

Evaluation of the Anatomical Variants of the Styloid Process in People Older than 20 Years

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Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT

Introduction: anatomical variants of the styloid process can cause clinical manifestations such as facial, neck, and ear pain and ischemic attacks due to compression of the internal carotid artery, all clinical manifestations of Eagle's syndrome that can be confused with alterations in the temporomandibular joint, so an early differential diagnosis is important. The objectives of this study were to evaluate the radiographic length of the styloid process, its elongation, its mandibular relationship, and its radiological pattern.

Material and Methods: In total, 652 images of the styloid process of people older than 20 years were analyzed through a retrospective evaluation of panoramic radiographs of a private clinic of Spain. The images were taken with a Kodak model 8000 Digital Panoramic System using Navigatium software, and measurements were made from the base of the temporal bone to the distal end of the styloid process. For the statistical analysis, the χ^2 test, dependent-samples t-test, kappa index, McNemar test, 1-way ANOVA model, and Kruskal-Wallis test were used.

Results: The mean radiological lengths of the left and right styloid processes were 27.26 ± 10.59 mm and 27.41 ± 10.64 mm, respectively. The prevalence of elongation was 28%, and this prevalence was similar on the left and right sides. The mandibular relationship class increased as the length of the styloid process increased.

Conclusion: Eighty-eight percent of patients between 51 and 60 years showed symmetry of the radiological pattern, the highest rate among the different age intervals, coinciding with the chronic development of the styloid process.

Keywords: "Eagle's syndrome"; "Elongated styloid"; "Styloid process"; "Panoramic radiography".

Introduction

The stylohyoid osteoligamentous system is formed by the styloid process of the temporal bone, which is attached to the hyoid bone by the stylohyoid ligament.¹ The styloid process is a thin and pointed bony eminence that arises from the inferior side of the petrous portion of the temporal bone and is directed in an anteroinferior direction toward the tonsillar fossa. Its vertex is located between the internal and external carotid arteries. Its location is considered clinically significant since it interacts with vital neurovascular structures such as the internal jugular vein, internal carotid artery, glossopharyngeal, vagus, accessory, and hypoglossal nerves.²

One of the most common variations of the styloid process is its elongation and/or the calcification of the stylohyoid ligament. The average length of the apophysis ranges between 20 and 30 mm and is considered elongated if it exceeds 30 mm,³ but it is also important to have an indication of its angulation through the mandibular relationship (classes 1, 2, and 3) and the ossification pattern (continuous or discontinuous) of the styloid process, to relate them to the presence of clinical symptoms associated with Eagle's syndrome.^{4,5}

The nonspecific symptomatology of Eagle's

syndrome makes it difficult to diagnose early.⁶ Its manifestations include cervical pain, otalgia, throat pain and foreign-body sensation, pain on neck rotation, headache, cervicofacial pain, dysphagia, shoulder pain, vertigo, tinnitus, and trismus, among others,^{5,7-9} so it is often confused with other orofacial, odontogenic, or temporomandibular diseases.¹⁰ In some cases, ischemic attacks can also occur due to compression or rupture of the carotid artery,¹¹⁻¹⁴ symptoms that increase the importance of an early diagnosis. To make an early diagnosis and assessment of the variants of the styloid process, we have digital panoramic radiographs as the first available and most simple test, as indicated by several studies in the literature.¹⁵⁻¹⁷

The objectives of this study were to evaluate the anatomical variability of the styloid process, its radiographic length, the prevalence of its elongation, its mandibular relationship (class 1: the vertex of the apophysis does not reach the mandibular ramus nor the angle of the mandible, class 2: the vertex reaches the mandibular ramus or the angle of the mandible; class 3: the vertex exceeds the angle of the mandible), and radiological pattern (continuous: single styloid bone formation; discontinuous: segmented or pseudoarticulated apophysis) in digital panoramic radiographs (Figure 1).

