

Radiomorphometric analysis of elongated styloid process in Udaipur population- a crosssectional study.

Running title- A CBCT study of styloid process and its variations in Udaipur population

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Abstract

Background: The styloid process (SP) elongation is known as Eagle syndrome when it causes clinical symptoms such as neck and cervicofacial pain. There can be several variations of the styloid chain, including the length of the process, thickness of the segments, angle and direction of the deviation, and the degree of ossification.

Aim and objectives: The present study was aimed to study the prevalence, morphology and calcified pattern of elongated styloid process on digital panoramic radiograph in right and left side according to Langlais et al.

Methods and materials: A total of 500 digital panoramic radiographs were obtained from digital panoramic system (X mind PANO D Plus) at 73 kvp, 10mA and 0.12 sec in the age group of 18-70 years

were chosen. The length of the styloid process was measured from the base of the tympanic plate to the tip of the process with the Dicom Software.

Results: In our study the prevalence of different variants of styloid process were as follows: non elongated styloid process (55.21%), elongated left side styloid process (5.43%), elongated right side styloid process (5.26%), elongated bilateral styloid process (34.10%). Type I morphology and Pattern B calcification was most common in all age groups. There was no statistically significant difference observed between genders and sides for styloid process elongation.

Conclusion: Panoramic radiography plays an important role in patients with symptoms of styloid process elongation. Elongation or calcification of SP in older adults was common without gender predilection in the present study.

Keywords: Styloid process, morphology, calcification, panoramic radiography.

Introduction

The styloid process elongation is known as Eagle syndrome. Embryologically, the styloid process, the stylohyoid ligament and the lesser cornu of the hyoid bone are developed from the second branchial arch cartilage called Reichert's cartilage. Because it is of the cartilaginous origin, the ligament has the potential to mineralize.^[1] There can be several variations of the styloid chain, including the length of the process, thickness of the segments, angle and direction of the deviation, and the degree of ossification. Therefore, it is necessary to define the type of elongation and calcification of each styloid in order to describe its radiographic appearance.^[2]

Dr. Watt Eagle proposed that surgical trauma (tonsillectomy) or local chronic irritation causes osteitis, periostitis, or tendonitis of the styloid process and the stylohyoid ligaments which results in reactive, ossifying hyperplasia.^[3]

Early, Eagle reported that the normal styloid process was ~2.5 cm in length, and any process longer than 2.5 cm might be considered abnormally elongated. An elongated styloid process is incidental in about 4% of the general population with a female-to-male predominance of 3:1. Patients are usually greater than 30 years of age, and this is usually a bilateral process (although unilateral cases are also seen).^[4]

Among the several imaging modalities used for diagnosis of the Eagle syndrome, panoramic radiography, lateral skull radiograph, Towne's view radiograph, anteroposterior skull radiograph, and CT scan are some of them. The complete details of the length, angulation, and relation to adjacent structures can be obtained from a CT scan by formulating a 3D-CT. Both Orthopantomogram (OPG) and CT can be used to assess the styloid process/stylohyoid ligament complex. In cases where mechanical vascular compression is potentially the cause of ischemic symptoms, angiographic examination (CT angiography or catheter angiography) should be obtained with the patient's head appropriately positioned to reproduce symptoms that may demonstrate mechanical stenosis of the carotid artery.^[5]

The wide variation seen in the studies conducted in different locations could be due to variations in the diagnostic and interpretation tools. Thus, there was a need to determine the prevalence and elongation of styloid process in relation to gender, sub age groups for understanding its variations among Udaipur population.

Materials and Methods

After due approval of Institutional Ethics Committee, this cross-sectional study was carried out in the department of oral medicine and radiology at a Darshan Dental dental college and hospital, during 2022. The study was designed to measure the dimensions of the styloid process for variations in morphological and calcification pattern in right and left side on digital panoramic radiographs. The study population comprised 500 images above the age of 18 years. They were previously referred to the radiology

department for several other reasons. Informed consent was taken from all the participants at the time of taking the scan that required data from their Panoramic scans can be used for further retrospective studies. Digital panoramic radiographs in which both right and left styloid process were visible from base till the tip of styloid process and subjects above 18 years of both genders were included. Radiographs with positioning and magnification error and stylohyoid process not visible were excluded. All the radiographs were taken Digital panoramic system (X mind PANO D Plus) at 73 kvp, 10 mA and 0.12 sec. The measurement of the styloid process dimensions was done directly on DICOM software. The magnification factor for the machine was taken in consideration.

