

Morphometrical Evaluation of the Styloid Process in Dry Human Skulls in South Indian Population

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Abstract

Background: The styloid process (SP) is a slender bony projection from the temporal bone, averaging 2.5 cm in length. It exhibits variations in length, curvature, and thickness, which may have clinical implications, particularly in Eagle's syndrome. This study is aimed to evaluate the morphological and morphometrical characteristics of the SP in dry human skulls. **Material and Methods:** A descriptive study was conducted on 100 dry human skulls from the Department of Anatomy, SABVMCRI, Bengaluru, over three months. Skulls with broken or eroded SPs were excluded. SP curvature, length, and thickness (at base, midpoint, and tip) were measured bilaterally. Data were analyzed using descriptive statistics in SPSS software. **Results:** The mean SP length was 18.2±4.16 mm (right) and 16.4±1.48 mm (left). Mean thickness at the base, midpoint, and tip was 4.63±0.37 mm, 3.62±0.26 mm, and 2.31±0.48 mm (right), and 4.85±0.47 mm, 4.10±0.17 mm, and 1.92±0.41 mm (left), respectively. Most SPs were straight (66 right, 82 left). Elongated SP (>30 mm) was rare, occurring in only 1% of specimens. **Conclusion:** The SP in this South Indian sample displayed predominantly straight morphology, shorter lengths, and low prevalence of elongation compared to earlier reports. These results provide valuable baseline data for anatomists, radiologists, and ENT surgeons, aiding in the diagnosis and management of clinical conditions such as Eagle's syndrome.

Keywords: Styloid process, Temporal bone, Morphology, Morphometry, Eagle's syndrome.

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INTRODUCTION

The styloid process (SP) is a slender, pointed bony projection extending from the temporal bone, with an average length of approximately 2.5 cm in adults. Although typically straight, the SP may exhibit an anteromedial curvature. Anatomically, it is closely related laterally to the parotid gland, with the facial nerve crossing its base and the external carotid artery situated near its tip.^[1] Medially, the SP lies in close proximity to the internal carotid artery, the sympathetic chain, the internal jugular vein, and several cranial nerves, which are - accessory, hypoglossal, vagus, and glossopharyngeal nerves.^[2]

The apex of the SP is connected to the ipsilateral lesser cornu of the hyoid bone via the stylohyoid ligament. Embryologically, the SP originates from the second branchial arch.^[3]

A SP is considered elongated when its length exceeds 3 cm.^[4] Elongation of the SP or ossification of the stylohyoid ligament can give rise to a clinical condition known as Eagle's syndrome. This syndrome is characterized by symptoms such as pharyngeal discomfort, otalgia (ear pain), and a persistent irritative sensation in the throat. The underlying mechanisms for these symptoms are often attributed to irritation or compression of adjacent neurovascular structures by the elongated SP.^[2]

Given the close anatomical relationships and clinical implications of SP variations, morphometric evaluation is

essential for understanding its normal range and deviations. This knowledge assists radiologists, ENT surgeons, and anatomists in diagnosing and managing conditions like Eagle's syndrome.

The present study was undertaken to assess the morphological (curvature) and morphometrical (length and thickness at the base, midpoint, and tip) characteristics of the SP in dry human skulls, and to compare the findings with those reported in previous literature.

Aims and objectives

The present study aims to evaluate the morphological and morphometrical characteristics of the SP of the temporal bone in dry human skulls. The objectives of the present study are to assess the curvature of the SP and to measure its length and thickness at three distinct levels—base, midpoint, and tip—on both sides.

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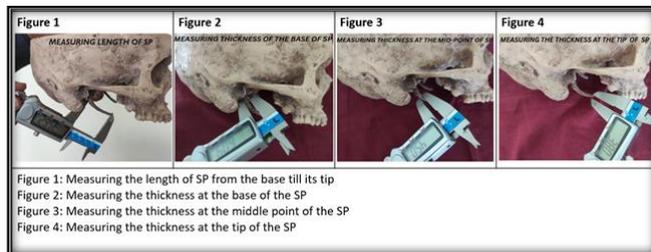
MATERIALS AND METHODS

Study Design: This descriptive study was conducted over a period of three months in the Department of Anatomy, Shri Atal Bihari Vajpayee Medical College and Research Institute (SABVMCRI), Bengaluru. A total of 100 dry human skulls available in the departmental osteology collection were examined. Each skull was assessed bilaterally for the morphological and morphometrical characteristics of the SP, including its curvature, length, and thickness at the base, midpoint, and tip.

