

# Elongated styloid process and atheroma in panoramic radiography and its relationship with systemic osteoporosis and osteopenia

P. C. A. Watanabe · F. C. Dias · J. P. M. Issa ·  
S. A. C. Monteiro · F. J. A. de Paula · R. Tiozzi

Received: 3 March 2009 / Accepted: 6 July 2009 / Published online: 24 July 2009  
© International Osteoporosis Foundation and National Osteoporosis Foundation 2009

## Abstract

**Summary** Association between the presence of an elongated styloid process, vascular calcification (atheroma) and the potential risk factor for osteoporosis was studied. Presence of an elongated styloid process was found to be correlated with systemic osteoporosis and also between elongated styloid process and atheroma.

**Introduction** The association between the presences of an elongated styloid process and vascular calcification (atheroma) with the potential risk factor assessment for osteoporosis was studied.

**Methods** Bone mineral density obtained by dual energy X-ray absorptiometry diagnosed osteopenia/osteoporosis on at least two of three sites (column, hips, and forearm) of 50 female patients. Panoramic maxillomandibular radiographs were taken and analyzed. Elongation of the styloid processes

was measured and the presence of atheromas in the carotid was investigated.

**Results** Eighty percent of the patients presented at least one side with elongated styloid process and the highest prevalence (87.5%) occurred in individuals between 60 and 69 years. Atheroma was found in four patients, three of which presented elongated styloid on at least one side and had diagnosed osteoporosis on at least two of the evaluated sites.

**Conclusions** Correlation was found between the elongation of the styloid process and systemic osteoporosis, and between elongated styloid process and atheroma. The method in this study might be used as part of a method for osteopenia/osteoporosis and atheroma risk assessment.

**Keywords** Atheroma · Osteoporosis · Panoramic radiography · Styloid process

P. C. A. Watanabe · F. C. Dias · J. P. M. Issa · S. A. C. Monteiro  
Department of Morphology, Stomatology and Physiology,  
School of Dentistry, University of São Paulo,  
Ribeirão Preto, São Paulo, Brazil

J. P. M. Issa  
Department of Biomechanics, Medicine and Rehabilitation  
of the Locomotor Apparatus, School of Medicine of Ribeirão  
Preto, University of São Paulo,  
Ribeirão Preto, São Paulo, Brazil

F. J. A. de Paula  
Department of Internal Medicine,  
School of Medicine of Ribeirão Preto, University of São Paulo,  
Ribeirão Preto, São Paulo, Brazil

R. Tiozzi (✉)  
Department of Dental Materials and Prosthesis,  
Ribeirão Preto School of Dentistry, University of São Paulo,  
Av. do Café s/no, Bairro: Monte Alegre,  
CEP 14049-900 Ribeirão Preto, SP, Brazil  
e-mail: rtiozzi@yahoo.com

## Introduction

Osteoporosis is a systemic disease characterized by a progressive reduction in the amount of bone mass and by modifications in the trabecular architecture, afflicting both genders and any bone. Despite osteoporosis and atherosclerosis being considered independent diseases, having in common only the fact that are more frequent in elderly individuals (65 years or more) [1], some recent studies report an association between low bone mineral density (BMD) and vascular calcification processes (atheroma) [1–3].

Regarding soft tissue calcification, literature showed that the calcification of the hyoid–styloid process includes the stylohyoid ligament, which connects the styloid process to the minor horn of the hyoid bone [4]. In a young female rats study, significant correlation between calcification of

the stylohyoid ligament and high serum concentration of calcium was found [5]. This plasma calcium concentration is associated to a fast loss of bone mass, leading to the possible association of this process with osteoporosis [5].