The selected radiographs were divided into four groups.

Group A: 18-29 years

Group B: 30-39 years

Group C: 40-49 years

Group D: 50 and above years

The greatest dimension of styloid process were measured from base to the tip of styloid process.[figure 1]

The radiographic appearances of styloid process and calcification pattern was graded according to Langlais et al.^[6]



Measurement of styloid process from base to tip.

The morphological variations of styloid process were

- i. Type I-elongated,
- ii. Type II-pseudo articulated,
- iii. Type III-segmented

The calcification variations of styloid process were

- i. Calcified outline,
- ii. partially calcified,

- iii. Nodular,
- iv. completely calcified

All the measurements obtained were entered into the Excel sheets and were subjected to statistical analysis.

Statistical analysis

Data were analyzed using SPSS version 21.0. Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean and standard deviation quantitative variables were compared using the one way ANOVA test (i.e., styloid process measurements and age) and independent t-test (i.e., styloid process measurements and sex). Chi-square test were used to determine the relationship between two scale parameters, whereas the correlation was defined as a measure of the strength of a linear variation between two variables. The p value ≤ 0.05 was considered as statistically significant.^[7]

Results

The study sample comprised 500 subjects aged between 18 and 70 years with a mean age of 45 years. About 240 (48%) subjects were female and 260 (52%) of them were male. The subjects were categorized into four age groups: 18-29 years, 30-39 years, 40-49 years, 50 and above years.

Using an independent t-test, association of the variations of length of styloid process was estimated. It was seen that the percentage of non elongated styloid process was maximum in all the age groups [Table 1].

Table 1: Distribution of variants of styloid process in study population

| Variant of styloid process | Percentage |
|--------------------------------------|------------|
| Non Elongated styloid process | 55.21% |
| Elongated Left side styloid process | 5.43% |
| Elongated Right side styloid process | 5.26% |
| Elongated bilateral styloid process | 34.10% |

The overall mean age of all study participants with elongated styloid process was 37.64 ± 7.3 years. The mean age of study participants with non elongated styloid process was 32.35 ± 6.1 years. The difference was highly significant statistically. The mean age was greater in study participants with elongated styloid process. [$P < 0.001$]. In males the mean age for elongated styloid process was 40.34 ± 7.6 years and non elongated styloid process was 30.38 ± 6.1 years. [$P < 0.001$] The mean age was greater in study participants with elongated styloid process. While in female group, The mean age of elongated styloid process was 34.94 ± 7.1 years and non elongated styloid process was 34.12 ± 5.9 years. The difference non-significant statistically [$P > 0.05$]. [Table 2]

Table 2: Comparison of difference in mean age between the study population, male and female in total study population

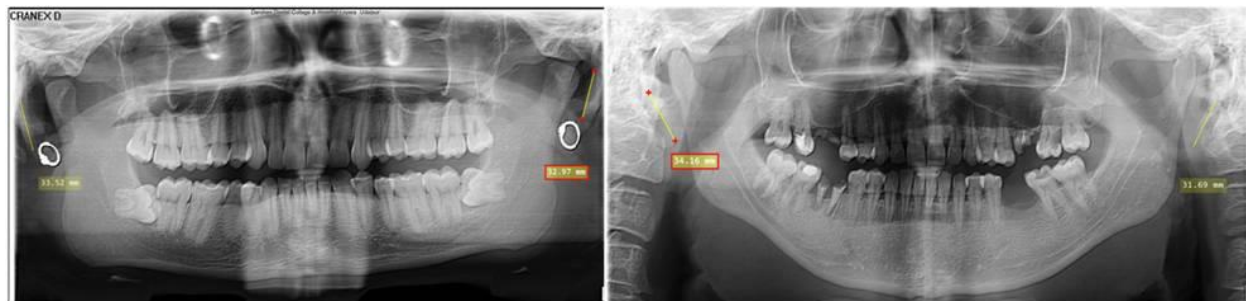
| Age group | | Mean age (years) | SD | t value | Sig |
|-----------|---------------|------------------|-----|-----------|--------------------------------|
| Overall | Elongated | 40.34 | 7.6 | t = 24.01 | P < 0.001 Strongly significant |
| | Not Elongated | 30.38 | 6.4 | | |
| Male | Elongated | 40.34 | 7.6 | t = 24.01 | P < 0.001 Strongly significant |
| | Not Elongated | 30.38 | 6.4 | | |