Inclusion and exclusion criteria

All dry human skulls available in the Department of Anatomy, Shri Atal Bihari Vajpayee Medical College and Research Institute (SABVMCRI), Bengaluru, were included in the study. Skulls with broken or eroded styloid processes were excluded to ensure accuracy of morphological and morphometric measurements.

Methods: Each skull was examined bilaterally for the SP under adequate lighting conditions. The curvature of the SP was noted and classified as straight or curved based on visual inspection. Morphometric measurements of the SP, including its length and thickness at three specific points—the base, midpoint, and tip—were recorded using a calibrated digital vernier caliper to the nearest 0.01 mm. Measurements were taken carefully and repeated twice to ensure accuracy. All observations were systematically entered into Microsoft Excel and subsequently analyzed using SPSS software to obtain descriptive statistics.



Statistical Analysis: The data collected from the morphometric measurements of the SP were compiled in Microsoft Excel and analyzed using SPSS software. For each parameter—length and thickness at the base, midpoint, and tip—descriptive statistics were computed, including mean, standard deviation (SD), and range (minimum to maximum values) for both right and left sides.

RESULTS



Figure 5: bar chart showing the distribution of curvature of SP

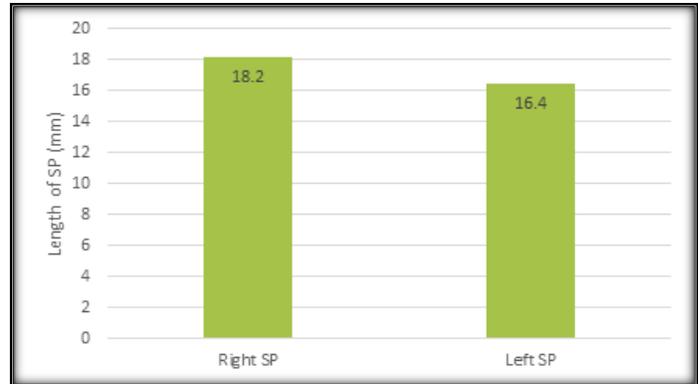


Figure 6: Bar chart showing mean length of SP

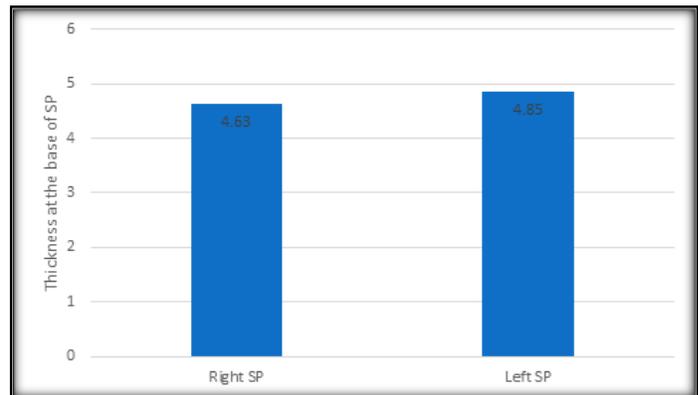


Figure 7: Bar chart showing mean thickness at the base of SP

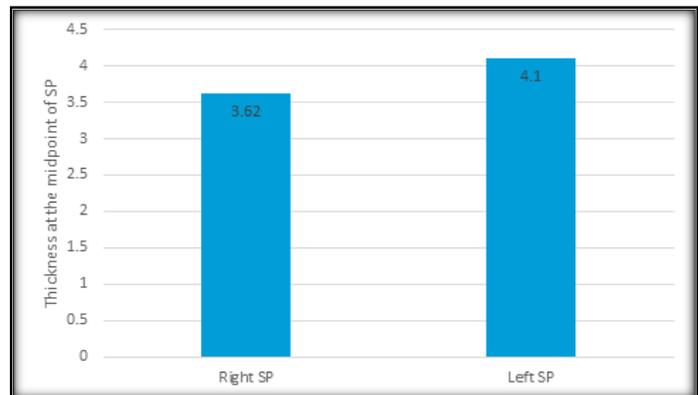


Figure 8: Bar chart showing mean thickness at the midpoint of SP

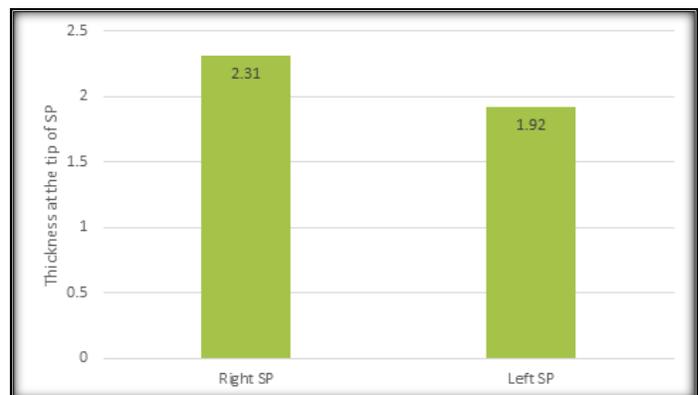


Figure 9: Bar chart showing mean thickness at the tip of SP

Table 1: shows the distribution of curvature patterns (straight and curved) of the styloid process on both right and left sides

Total styloid process 200	Right(n=100)	Left(n=100)
Straight styloid process	66%	82%
Curved styloid process	34%	18%

Table 2: presents the range, mean, and standard deviation of the length of the styloid process.

Length of the styloid process	Right	Left
Number	100	100
Range(mm)	10.08-35.62	10.57-30.52
Mean(mm)	18.2+/- 4.16	16.4+/-1.48

Table 3: illustrates the range, mean, and standard deviation of thickness at the base of the styloid process.