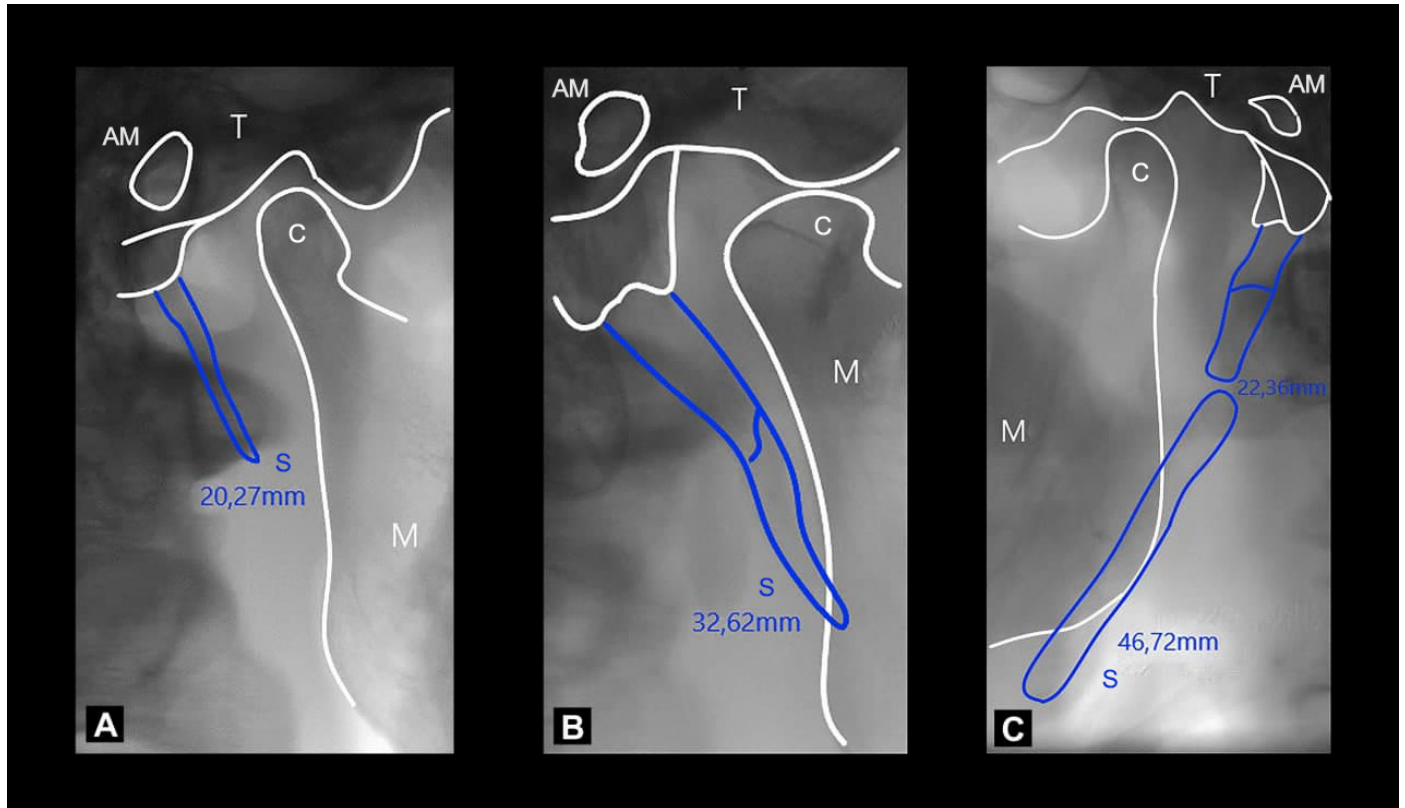


Figure 1. Anatomical variability of the styloid process. (T) temporal bone, (M)

Materials and Methods

For this study, we conducted a cross-sectional retrospective observational descriptive analysis in a study population of patients over 20 years of age who attended a private clinic in the city of Alicante, Spain, during the years 2013 to 2018 and signed the corresponding informed consent form for protection of their data. A simple convenience selection of 326 panoramic radiographs was performed. All met the eligibility criteria, such as age older than 20 years; images that allowed visualization of the mandible, the upper part of the hyoid bone, the external auditory meatus, and the mastoid process of the temporal bone; images where no trauma, surgical interventions, or pathology were observed; and images that were not distorted, with magnification errors, or of low quality.