| | | | | | |
|---------|---------------|-------|-----|----------|-------------------------|
| Females | Elongated | 34.94 | 7.1 | t = 1.42 | P >0.05 Non-significant |
| | Not Elongated | 34.12 | 5.9 | | |

Chi-square test was applied to determine the association of morphological variation and side of calcification in styloid process in different age groups of subjects. The Type I morphological variant on left side, right side and bilaterally was 13%, 12% and 36%. The Type II morphological variant on left side, right side and bilaterally was 08%, 10%, 24%. The Type III morphological variant on left side, right side and bilaterally was 04%, 09% and 22%. While in group A, B,C and D, the type I [elongated, figure 2] morphological variant in male were most commonly seen then female.[table 3]

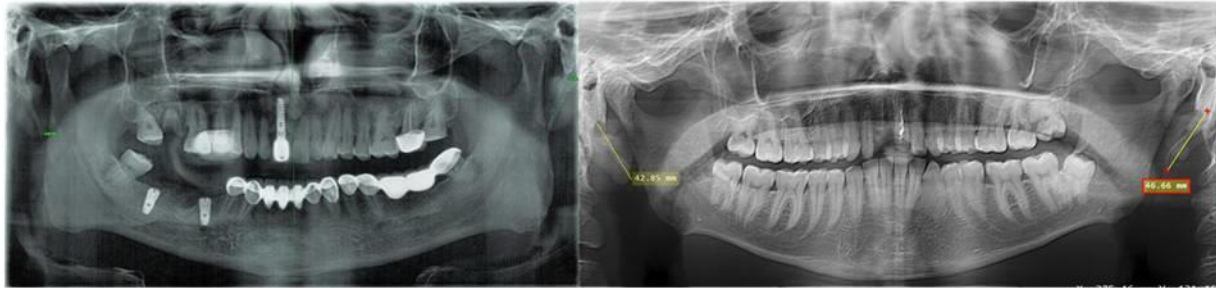
Table 3: Prevalence of type of morphology among group A, B,C and D

| Group | Morphological type | Male (%) | Female (%) |
|-------|--------------------|----------|------------|
| A | Type I | 30 | 26 |
| | Type II | 10 | 9 |
| | Type III | 7 | 6 |
| B | Type I | 37 | 16 |
| | Type II | 12 | 6 |
| | Type III | 8 | 3 |
| C | Type I | 32 | 20 |
| | Type II | 16 | 5 |
| | Type III | 12 | 3 |
| D | Type I | 34 | 23 |
| | Type II | 13 | 2 |
| | Type III | 14 | 4 |



Most common morphological pattern (type 1) in all the groups.

One-way ANOVA was applied to determine the prevalence of calcification pattern in right, left and bilaterally. The prevalence of Pattern A styloid calcification on left side, right side and bilaterally was 14%, 13%, 24%. The prevalence of Pattern B styloid calcification on left side, right side and bilaterally was 17%, 16%, 37%. The prevalence of Pattern C styloid calcification on left side, right side and bilaterally was 05%, 08%, 20%. The prevalence of Pattern D styloid calcification on left side, right side and bilaterally was 03%, 02% and 12%. While in group A, B,C and D, the pattern B [partially calcified, figure 3] morphological variant in male were most commonly seen then female.[table 4]



Most common calcification pattern (pattern B) in all the groups.