Thickness at the base of styloid process	Right	Left
Number	100	100
Range(mm)	3.88-6.09	3.54-5.89
Mean(mm)	4.63+/-0.37	4.85+/-0.47

Table 4: displays the range, mean, and standard deviation of thickness at the midpoint of the styloid process.

Thickness at the midpoint of the styloid process	Right	Left
Number	100	100
Range(mm)	3.11-4.50	3.44-4.47
Mean(mm)	3.62+/-0.26	4.1+/-0.17

Table 5: summarizes the range, mean, and standard deviation of thickness at the tip of the styloid process.

Thickness at the tip of the styloid process	Right	Left
Number	100	100
Range(mm)	1.50-3.88	1.51-2.66
Mean(mm)	2.31+/-0.48	1.92+/-0.41

Table 6: Morphometrical data of the specimen having bilaterally elongated styloid process

Parameter	Side	
	Right	Left
Curvature	Curved	Straight
Length (mm)	35.62	30.52
Thickness at the base (mm)	6.09	5.89
Thickness at the mid-point (mm)	4.5	4.36
Thickness at the tip (mm)	3.8	2.66



Figure 10: Specimen showing bilaterally elongated SP

DISCUSSION

The word styloid process originates from the word ‘stylos,’ which means, the pillar, in Greek language.^[5] The SP gives

attachments to three muscles, two ligaments and related to several important structures. The styloglossus muscle arises from the anterior surface of the tip of the styloid process and is supplied by the hypoglossal nerve. The stylohyoid muscle originates from the posterior surface of the styloid process, midway between its tip and base, and receives innervation from the facial nerve. The stylopharyngeus muscle takes origin from the medial surface of the base of the styloid process and is supplied by the glossopharyngeal nerve. The stylohyoid ligament extends from the tip of the styloid process to the lesser cornu of the hyoid bone. The stylomandibular ligament extends from the tip of the styloid process to the angle of the mandible.^[6]

The styloid process (SP) forms a part of the stylohyoid complex, along with the lesser cornu of the hyoid bone and the stylohyoid ligament. The stylohyoid complex develops from Reichert’s cartilage of the second pharyngeal (hyoid) arch. It consists of four developmental components. The tympanohyal forms the base of the SP, the stylohyal forms the shaft of the SP, the ceratohyal develops into the stylohyoid ligament and the hypohyal forms the lesser cornu of the hyoid bone.^[7]