All the data, selected together with the technician of the radiology department, were rigorously adjusted to the eligibility criteria, using only the age and sex of the patient as ceded data. Communication and treatment of the data followed Organic Law 15/1999, of December 13, Protection of Personal Data (BOE No. 298 of December 14, 1999) (Boletín oficial del Estado, 1999).

The images were taken by the same X-ray operator with Kodak equipment (Eastman Kodak Company, Rochester, NY, USA), a model 8000 Digital Panoramic System, for panoramic radiography. The program “Panoramic exam” was selected, and within this kilovoltage, the milliamperage and the exposure time

were determined by the parameters Type, which was always set as adult, and Size, which was calibrated to small, medium, or high depending on the complexion of the patient.

The images were stored and processed in PANO format using Navigatium software on an HP computer (Hewlett-Packard Company, Palo Alto, CA, USA) model Pavilion Desktop, with a Philips 246V5L screen of 24” and 1920 × 1080 pixels.

Before analysis, all the images were calibrated, and 20 panoramic radiographs were randomly selected with the reference anatomical traces, which were measured again by the same operator, to verify the coincidence and the absence of errors (intraoperator calibration). Then the same radiographs were measured by a collaborator outside the investigation to verify the interoperator calibration.

We proceeded to look for any indication of radiopacity that would reveal the existence of ossification at any level of the so-called stylohyoid apparatus in the radiographic area between the temporal and body of the hyoid.

The study variables examined were age, sex, side (left or right), elongation (length > 30 mm), radiological pattern (continuous or discontinuous), and mandibular relationship class (1, 2, or 3). The data obtained were recorded in a data collection form created for this purpose with the Microsoft Excel program, which was entered into SPSS 15.0 for statistical analysis using the χ^2 test, the dependent-sample t-test, the kappa index,

the McNemar test, the 1-way ANOVA model, and the Kruskal-Wallis test.

Results

A total of 652 images of the styloid process were analyzed in digital panoramic radiographs. The mean patient age was 50.7 years (range from 20 to 87 years), with a female prevalence of 79.4% in the sample. The mean radiological length of the styloid process was recorded as 27.26 ± 10.59 mm and 27.41 ± 10.64 mm for the left and right sides, respectively. There was symmetry in length, with an average difference between sides of 0.15 ± 8.18 mm (p = 0.747).

Regarding the variability of the length of the styloid process, 27.9% of the images presented elongation (> 30 mm), with no differences (p = 0.833) between the right (27.6%) and left sides (28.2%). However, the prevalences of right and left elongation were significantly higher in men (43.3%, 41.8%, respectively) than in women (23.6%, 24.7%) (p = 0.001, p = 0.006).

The distribution of styloid process elongation by age showed that on the right side, 22.1% of patients younger than 40 years had an elongated apophysis, 30.3% of those 41 to 50 years, 30.5% of those aged 51 to 60 years, and 28.3% of those over 60 years. The prevalence was similar across age groups (p = 0.592). On the left side, elongation was detected in 30.3% of patients younger than 40 years, in 26.9% of those 41 to 50 years, in 30.5% of those 51 to 60 years, and in 26.1% of those older than 60 years (Figure 2).

In each sex or age group, symmetry between sides was detected (p > 0.05), which was less evident among the youngest due to its greater length on the left side (p = 0.065).

A radiological image of the styloid process with a mandibular relationship of class 1 prevailed in 48% on the right side and 56.4% on the left side; class 2, 35.6% and 38.3%; and class 3, 6.4% and 5.2%, respectively. There was a directly proportional relationship between the length and the class on each side. That is, the length in class 1 (22 mm left side/21.9 mm right side) was significantly lower than the length in class 2 (32.1 mm/32.2 mm), which was significantly less than the length in class 3 (55 mm/50.3 mm). A proportional increase in the prevalence of the discontinuous radiological pattern and the mandibular relationship class was also observed: class 1 (left 24.5%/right 25.4%), class 2 (40.8%/41.4%), and class 3 (82.4%/76.2%).

