori@kyu-dent.ac.jp

## **Structured abstract**

**Objectives:** To evaluate the clinical significance and variation of an elongated styloid process associated with advanced calcification as detected on panoramic radiographs among 80-year-old subjects.

**Methods:** Panoramic radiographs of 659 patients (262 men and 397 women) and data of their general and dental health conditions were used for the evaluation of the relationship between an elongated styloid process and general health among 80-year-olds. This study was part of the 8020 Data Bank Survey, which was designed to collect the baseline data of general and dental health conditions in 80-year-old subjects. The morphology of the styloid process was allocated to one of 12 patterns according to Jung et al. The lengths of the styloid processes were measured directly on the radiographs from the caudal margin of the tympanic plate to the tip of the styloid process.

**Results:** All of the styloid processes from the 659 panoramic radiographs could be allocated to one of 12 morphological patterns and some of their radiographic findings suggested calcification of the carotid artery and lymph nodes. In 80-years-old subjects, the average length of the styloid process was 36.7 mm, and ranged from 13.0 mm to 153.0 mm. There appeared to be correlations between the length of the styloid process, and serum calcium concentration and heel bone density, but not with the Community

Periodontal Index (CPI).

**Conclusions:** Dentists should recognize the existence of morphological variation in the styloid process, especially in its length, apparent on panoramic radiographs of 80-year-old patients. In addition, the longer length of the styloid process in 80-year-old patients may be a predictor of bone density and high serum calcium concentration level. The findings from the present study may provide potentially life-saving information about elderly people.

## Introduction

The number of aged persons is increasing worldwide and the variety of their oral and general diseases is also increasing. In 1998, the Japanese Ministry of Health and Welfare conceived a project to evaluate the relationship between oral health and general health in individuals who were 80 years old in Fukuoka Prefecture. The present study makes extensive use of panoramic radiographs obtained in this project.

“Elongated styloid process” is a term used since a publication by Eagle<sup>1</sup> in reports concerning findings in dento-maxillofacial and ear-nose-throat patients.<sup>1-12</sup> The term defines a styloid process that is longer than normal and thus associated with advanced calcification of the process and its ligament. Reports have described the ranges of lengths and variations of the styloid process in 80-year-old subjects, but these data may be unreliable due to relatively small sample sizes.<sup>3-5, 7, 10-12</sup> In addition, the clinical significance of an elongated styloid process for general health conditions remains obscure, because previous studies have focused on local complaints due to the influence of Eagle’s report,<sup>1, 2</sup> but not on general conditions.

In previous reports,<sup>13-20</sup> we demonstrated that 80-year-olds who were physically active retained a higher number of their teeth and had a higher bone density than 80-year-olds who were not active. Tooth loss appears to be a predictor of

abnormal electrocardiograph findings, including ST depression, T-wave abnormalities, and arrhythmias.<sup>14</sup> In addition, a relationship between perceived chewing ability and physical fitness suggests that chewing ability might be a predictor of physical fitness.<sup>17,</sup>  
<sup>19</sup> Furthermore, the rate of calcified carotid artery atheromas detected on panoramic radiographs among 80-year-old subjects was 5%, and it appears that panoramic radiography might be a useful imaging modality for the identification of some asymptomatic patients at substantial risk for stroke.<sup>20, 21</sup>

The purpose of the present study was to evaluate the lengths and variations of styloid processes in 80-old-year subjects using more subjects than previous studies. In addition, the correlation between general health conditions and the length of the styloid process was evaluated.

## Materials and Methods

Panoramic radiographs were obtained in 1998 from 1282 persons who were 80-year-old residents of Fukuoka Prefecture (3 cities, 4 towns, 1 village, and 1 ward). Of the 697 radiographs taken, 659 (from 262 men and 397 women) were used in this study. The other 38 radiographs were eliminated from this study because they involved inadequate positioning.

Panoramic radiography was performed by visiting locations in a van in which panoramic equipment had been set up. The radiographs were obtained with Super Veraview® equipment (J. Morita, Kyoto, Japan) at 5 to 10 mA and 60 to 80 kV depending on the subject's jaw size. The lower jaw of each subject was positioned on a chin rest of the machine in the prescribed clinical position with the Frankfort plane parallel to the floor of the van. The subjects were seated during the exposure. Fuji RX-L films (Fuji Film Co., Tokyo, Japan) with Kyokko ST- II screens (Kyokko, Tokyo, Japan) were used for panoramic radiographs.