Table 4: Prevalence of pattern of calcification among group A,B,C and D

| Groups | Styloid Calcification | Male (%) | Female (%) |
|--------|-----------------------|----------|------------|
| A | Pattern A | 8 | 6 |
| | Pattern B | 46 | 37 |
| | Pattern C | 4 | 3 |
| | Pattern D | 2 | 1 |
| B | Pattern A | 9 | 7 |
| | Pattern B | 47 | 18 |
| | Pattern C | 2 | 1 |
| | Pattern D | 3 | 2 |
| C | Pattern A | 13 | 12 |
| | Pattern B | 51 | 48 |
| | Pattern C | 2 | 1 |
| | Pattern D | 3 | 2 |
| D | Pattern A | 17 | 15 |
| | Pattern B | 54 | 45 |
| | Pattern C | 6 | 5 |
| | Pattern D | 4 | 3 |

Discussion

The elongation of the styloid process and structural changes in stylohyoid ligament with its clinical symptoms and signs were first described by Eagle. Hence, it is termed as the Eagle’s syndrome. The styloid process palpation in the tonsillar fossa is indicative of SPE which are not normally palpable. If highly suspicious for Eagle’s syndrome, confirmation can be done by radiographic imaging. The pathophysiology behind the pain due to elongated styloid process was compression of the neural elements, the glossopharyngeal nerve, lower branch of the trigeminal nerve, and/or the chorda tympani by the elongated styloid process. The compression further leads to proliferation of granulation tissue that causes continuous pressure on surrounding structures and results in pain.^[8,9]

The important radiographic views taken for evaluation of styloid process are Panoramic, Lateral oblique of ramus of mandible, Towne’s view, AP view, Transpharyngeal view, and CT scan. Since the styloid process may exhibit anatomical variations that differ from person to person and population to population.^[10]

Panoramic radiographic techniques usually distort the dimension of the styloid process and produce magnification of the radiographic image which depends on the angulations of the process itself. Therefore, a simple millimeter measurement is not a suitable criterion because of the radiologic factors involved. Taking this factor into consideration, to determine the length of styloid process, ruler

measurement was not chosen. The elongated styloid process in the radiographs were determined according to the method proposed by Ferrario et al.^[11]

According to our knowledge, the present study is the first report investigating the styloid process elongation prevalence, morphology, and calcification pattern and its relation to subject gender and age on digital panoramic radiographs in Udaipur population.

In our study the prevalence of different variants of styloid process were as follows: non elongated styloid process (55.21%), elongated left side styloid process (5.43%), elongated right side styloid process (5.26%), elongated bilateral styloid process (34.10%). The prevalence of non Elongated styloid process was maximum followed by elongated bilateral styloid process. The mean age of elongated styloid process in total study population was 37.64 ± 7.3 years while mean age of non elongated styloid process was 32.35 ± 6.1 years. The difference was significant statistically showing increase in cases of elongation of styloid process on increasing age. Type I calcification and Pattern B calcification was most common in all age groups.

Previous studies by Bozkir et al^[12] reported the bilateral elongation in 75% and unilateral in 25% of cases on panoramic radiography. Our study also showed that in elongated styloid process 77.9% of cases were bilateral and 22.2% cases were unilateral. More CB and Asrani MK^[13] conducted the study on styloid process elongation by using 500 digital panoramic radiographs. They found that the average length of the left and right styloid was 25.41 ± 6.32 mm and 25.53 ± 6.62 mm. The length of both styloid increased with age and males had longer styloid than females. Elongated styloid were present in 19.4% of the panoramic radiographs. Langlais type I elongated styloid and a partial calcification pattern were more common than others which was similar with our study. They concluded that panoramic radiography was useful for detection of an elongated styloid process and / or ossification of the stylohyoid ligament in patients with or without symptoms, and helps avoid a misdiagnosis of tonsillar pain or pain of dental, pharyngeal, or muscular origin.

Subbulakshmi AC^[14] conducted a study on Central Brazilian population and its relation to gender, age and side. Digital panoramic radiographs of 736 patients (412 female and 324 males, with a mean age of 35.03 years) were used. Styloid process measuring more than 30 mm was considered elongated which was in accordance with our study. They concluded that the prevalence of elongated styloid process was high and no statistically significant correlation was found between the presence of elongated styloid process [SPE] and the studied variables with the exception of the age.

Shete M, Khalekar Y and Byakodi R^[14] conducted the study on 500 digital panoramic radiographs. They concluded that Panoramic radiography is useful for detection of an SPE and/or ossification of the stylohyoid ligament in patients with or without symptoms and helps to avoid a misdiagnosis of tonsillar pain or pain of dental, pharyngeal, or muscular origin.