The class 1 mandibular relationship prevailed in women, at 61% on the right side, while this rate was 46.3% in men on the right side. Class 2 described 35.9% of women and 47.8% of men on the left side. Class 3 described 5.4% of women and 10.4% of men on the right side.

According to the distribution of mandibular relationships by age, class 1 prevailed in the group < 40 years old, with 65.1% and 69.8% on the left and right sides, respectively; class 2 prevailed, with 44.1%, in the group of 51-60-year-olds on the left side and with 41.6% in the group of 41-50-year-olds on the right side;

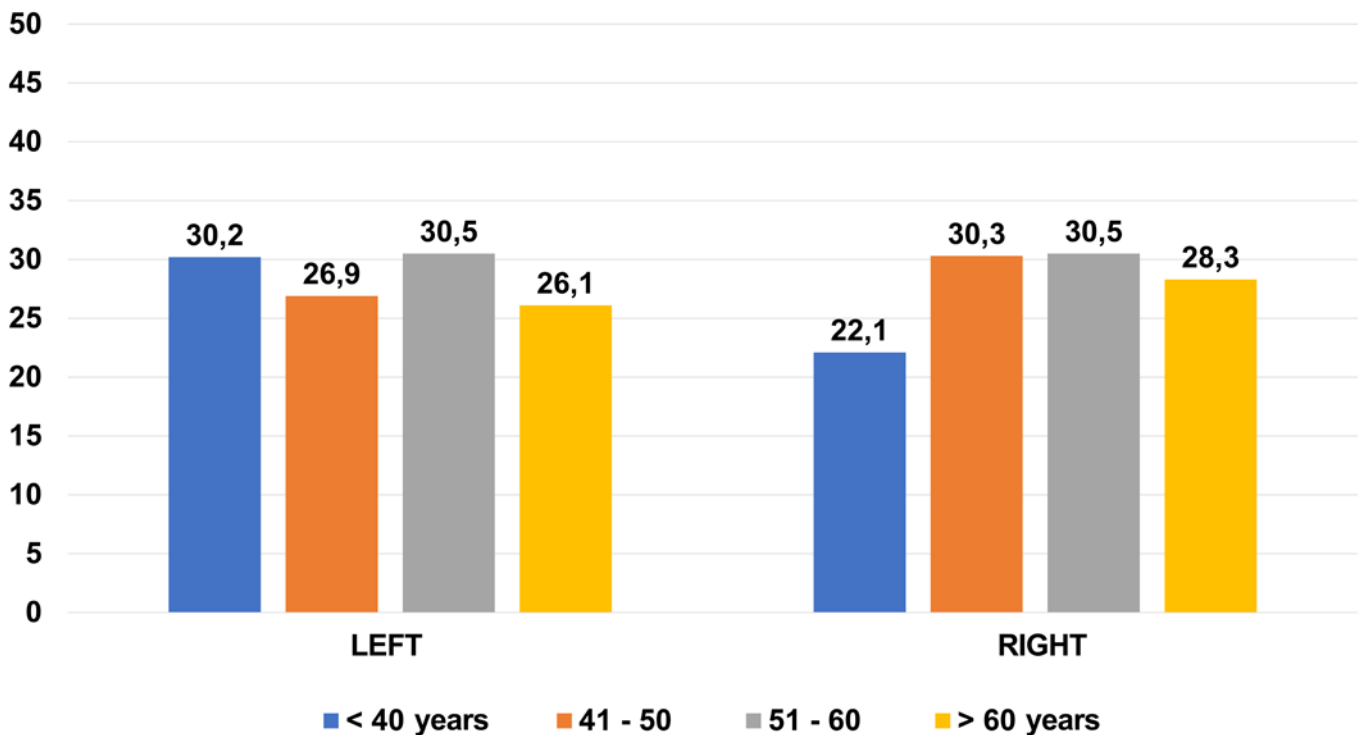


Figure 2. Prevalence of an elongated styloid process according to age by side (in %).

and class 3 was more common in the group > 60 years than in any other group, with 7.6% on the left side and 8.7% on the right. These data show the possible relationship of elongation or calcification of the styloid process with age > 60 years, where a fair prevalence of class 3 was observed on both sides (Figures 3 and 4).