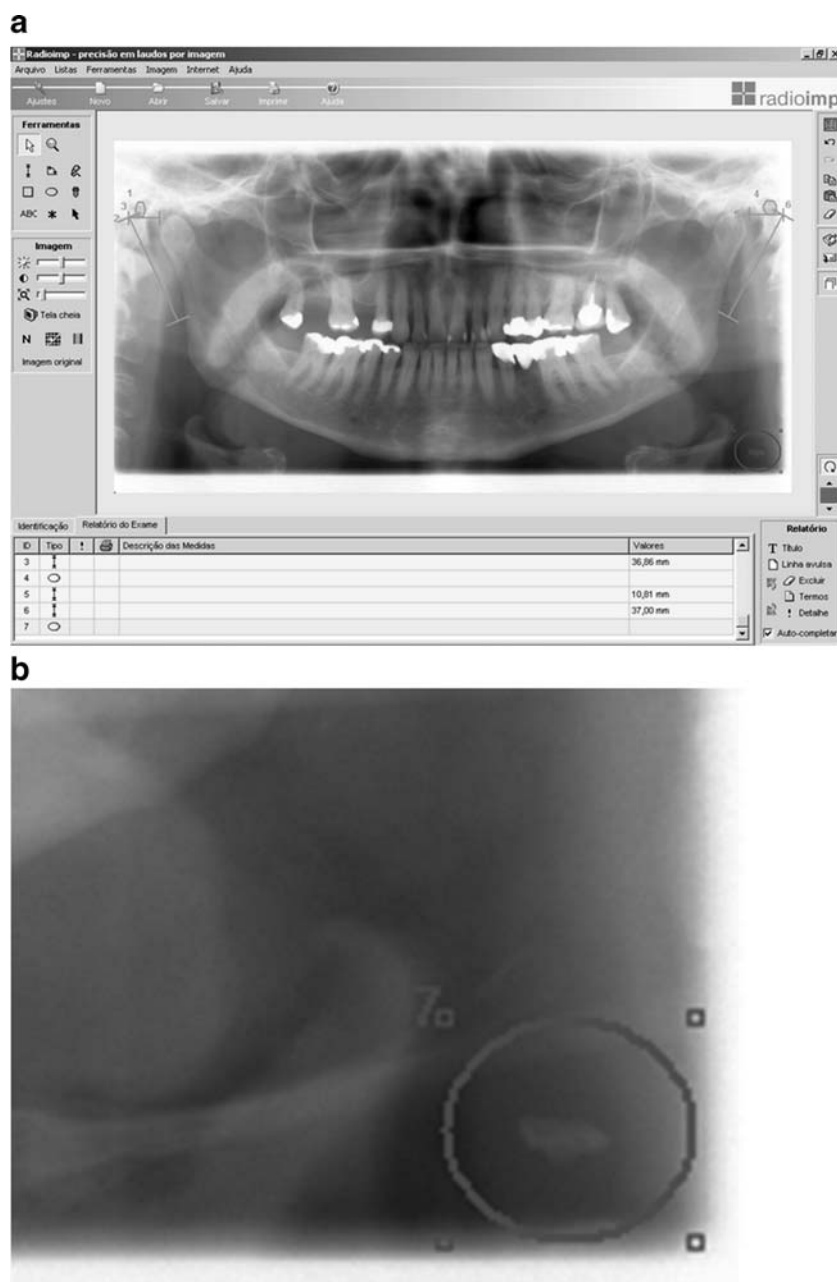
The calcification mechanism of soft structures is reported by some studies [1] to be similar to the osteogenesis process, involving several cells, proteins, and cytokines, preceding tissue mineralization. These authors also report that ectopic bone tissue has been identified in calcified plaques and that specific bone cells were found on the arterial wall evidencing a transdifferentiation of endothelial cells into osteoblasts and also finding osteoclast-like cells on calcified arteries.

Some epidemiological studies found correlation between vascular calcification and osteoporosis [2, 3]. This association has been denied on several occasions and interpreted as secondary to the aging process; however, data show that this relation is significant even in advanced age. In addition, risk of cardio- and cerebral-vascular diseases has been described on post-menopausal and osteoporotic women by literature and the presence of atheromas might be one risk factor.

Considering that panoramic radiograph is a routine exam in the medicine and oral medicine practices, its great advantage is to allow practitioners to analyze components of the stomatognathic system in addition to other near structures [6]. Through this technique, it is possible to

**Fig. 1 a** Detecting the presence of calcifications in the carotid.

**b** Higher magnification of atheroma presence



identify and measure the styloid process of the temporal bone having the external acoustic meatus as reference point and also to identify calcified fat plaques (atheromas) on the walls of carotid arteries in the bifurcation region, near the hyoid bone image.

This study aimed to investigate the correlation between the presences of elongated styloid processes (ESP) and vascular calcification (atheromas) in patients with diagnosed osteopenia/osteoporosis. The analysis was conducted using digital panoramic radiographs of these patients.