Eagle’s syndrome is a clinical condition caused by elongation of the SP or calcification of the stylohyoid ligament, leading to a variety of cervicofacial and pharyngeal symptoms. Two types of syndromes were described by Eagle. ‘Classic styloid syndrome’ occurring mainly after tonsillectomy and is characterized by dysphagia, odynophagia, a sensation of increased salivation, and a sensation of a foreign body in the pharynx, sometimes accompanied by vocal changes. Second type is ‘stylocarotid syndrome’ caused by the stylohyoid complex exerting pressure on the internal and external carotid arteries, regardless of tonsillectomy. The symptoms are caused by the stimulation of the sympathetic nerve plexus around the blood vessel. Orbital pain, parietal headache can occur and can be

confused with cluster headache and migraine. In severe cases, vision disturbance and syncopal attacks can occur.^[8] Evaluation of the styloid process on digital panoramic radiographs was done by Chandramani B More and Mukesh K Asrani,^[9] in 2010. The study was conducted on 500 digital panoramic radiographs and a total of 1000 SPs were evaluated. The radiographic length of the styloid process was measured on both sides using the measurement toolbars on the accompanying analysis software. The average length of the left styloid was 25.41 ± 6.32 mm and that of the right styloid was 25.53 ± 6.62 mm which is more compared to the present study. 163 SPs (16.3%) were elongated [84 on the right side (8.4%) and 79 on the left side (7.9%)] which is higher than that of the present study.

The findings observed in this study are compared with the previous studies in the following tables:

Table 7: Comparison of mean length of SP with previous studies

Serial No.	Authors	Mean length of SP (in mm)	
		Right	Left
1	Rachna Magotra, Shayama Razdan, ^[5] (2008)	54	52
2	H.A. Balcioglu, ^[10] (2009)	25.78 ±5.68 (male) 22.69±3.68 (female)	25.80 ±5.75 (male) 22.75± 3.65 (female)
3	Chandramani B More, Mukesh K Asrani, ^[9] (2010)	25.53 ± 6.62	25.41 ± 6.32
4	M.I. Kosar et al, ^[11] (2011)	42 (male) 37 (female)	43 (male) 40 (female)
5	Haluk Öztunç et al, ^[12] (2014)	29 (male) 30 (female)	
6	Sachin Patil et al, ^[2] (2014)	38	35
7	Rajanigandha Vadgaonkar et al, ^[13] (2015)	17.8±9.3	18.2±5.6
8	Sarita Ramlu Margam, Surekha Dilip Jadhav, ^[14] (2015)	17.89 (males) 13 (females)	15.43 (males) 16.83 (females)
9	Azin Shayganfar et al, ^[15] (2018)	26.2±7.4 (male) 24.5±7.2 (female)	25.8±7.9 (male) 24.6±7.8 (female)
10	Ahmet Dursun et al, ^[16] (2021)	22.93±9.40 (male) 20.58±8.03 (female)	22.55±8.55 (male) 20.68±7.54 (female)
11	S. Tanaka et al, ^[17] (2021)	27.04 ± 7.88	
12	Eldan Kapur et al, ^[18] (2022)	25.8±4.68	24.2±4.54
13	S. Priyadarshini et al, ^[19] (2022)	35 (male) 27 (female)	32 (male) 28 (female)
14	Nagaraj Maradi et al, ^[20] (2023)	24	27
15	Manjunath TH, Santhosh CS3 (2023)	25.76±4.02 (male) 24.46±6.12 (female)	24.52±5.22 (male) 23.72±3.96 (female)
16	Yoon-Jung Kang et al, ^[21] (2024)	39.2	31.2
17	Ruben D. de Ruiter et al, ^[22] (2024)	52.1±15.6	
18	Zhang Yang et al, ^[23] (2024)	30.7±10.97 (male) 27.82±8.6 (female)	30.7±11.91 (male) 26.78±8.08 (female)
19	Present study	18.2±4.16	16.4±1.48

The mean length of SP of the present study is comparable to that reported by Rajanigandha Vadgaonkar et al and Sarita Ramlu Margam (left side).^[13,14]

Table 8: Comparison of mean thickness of SP with previous studies

Serial No.	Authors	Thickness of SP (mm)					
		At base		At mid-point		At tip	
		Right	Left	Right	Left	Right	Left
1	Rajanigandha Vadgaonkar et al, ^[13] (2015)	4.4±1.2	4.4±0.9	3.2±0.4	3.8±0.7	1.5±0.6	1.4±0.5
2	Sarita Ramlu Margam, Surekha Dilip Jadhav, ^[14] (2015)	4.53 (males) 4.33 (females)	4.83 (males) 5.00 (females)				
3	S. Tanaka et al, ^[17] (2021)	5.41 ± 1.77				2.21 ± 1.22	
4	Present study	4.63±0.37	4.85±0.47	3.62±0.26	4.1±0.17	2.31±0.48	1.92±0.41