In terms of the radiological pattern, below we will describe the discontinuous anatomical variant of the styloid process. The percentages were similar for both sides 33.7% left and 34.4% right, without significant differences by sex.

Figure 5 shows the percentages of the discontinuous pattern, which exhibited certain changes according to

the age of the patient, although it was only significantly common on the left side ($p = 0.038$) or when both sides were considered together ($p = 0.010$).

Discontinuity decreased with age, though it reached a minimum between 51-60 years and in the oldest group rebounded to the level of 41-50-year-olds. On the right side, the descriptive trend was the same, but there is not as much heterogeneity. On the left side, the highest rate, in the youngest group (43%), was far from the lowest rate of 20.3% seen in the 51-60-year-olds, which explains the significance detected. The symmetry of the radiological pattern strongly depended ($p = 0.065$) on the age of the patient.

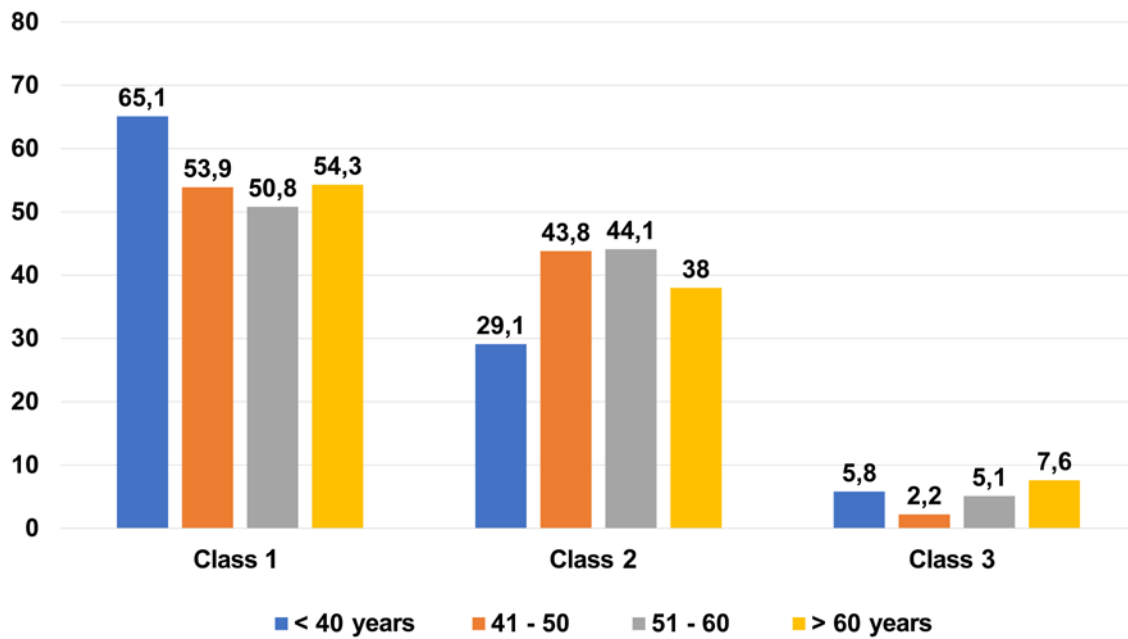


Figure 3. Mandibular relationship of the styloid process according to age on left side (in %).