## Methods

This study used 50 patients from the Radiology service of the Dental School of Ribeirão Preto, University of São Paulo, Brazil. All patients were female between 35 and 84 years old who had osteopenia/osteoporosis diagnosed on at least two of the following three different sites analyzed (radius, column, and femoral head). Osteopenia/osteoporosis diagnosis was based on bone densitometry exam (DEXA—dual energy X-ray absorptiometry).

Each patient's radiographic results were expressed as standard deviations of the result obtained and in relation to young female adults' bone mass average (T-score). This criterion is used to define the osteoporosis diagnosis according to the World Health Organization. Values are: Normal=scores until  $-1$  standard deviations (SD) from young female adult mean; Osteopenia=score between  $-1.1$  and  $-2.5$  SD below the mean; and Osteoporosis=score of  $-2.6$  SD or more below the mean [7].

Digital panoramic radiographs were obtained using the same X-ray machine (Ortophos—Sirona Dental) with the

following mean values of exposure: 62 kVp and 16 mA, and rotation time of 14.1 s. All radiographs went through a screening method to check image quality and definition of the region of interest used in this study.

Length of styloid processes from both sides was assessed through linear measurements using Radiocef Studio—Radioimp computer software (Radiomemory, Brazil) and values higher than 30 mm were considered elongated [8–10]. The presence of vascular calcifications was evaluated to establish the possibility of diagnosing atheromas using the same radiographs and analyzing the region below the hyoid bone, near C3 and C4 vertebrae of both sides, referring to the location of the carotid artery bifurcation (Fig. 1a and b).

To determine image size of the styloid process, “circle” tool of Radioimp computer software was used to identify and select the external acoustic meatus. Length (mm) of the styloid process was measured by tracing a horizontal line below the inferior edge of the external acoustic meatus and another one starting from the apex of the styloid process (distal part). Connection of both straight lines determined the proximal part (tympanohyal) of the styloid process and length from distal to proximal parts was assessed (Fig. 2).

## Method error

The method error of measuring the length of the styloid process was performed in 15 radiographs. Measurements were obtained in two different sessions with a 7-day interval. In each session, an average of three measurements was considered for each side and used later to assess the results. Method error (Se) was calculated using Dahlberg's formula:  $Se = \sqrt{d^2/2n}$ , where “Se” is the standard deviations of the differences of each of the replicates from its

**Fig. 2** Determining the image size of the styloid process using Radioimp software



**Table 1** Age groups and variables prevalence

Age group (years)	Number of patients	Osteopenia/osteoporosis (3 sites)	Osteoporosis (2 or 3 sites)	One ESP	Both ESP	Atheroma
30–39	2 (4%)	0	2 (100%)	2 (100%)	1 (50%)	0
40–49	10 (20%)	5 (50%)	1 (10%)	7 (70%)	5 (50%)	0
50–59	14 (28%)	8 (57%)	4 (29%)	10 (71%)	6 (43%)	2 (14%)
60–69	16 (32%)	12 (75%)	9 (56%)	14 (87%)	9 (56%)	0
70–79	7 (14%)	5 (71%)	4 (57%)	6 (86%)	2 (29%)	2 (29%)
80–89	1 (2%)	0	1 (100%)	1 (100%)	1 (100%)	0
Total	50 (100%)					

ESP elongated styloid process

mean, “*n*” is the number of radiographs recorded, and “*d*” is the difference between two length measurements in a radiograph [11, 12]. Percentage errors were calculated using the formula: % = (Se/mean) 100%, where “Se” is the result from Dahlberg’s formula and mean corresponds to the mean value of the total of the initial and second measurements. The difference between the first and second (1 week later) series of measurements was 0.7 mm, corresponding to 2.11% of the total variance.

The presence of vascular calcifications (atheromas) was also obtained in two different sessions with a 7-day interval. Each session verified the presence or absence of vascular calcifications. Since no size was measured, no error was encountered in this method, and the results in both sessions were the same.