Gupta N, Khan M, Doddamani LG, Kampasi N and Ohri N^[15] conducted research on 80 digital panoramic radiograph to study the type of SP as per Langlais classification. The average length of the left and right-side SPs was 29.1882 ± 6.86 and 28.16 ± 6.44 , respectively. Majority of patients were found to be asymptomatic, and Langlais, Type I elongated SP was more common than others. They concluded that Digital panoramic radiographs are valuable tools in early detection of elongated SP which was in accordance to our study.

Chaurasia A, Chaudhary A and Patil R^[16] conducted the research on 200 panoramic radiographs with aims at age and sex related changes in styloid process. The one-way ANOVA test showed that length of right styloid process is statistically significant ($p < 0.05$) and slightly higher in 36 to 50 years of age group.

However, length of Left styloid process was not differed ($p>0.05$) between the age groups i.e. found to be statistically the same which was similar to our study. They concluded that the length of styloid process can be used as morphometric tool in determination of age and sex of a particular individual having gender identification and age issues.

Katti G, Puranik K, Shahbaz S, Ghali S^[17] conducted a study on 120 digital panoramic radiographs with an age range of 21-60 years to determine the incidence of type/patterns of calcification in SP and correlation between types and patterns of calcification of styloid process with age and gender. The most common type & pattern in all the age groups was Type I & Type A of styloid process respectively. On comparison with male and female the most common type of styloid process is Type I and most frequent pattern is Type A which was in accordance to our study.

The precise knowledge about anatomy of both normal and abnormal styloid process is important for clinicians, surgeons, and radiologists. The study by Bagga M et al^[18] highlighted the prevalence of anatomic-radiological features of elongated Styloid process on panoramic radiography using 1706 digital panoramic radiographs. It was observed that bilateral elongation having “Elongated” Type SP with “partially calcified” pattern was the most frequent SP. although elongated Styloid was more prevalent among male population ($P < 0.001$). It was concluded that dentists should recognize the existence of morphological variation in elongated Styloid process apparent on panoramic radiographs. According to our knowledge, this is the first study conducted in Solan region to evaluate Styloid process elongation (SPE) and also had recorded highest prevalence of SPE in comparison with other studies conducted in Indian population. Authors found calcification of the Styloid process is common in older age groups with no correlation to gender and site predilection. “Type I” with “partially calcified” of the Styloid process was observed most frequently in the population studied.^[19]

Kashyap RR et al^[20] aimed to analyze the prevalence of various morphological patterns of the styloid process in South Indian population using 1200 digital panoramic radiographs. It was found that among the types of the styloid process, elongated type was the most common type present on both the sides. Among the patterns of calcification, completely calcified was the most common type observed, followed by calcified outline pattern which was in accordance to our study. It was concluded that it is important for the clinicians to be aware of the variations seen in the morphological pattern of the styloid process as panoramic radiograph is a routine screening radiograph.

Limitations

The study has few limitations; panoramic radiography is a 2D imaging technique, further advanced imaging studies are required to correlate the symptoms, dietary patterns, lifestyles and styloid process elongation.^[21]

Conclusion

Panoramic radiography plays an important role in patients with symptoms of styloid process elongation and can thus help to avoid misinterpretation of the symptoms as tonsillar pain or pain of dental, muscular, or pharyngeal origin. Elongation or calcification of SP in older adults was common without gender predilection in the present study. “Type I Morphology” Styloid Process was observed most frequently in the population studied. Since panoramic radiography is a 2D imaging technique, further advanced imaging studies are required to correlate the symptoms, dietary patterns, lifestyles and styloid process elongation.

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Conflicts of interest- There are no conflicts of interest.