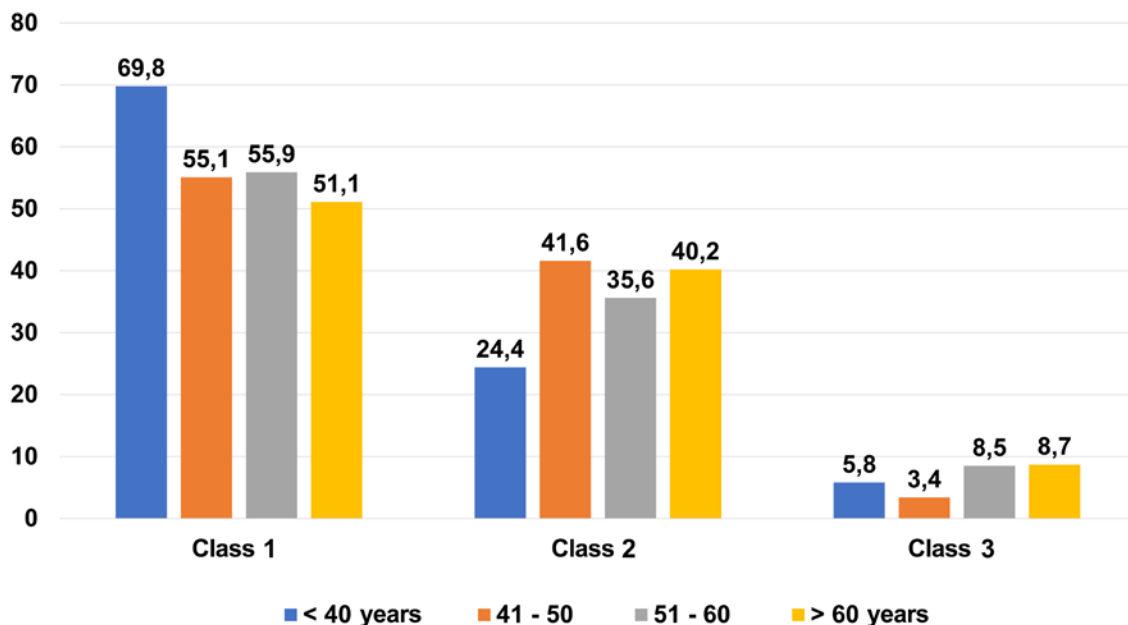


Figure 4. Mandibular relationship of the styloid process according to age on right side (in %).

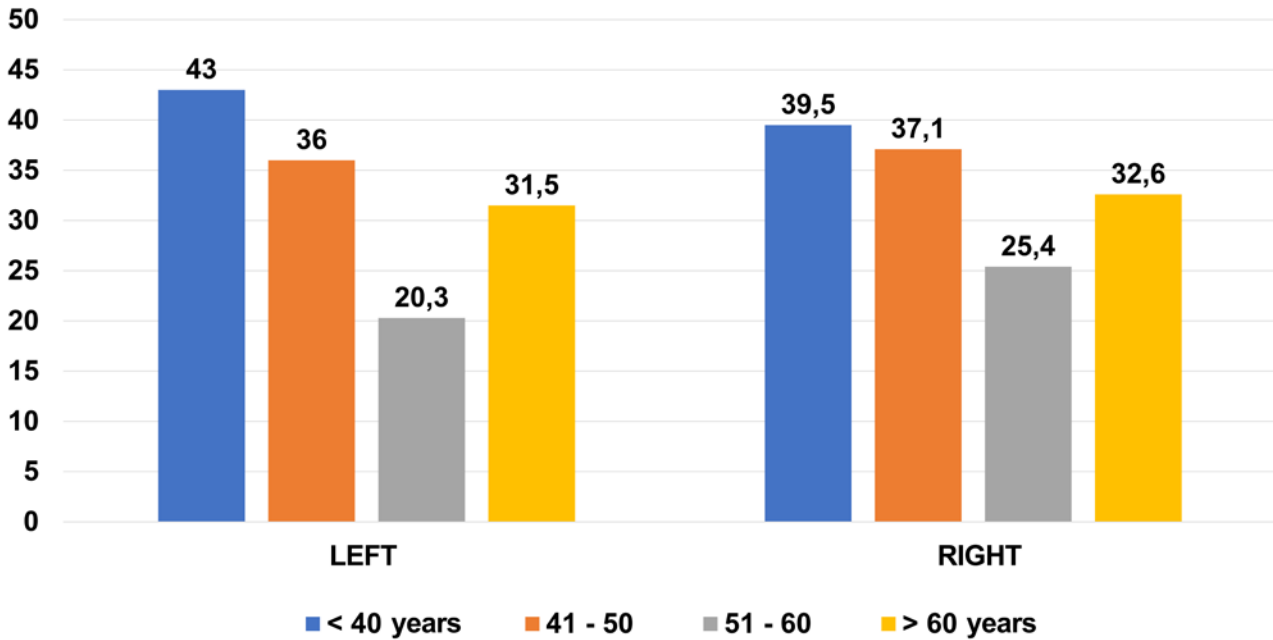


Figure 5. Discontinuous pattern of the styloid process as a function of age per side (in %).