#### Data analysis and statistics

All measurements were transferred to an Excel (Microsoft, USA) table containing patient’s data with age, gender, length of the styloid process, results of DEXA, and presence of an image suggesting atheroma. Statistical power analysis was determined as 0.6205 for length measurement and atheroma detection in this study. Since qualitative variables were used, data were submitted to Pearson chi-square test, using SPSS 17.0 (SPSS Inc., USA) computer software and using Monte Carlo simulation due the fact that some data fields in the contingency table had very low frequency. Therefore, from 10,000 re-samples and 95% confidence level, an empiric Pearson chi-square

distribution was generated and significance of the test obtained. Variable results were considered dependent and correlated when  $p < 0.05$  [13].

#### Results

This study found that 30 (60%) of the 50 patients had osteopenia/osteoporosis on all three analyzed sites. Forty patients (80%) had at least one of the styloid processes elongated. Four patients (8%) presented calcification in the carotid artery bifurcation region, indicating an atheroma site (Table 1).

In the correlation study, association was found between osteopenia/osteoporosis diagnosed on the three analyzed sites and the elongation of one or both styloid processes ( $p < 0.05$ ). Also, when comparing osteopenia/osteoporosis on the three sites and both elongated styloid processes, correlation was found ( $p < 0.05$ ). Comparing osteopenia/osteoporosis on the three sites and atheroma, no significance was found ( $p > 0.05$ ) (Table 2).

When diagnosis for osteoporosis was found on two or three of the analyzed sites, no correlation occurred with an elongated styloid process on one or both sides ( $p > 0.05$ ). No correlation existed between osteoporosis on two or three sites and atheroma ( $p > 0.05$ ) (Table 2).

Variables elongated styloid process on one or both sides and atheroma were not correlated ( $p > 0.05$ ). When considering the elongation of both styloid processes and atheroma, correlation was found ( $p < 0.05$ ) (Table 2).

**Table 2** Variables comparison and correlation

	Osteopenia/osteoporosis (3 sites)			Osteoporosis (2 or 3 sites)			One ESP	Both ESP
	One ESP	Both ESP	Atheroma	One ESP	Both ESP	Atheroma	Atheroma	Atheroma
<i>p</i> values	0.03	0.02	0.08	0.88	0.06	0.11	0.79	0.04

Variables are correlated when  $p < 0.05$

ESP elongated styloid process

## Discussion

This study investigated the correlation between an elongated styloid process and vascular calcification (atheromas) in patients with osteopenia/osteoporosis, based on the analysis of digital panoramic radiographs.

The age group in this study was from 34 to 84 years and 50 patients were analyzed. Forty (80%) individuals, with diagnosed osteopenia/osteoporosis on at least two sites, had elongated styloid processes (Table 1), indicating an association between low bone mineral density and ectopic calcification process. Mineralization or ossification of the styloid process is common; incidence of 18% of elongated styloid processes was found in an analysis of 1,771 oral panoramic radiographs in general population, studying both men and women [14]. Also, calcified styloid processes were more common in patients between 50 and 59 years [14]. This study found that 24 (80%) of the 30 patients in the age group between 50 and 69 years had at least one elongated styloid process (Table 1) and is in accordance with the results found by another study [10].

The presence of more than one site (two or three) diagnosed with osteopenia/osteoporosis was considered as a systemic condition for this disease. Evaluated sites were the radius, column, and femur. According to the WHO, bone density should be evaluated on two or more bone sites and one of them must be the column or hip (femur) [8].

An incidence of 8% (four patients) of patients with vascular calcification was found in this study. A prevalence of 2% to 11% of patients with calcifications in the carotid artery was found in a study that analyzed panoramic radiographs of dental patients [15]. Atheromas were also reported [16] as varying from 2% to 5%, with a higher frequency rate in menopausal women and in individuals aged 65 years and older (up to 20%). Menopausal women present physiological alterations favorable to atherosclerosis [17]. This process is explained by the reduction of estrogen level leading to a low LDL molecule breakdown and to the reduction of HDL levels, increasing the probability of atheroma occurrence.

This study showed no significant correlation between osteopenia/osteoporosis and atheromas ( $p=0.089$ ). Detection of calcifications in the carotid artery using panoramic radiographs was considered as limited and of low sensitivity by another study [14] and agrees to the results found in this research study. Some general medicine studies relate osteoporosis with vascular calcification [1–3] and with calcification of the stylohyoid complex [4].