Bilateral styloid processes were studied on panoramic radiographs in subdued ambient light with a standard viewing box and a hot spot illumination source, a Spotlux 102® light (Hoken Shizai, Tokyo, Japan).

Using the measurement method of Jung et al. for elongated styloid processes,<sup>7</sup>

lengths of bilateral styloid processes were evaluated. In brief, the measurements were taken on the frontal side of the temporal bone.<sup>7</sup> In this area on the panoramic radiographs, a thin transparent line is generally visualized between the shadows of the styloid process and the tympanic bone. This transparent line corresponds to the cleft between the styloid process and the tympanic plate of the temporal bone (Fig. 1). The tip of the styloid process is its bony end, including mineralized parts of the ligament. The measurements were carried out using a millimeter ruler in dimmed room lighting, directly from the films placed on a light box with a frame adjustable from 1.5 cm X 4 cm to 4 cm X 8 cm. Before the measurements were taken, the position and visualization of the marks were evaluated simultaneously by a junior examiner and a senior examiner for consistency. To check the intraobserver and interobserver variations, measurements were repeated after some weeks on a subset of 50 panoramic radiographs. Deviations in mean length of the styloid process between first and second measurements were <1.2%.

Next, the calcification patterns of the styloid processes in 80-year-olds were divided into 12 groups according to Jankowski.<sup>3</sup> In brief, the pattern of calcification was described according to the center of calcification involved: Region 1, tympanohyal; Region 2, stylohyal; Region 3, ceretohyal; Region 4, hypohyal. The 12 patterns shown

in Figure 2 are derived from the pattern of calcification in the regions and whether the regions were continuous or distinct.

Subjects were first given a physical examination consisting of body weight and height, physical stamina, blood pressure, and electrocardiography. Measurements of the heel bone density, total blood cholesterol, and serum calcium concentration were also included in these examinations. Oral health examinations included tooth number and assessment using the Community Periodontal Index (CPI). The relationships between the longer length of the styloid process between right and left side and the examinations mentioned above were evaluated.

All statistical analyses were performed by means of Stat View™ version 5.0 software (SAS Institute Inc., Cary, NC, USA). Differences in mean values between the two groups were analyzed by Student's t-test. Categorical variables were compared by the  $\chi^2$  test. The relationship between categorical variables was assessed using the Pearson correlation coefficient. Results were considered statistically significant if  $p < 0.05$ .

In this study, the Human Investigations Committee of Kyushu Dental College protected individuals' rights, and informed consent was obtained from all study subjects.



## **Results**

### **The lengths of the styloid process in 80-year-old subjects**

The 80-year-old subjects were 262 men and 397 women. The distribution of styloid process lengths is shown in Table 1. Of the 659 individuals, the lengths of the bilateral styloid processes on panoramic radiographs ranged from 0.0 mm to 153.0 mm (Fig. 3), and the average lengths and standard deviation (SD) were  $36.7 \pm 10.1$  mm. There were no significant differences between right ( $35.9 \pm 9.6$  mm) and left ( $37.4 \pm 10.5$  mm) sides in the lengths of the styloid processes (t test;  $P=0.10$ ). A significant difference was found between men ( $38.9 \pm 12.2$  mm) and women ( $30.3 \pm 7.5$  mm) on the lengths of the styloid processes (t test;  $P=0.03$ ).

### **The variations of styloid process in 80-year-old subjects**

The distribution of the 12 morphological patterns in these 80-year-olds is shown in Table 2. Pattern E had the highest rate of all patterns and Pattern D was next highest. Patterns F to K, in which calcification of the stylohyoid ligament was defined, were also relatively numerous. In addition, various types of styloid processes on panoramic radiographs were seen in Patterns F to K. In particular, calcification of the stylohyoid ligament in some cases of Patterns H and J could not be distinguished from

calcification of the carotid artery, phleboliths, and lymph node calcification (Fig. 4).

### **Relationship between the length of the styloid process and general health**

The average and SD various parameters in their general and dental health conditions of 80-year-old subjects is shown in Table 3.