Discussion

The average radiological length of the styloid process in our study was 27.26 ± 10.59 mm and 27.41 ± 10.64 mm on the left and right sides, respectively, comparable to the findings of other studies, such as the one performed in a population of Sri Lanka using panoramic radiographs, which reported an average length of 25.5 ± 5.5 mm on the left and 26.9 ± 5.4 mm on the right.¹⁸

The prevalence of elongation of the styloid process in this study was 28%, in line with the data reported in previous studies, where the incidence was 33%, 29%, 28%, or 30%.^{16, 18-20} However, other studies using digital panoramic radiography have reported a prevalence of elongated styloid processes of 51% and 55.8%, respectively.^{21, 22} The discrepancies in these rates can be attributed to the differences in the population, their ethnic origin, and the criteria for the acquisition and interpretation of images.

The data on the incidence of elongated apophysis according to sex are inconclusive. Some studies, such as ours, report a higher prevalence in males,^{18, 23} and others in females.¹⁵ Due to the lack of consensus, sex is not considered a relevant aspect in the etiology of this anatomical variation.

The elongation of the apophysis in relation to age shows a chronic development of calcification.^{24, 25} Our results agree with this trend, showing a higher incidence and symmetry of elongated apophysis in patients between 51 and 60 years.

In the radiographic images of the styloid process, we studied its relationship with the mandible, since some authors^{4, 26, 27} consider that its anteromedial projection

may be related to the appearance of symptoms in patients. We measured the reach or exceedance of the styloid process in relation to the mandible, which indicates an increase in length and medial angulation, which is why those of class 1, which do not reach the mandible, are not likely to arouse symptoms, while those of classes 2 and 3 are, but more studies are required to confirm this statement.

The classification by O'Carroll (1984)²⁸ describes high stylohyoid ossifications located between the temporal bone and mandibular foramen, medium ossifications between the mandibular foramen and the angle of the mandible and low ossifications between the angle of the mandible and the lesser horn of the hyoid. The low O'Carroll ossifications had a frequency of 0.6% and would be equivalent to the class 3 relationship described in this study with a rate of 5.8%.

Ruprecht *et al.* (1988)²⁹ used lines to divide the area between the temporal bone and the hyoid into five areas, of which only the fourth category of its classification places the ossifications between the lower edge of the mandible and the lesser horn of the hyoid is comparable to mandibular class III and showed a frequency of 1.2% for the 40-49-year age group and 3.6% for those aged 50-59 years. In their results, as in ours, the locations that exceeded the angle of the mandible were more frequent in the older age groups (2.8% for the 41-50 group and 6.8% for the 51-60 group).

In this study, a predominance of the –unilateral– discontinuous radiological pattern was found on the left side, as in the work of Gomes do Nascimento *et al.* (2015)²¹. Processes with a discontinuous pattern were considered to be those classified as pseudoarticulated or segmented class II or III by Langlais *et al.* (1986)³.

Conclusions

The present study contributes to the knowledge on the radiographic evaluation of the styloid process and its anatomical variations. Slightly more than a quarter of our sample presented an elongated styloid process. No significant relationship was observed between sex any variable studied. A positive association was seen between the mandibular relationship class and the radiological length or the presence of a discontinuous pattern of the styloid

process, and class 3 cases were more frequent in older age groups. Patients aged between 51 and 60 years showed the highest rate of symmetry of the radiological pattern, coinciding with the chronic development of calcification of the styloid process described in the literature.

Acknowledgments

We thank Alba Lledó for her help with the preparation of the study sample.

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Mini Curriculum and Author's Contribution

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Received: September 3, 2021
Accepted: November 1, 2021

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