The present study used panoramic radiograph technique to evaluate the correlation between variables osteoporosis, atheroma, and elongated styloid process. Nowadays, panoramic radiography technique is an excellent method for diagnosis of clinical conditions that affect the structures of

the stomatognathic system, thanks to the technical development of X-ray equipment, making it more accurate, mainly when we use digital image systems. This radiographic exam can produce important information on the general health condition of the patient, since detection of ectopic calcification is possible and able to relate with systemic condition. In this context, medical–dental professionals that routinely work with panoramic radiographs can contribute to identify and early detect diseases such as atherosclerosis and osteoporosis.

According to the results found in this research and within the limitations of the methodology used, association was found between elongated styloid process and atheroma, and between elongated styloid process and osteoporosis/osteopenia. The method in this study might be used as part of a method for osteoporosis and atheroma risk assessment. Further studies, measuring length of styloid process, using a larger sample and a group of patients with suspected osteoporosis are indicated. Also, limitation in the detection of calcifications in the carotid artery using panoramic radiographs should be considered and evaluated in future studies.

**Conflicts of interest** None.

## References

1. Danilevicius CF, Lopes JB, Pereira RM (2007) Bone metabolism and vascular calcification. *Braz J Med Biol Res* 40:435–442
2. Naves M, Rodriguez-Garcia M, Diaz-Lopez JB et al (2008) Progression of vascular calcifications is associated with greater bone loss and increased bone fractures. *Osteoporos Int* 19:1161–1166
3. Reddy J, Bilezikian JP, Smith SJ et al (2008) Reduced bone mineral density is associated with breast arterial calcification. *J Clin Endocrinol Metab* 93:208–211
4. Okabe S, Morimoto Y, Ansai T et al (2006) Clinical significance and variation of the advanced calcified stylohyoid complex detected by panoramic radiographs among 80-year-old subjects. *Dentomaxillofac Radiol* 35:191–199
5. Park JH, Omi N, Nosaka T et al (2008) Estrogen deficiency and low-calcium diet increased bone loss and urinary calcium excretion but did not alter arterial stiffness in young female rats. *J Bone Miner Metab* 26:218–225
6. Watanabe PAC, Campos M, Pardini LC (1998) Síndrome do proceso estilóide alongado (Síndrome de Eagle). *Revista da APCD* 52:487–490
7. Health OW (2004) Scientific group on the assessment of osteoporosis at primary health care level. World Health Organization, Brussels
8. Mortellaro C, Bianucci P, Picciolo G et al (2002) Eagle's syndrome: importance of a corrected diagnosis and adequate surgical treatment. *J Craniofac Surg* 13:755–758
9. Thot B, Revel S, Mohandas R et al (2000) Eagle' syndrome. Anatomy of the styloid process. *Indian J Dent Res* 11:65–70
10. Rizzatti-Barbosa CM, Ribeiro MC, Silva-Concilio LR et al (2005) Is an elongated stylohyoid process prevalent in the elderly? A radiographic study in a Brazilian population. *Gerodontology* 22:112–115

11. Battagel JM (1993) A comparative assessment of cephalometric errors. *Eur J Orthod* 15:305–314
12. Cousley RR, Grant E, Kindelan JD (2003) The validity of computerized orthognathic predictions. *J Orthod* 30:149–154 discussion 128
13. Siegel S (1977) *Estatística não-paramétrica para as ciências do comportamento*. Mc Graw-Hill do Brasil, São Paulo
14. Correll RW, Jensen JL, Taylor JB et al (1979) Mineralization of the stylohyoid-stylomandibular ligament complex. A radiographic incidence study. *Oral Surg Oral Med Oral Pathol* 48:286–291
15. Yoon SJ, Yoon W, Kim OS et al (2008) Diagnostic accuracy of panoramic radiography in the detection of calcified carotid artery. *Dentomaxillofac Radiol* 37:104–108
16. Albuquerque DF, Menezes AV, Carlos MX et al (2005) Detecção de calcificações na artéria carótida em radiografias panorâmicas: revisão da morfologia e patologia. *Clin Pesq Odontol* 2:129–136
17. Souza AE, Ciccone JC, Watanabe PCA et al (2004) Contribuição da radiografia panorâmica na detecção de ateromas em artéria carótida. *RGO—Revista Gaúcha de Odontologia* 52:83–85