**Serum calcium concentration:** A significant correlation was found between the serum calcium concentration and the length of the styloid process (Pearson  $r=0.328$ ,  $P=0.02$ ).

The longer the styloid process was, the higher the serum calcium concentration was.

**Heel bone density:** A significant correlation was found between heel bone density and the length of the styloid process (Pearson  $r=0.328$ ,  $P=0.02$ ). The longer the styloid process was, the higher heel bone density was.

**Blood pressure:** No significant correlation was found between the length of the styloid process and the frequency of patients with higher systolic blood pressure in 80-year-old subjects (Pearson  $r=0.312$ ,  $P=0.10$ ).

**Electrocardiographs:** There was no significant correlation between the frequency of abnormal electrocardiographs (ST segment depression, T-wave abnormalities, and Q-wave) and the length of the styloid process (Pearson  $r=0.102$ ,  $P=0.50$ ).

**Total serum cholesterol:** There was no significant correlation between the total

cholesterol serum concentration and the length of the styloid process (Pearson  $r=0.112$ ,  $P=0.08$ ).

**Smoking:** There were no significant differences in the length of the styloid process between subjects who smoked tobacco and those who did not ( $P=0.1$ ). The average length of the styloid process in subjects who smoked was  $39.8 \pm 10.1$  mm, but  $36.5 \pm 10.5$  mm in those who did not.

**Body weight and height:** There was no significant correlation between the body mass index (BMI) and the length of the styloid process (Pearson  $r=0.132$ ,  $P=0.08$ ).

**Physical stamina:** There was no significant correlation between physical stamina and the length of the styloid process (Pearson  $r=0.102$ ,  $P=0.10$ ).

### **Correlation between the length of the styloid process and oral health**

**Number of teeth:** There was no significant correlation between the number of remaining teeth and the length of the styloid process (Pearson  $r=0.272$ ,  $P=0.08$ ).

**Community Periodontal Index:** There was no relationship between CPI and the length of the styloid process (Pearson  $r=0.289$ ,  $P=0.1$ ).

## Discussion

In the present study, we demonstrated that the lengths of the styloid processes in 80-year-old subjects were much longer than previously reported and that the morphological changes were more variable. In addition, a significant relationship was found between the length of the styloid process, and high serum calcium concentration and heel bone density. The longer the styloid process was, the higher high serum calcium concentration and heel bone density were.

The lengths and variation of styloid processes, including Eagle's syndrome-related description, have been previously reported.<sup>1-12</sup> In these reports, "elongated styloid processes" were defined as those with lengths of more than 35 mm on panoramic tomographs or those with lengths of more than 30 mm on posterior-anterior skull projection radiographs.<sup>22, 23</sup> Using these definitions as criteria, more than 55% of the 80-year-old subjects in the present study had elongated styloid processes. The rate of subjects with an elongated styloid process in our study was relatively higher than those in previous reports<sup>3-12, 22, 23</sup> and the average length of the styloid process was also longer. The sample sizes of subjects more than 80 years old in previous studies were much smaller than that in the present study, so the rates determined in the previous studies were probably less reliable. In addition, the exact

lengths of the styloid process ranged from 0.5 cm to 5.5 cm and the average was almost 2.8 cm in data of studies using three-dimensional computed tomography examinations and cadavers.<sup>5</sup> We believe that our data is more reliable due to the bigger sample size in the present study. We suggest that the length criterion for elongated styloid processes should be reconsidered as the number of aged persons increases worldwide. We propose that the length of an elongated styloid process should be over 4.5 cm on the panoramic radiographs of subjects more than 80 years old based on the rate of less than 15%. In addition, a recent report demonstrated that only two of 32 patients with elongated styloid processes had any symptoms of Eagle's syndrome.<sup>4</sup> Therefore, we supposed that the evaluation of elongated styloid processes on panoramic radiographs might be of no value for diagnosis of Eagle's syndrome. Our recommendation is that clinicians consider the possibility of Eagle's syndrome when both the clinical and radiographic evidence support this diagnosis.