References

1. Zhang FL, Zhou HW, Guo ZN, Yang Y. Eagle Syndrome as a Cause of Cerebral Venous Sinus Thrombosis. *Can J Neurol Sci* 2019 May;46(3):344-345.
2. Qureshi S, Farooq MU, Gorelick PB. Ischemic Stroke Secondary to Stylocarotid Variant of Eagle Syndrome. *Neurohospitalist* 2019 Apr;9(2):105-108.
3. Omami G. Retromandibular Pain Associated With Eagle Syndrome. *Headache* 2019 Jun;59(6):915-916.
4. Montevicchi F, Caranti A, Cammaroto G, Meccariello G, Vicini C. Transoral Robotic Surgery (TORS) for Bilateral Eagle Syndrome. *ORL J Otorhinolaryngol Relat Spec* 2019;81(1):36-40.
5. Vadgaonkar R, Murlimanju BV, Prabhu LV, Rai R, Pai MM, Tonse M, Jiji PJ. Morphological study of styloid process of the temporal bone and its clinical implications. *Anat Cell Biol* 2015 Sep;48(3):195-200.
6. Langland OE, Langlais RP, Preece JW. Principles of dental imaging. 2nd ed. Baltimore, MD. Lippincott Williams & Wilkins 2002.
7. Péus D, Kollias SS, Huber AM, Huber GF. Recurrent unilateral peripheral facial palsy in a patient with an enlarged styloid process. *Head Neck* 2019 Mar;41(3):E34-E37.
8. Lavine MH, Stoopack JC, Jerrold TL. Calcification of the stylohyoid ligament. *Oral Surg Oral Med Oral Pathol* 1968 Jan;25(1):55-8.
9. Patil S, Ghosh S, Vasudeva N. Morphometric study of the styloid process of temporal bone. *J Clin Diagn Res* 2014 Sep;8(9):AC04-6.
10. Ilguy M, Ilguy D, Guler N, Bayirli G. Incidence of the type and calcification patterns in patients with elongated styloid process. *The Journal of International Medical Research* 2005; 33:96–102.
11. Bozkir MG, Boga H, Dere F. The evaluation of elongated styloid process in panoramic radiographs in edentulous patients. *Tr J Med Sci* 1999;29:481-5.
12. More CB, Asrani MK. Evaluation of the styloid process on digital panoramic radiographs. *The Indian Journal of Radiology and Imaging* 2010; 20:261-265.
13. Subbulakshmi AC, Mohan N, Thiruneervannan R, et. al. Positioning errors in digital panoramic radiographs: A study. *Journal of Orofacial Sciences* 2016 8(1), 22-26.
14. Shete M, Khalekar Y, Byakodi R. Evaluation of styloid process using digital panoramic radiographs. *SRM Journal of Research in Dental Sciences* 2015;6(4):215-219.
15. Gupta N, Khan M, Doddamani LG, Kampasi N, Ohri N. A study on assessment of the length of styloid process in digital panoramic radiographs. *Journal of Indian Academy of Oral Medicine and Radiology* 2015; 27:516-519.
16. Chaurasia A, Chaudhary A, Patil R. Morphometric evaluation of styloid process on digital panoramic radiograph-A radio anthropometric study. *Journal of Oral Medicine, Oral Surgery, Oral Pathology and Oral Radiology* 2017; 3(3):130-135.
17. Katti G, Puranik K, Shahbaz S, Ghali S. The Evaluation of the Type & Calcification Patterns in Styloid Process: A Retrospective Digital Radiographic Study. *Scholars Journal of Dental Sciences* 2017;4(11):480-485.
18. Bagga M, Bhatnagar D, Kumar N. Elongated styloid process evaluation on digital panoramic radiographs: A retrospective study. *J Indian Acad Oral Med Radiol* 2020;32:330-4.
19. Czako L, Simko K, Thurzo A, Galis B, Varga I. The Syndrome of Elongated Styloid Process, the Eagle's Syndrome-From Anatomical, Evolutionary and Embryological Backgrounds to 3D Printing and Personalized Surgery Planning. Report of Five Cases. *Medicina (Kaunas)* 2020 Sep 9;56(9):458-462.

20. Kashyap RR, Kashyap RS, Naik V, Kini R. The styloid process: Morphological variations in South Indian population. *Indian J Otol* 2015;21:25-8.
21. Sridevi K, Mahesh N, Krishnaveni B, Deepika ADN, Thejasri V, Leninson BHD. Evaluation of Styloid Process and Its Anatomical Variations: A Digital Panoramic Study with Systematic Review. *J Int Soc Prev Community Dent* 2019 May-Jun;9(3):256-262.