In the styloid process of 80-year-old subjects, we noted various morphological findings on panoramic radiographs by the various types of calcifications in the styloid ligaments in addition to its increased length. The types of styloid process and styloid ligament calcifications on the panoramic radiographs in 80-year-olds were divided into 12 patterns according to Jankowski's report.<sup>3</sup> Not surprisingly, the rate of the

fragmentation type of ligament calcification was relatively high. Contrary to our expectation, the patterns of calcifications in the styloid process and styloid ligament in 80-year-old subjects were relatively similar to those in other age groups. A recent evaluation of the styloid process using three-dimensional computed tomography<sup>5</sup> also demonstrated that patterns of calcification of the styloid process and styloid ligament resembled our and Jankowski's data.<sup>3</sup> However, the present results indicated that there are some particular cases in which dentists should analyze the styloid process and surrounding tissues on panoramic radiographs. As indicated in Figure 3, the point type of styloid ligament calcification seen as a radiopaque nodular mass on panoramic tomographs were relatively similar to calcified carotid artery atheromas and lymph node calcification. We suppose that dentists should evaluate the location of a radiopaque nodular mass to distinguish between the two conditions mentioned above.<sup>22, 23</sup> If a nodular mass were present on the line of extension of the styloid process, we might diagnose it as styloid process calcification.<sup>22, 23</sup> However, we should perform an additional examination using computed tomography if we could not judge the distinction between them.

Next, we evaluated the general health conditions in the subjects with and without elongated styloid processes. As unexpected, a significant correlation was

found between high serum calcium concentration and the length of the styloid process. On renal stone a high serum calcium concentration did not tend to promote ectopic calcifications, but local calcium concentration level.<sup>24</sup> The phenomena could not be explained based on pathologic physiology clearly.<sup>24</sup> However, we suppose that elongated styloid processes might be an indicator of a tendency toward a high serum calcium concentration. Although there was a limitation based on the cross-sectional design of the present study, a linear dose-dependent relationship between an elongated styloid process and the heel bone density was demonstrated significantly. The result might be reasonable because of the advanced mineralization as pathologic physiological evidence connecting the two. Additional investigations are needed to elucidate the relationship between the two, and our data should suggest further studies.

The present and previous reports indicate that panoramic radiographs include information on general health conditions as well as on teeth and jaws.<sup>20, 21, 26</sup>

Therefore, we propose that dentists should pay attention not only for pathosis of the teeth and jaws, but also for information on general health conditions.

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## Figure legends

### Figure 1

Anatomical landmark used as the method for measurement of the styloid process length.

A) Cleft between the lower margin of the tympanic plate of the temporal bone and the styloid process on panoramic radiographs as a slit between contour of the tympanic plate and the styloid process.

B) The method of measurement of the styloid process length is drawn as scheme of

Figure 1A. Circle show origin for measurements, and the length of arrow means the length of styloid process on the panoramic radiographs.

C) Figure 1C is a superimposition of Figures 1A and 1B.

### Figure 2

The 12 plus exceptional patterns of calcification of styloid process. (A) Region 1:

tympanohyal alone; (B) Region 2 stylohyal alone; (C) Regions 1 and 2, separate; (D)

Regions 1 and 2, continuous; (E) Regions 1, 2, and 3, continuous; (F) Regions 1, 2, and

3, separate; (G) Regions 1 and 2, continuous, but separate from 3; (H) Regions 2 and 3,

continuous; (I) Regions 2 and 3, continuous, but separate from 3; (J) Region 3 alone;

(K) Regions 3 and 4, continuous; (L) No styloid process visible

**Figure 3**

Longer styloid processes with advanced calcification on panoramic radiograph.

A) Left styloid process (arrows) was the longest among all subjects, and ranged from a thin transparent line to hyoid bone continuously. The length was over 150 mm.

B) Typical long styloid processes (arrows) were demonstrated bilaterally, and ranged from a thin transparent line to mandibular angle continuously.

**Figure 4**

As are cases with calcification of the stylohyoid ligament could not be clearly distinguished from ectopic calcification including the carotid artery, phleboliths, and lymph node calcification.

(A) Ectopic calcification visible on the right side of the neck, adjacent to the lower intervertebral space (white arrow) as shown on a panoramic radiograph. We suppose that its structure may be a calcification of the carotid artery based on location.

(B) Ectopic calcification visible on the left side of the neck, behind the left mandibular angle (white arrow) as shown on a panoramic radiograph. We suppose that its structure may be a lymph node calcification based on the size and location.