The mean thickness of SP recorded in our study is comparable with that reported by most of the studies.^[13,14,17] However, the mean thickness of SP at the tip of present study is greater than that reported by Rajanigandha Vadgaonkar et al.^[13]

Table 9: Comparison of prevalence of elongated styloid process with the previous studies

Serial No.	Authors	Prevalence of elongated SP
1	H.A. Balcioglu, ^[10] (2009)	3.30%
2	Chandramani B More, Mukesh K Asrani, ^[9] (2010)	16.30%
3	Mun Bhawni Bagga et al, ^[24] (2012)	52.10%
4	Haluk Öztunç et al, ^[12] (2014)	54.00%

5	Sachin Patil et al, ^[2] (2014)	14%
6	Jinu Merlin Koshy et al, ^[25] (2015)	9%
7	Rajanigandha Vadgaonkar et al ¹³ (2015)	4.50%
8	A.H. Baykan et al, ^[26] (2019)	20.70%
9	S. Tanaka et al, ^[17] (2021)	29.50%
10	Eldan Kapur et al, ^[18] (2022)	7.00%
11	Manjunath TH, Santhosh CS, ^[3] (2023)	3.06%
12	George Triantafyllou et al, ^[27] (2025)	35.00%
13	Munirah Batarfi et al, ^[28] (2025)	20.00%
14	Present study	1%

The prevalence of elongated SP in the present study is much less compared to that reported by most of the studies.^[2,9,10,12,13,17,24,25,28] Low prevalence of elongated SP may be attributed to variations in the race.

Table 10: Comparison of curvature of SP with previous study

Serial No.	Authors	Straight (in %)		Curved (in %)	
		Right	Left	Right	Left
1	Sarita Ramlu Margam, Surekha Dilip Jadhav (2015)	37.5 (male) 30 (female)	41.9 (male) 25 (female)	7.5 (male) 30 (female)	2.3 (male) 15 (female)
2	Present study	33	41	17	9

Medial angulation of the styloid process can compress nearby neurovascular structures and cause pharyngeal or tonsillar fossa irritation. Measurements of SP angulation can be performed in vivo using high-resolution computed tomography (CT) imaging, particularly 3D reconstructed images. These allow accurate visualization of the SP in relation to surrounding anatomical structures, determination of mediolateral and anteroposterior angulation, bilateral comparison in living individuals and correlation of angulation with symptoms for clinical relevance.

The study has a relatively small sample size, which may limit the generalization of the findings. Age and sex of the specimens were not considered, hence analysis of variations in SP morphology and morphometry based on these factors cannot be done. The study was conducted on skulls from an exclusively South Indian population, so the results may not be applicable to other ethnic or geographic groups.

The present study measures the length, curvature, and thickness of the SP in dry skulls. Further research can be done on angulation of the SP as an additional morphometric parameter. Measurement of angulation would provide deeper insights into the spatial orientation of the styloid process and its potential role in conditions such as Eagle’s syndrome.

CONCLUSION

This study provides detailed morphological and morphometrical data on the SP, focusing on its length, curvature, and thickness at different levels. The average SP length observed was shorter than that reported in many previous studies, while thickness closely matched existing literature. Most SPs exhibited a straight configuration, and elongation (>30 mm) was rare, occurring in only 1% of specimens. These findings indicate population-specific variations and offer valuable baseline information for radiologists and surgeons, particularly ENT specialists, in the diagnosis and management of conditions like Eagle’s syndrome.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Stranding Susan. Special senses - external & middle ear. In: Susan Stranding, eds. Gray’s Anatomy: The Anatomical Basis of Clinical Practice. 41st ed. London: Elsevier Churchill Livingstone; 2008: 617
2. Patil S, Ghosh S, Vasudeva N. Morphometric study of the styloid process of temporal bone. J Clin Diagn Res. 2014;8(9):AC04–AC06.
3. Manjunath TH, Santhosh CS. A morphometric study of styloid process and its forensic importance. Int J Acad Med Pharm. 2023;5(5):1245–7.
4. Eagle WW. Elongated styloid processes: Report of Two Cases. Arch Otolaryngol. 1937;25(5):584–7
5. Magotra R, Razdan S. Elongated styloid process: anatomical variations. JK Sci 2008;10:203-5
6. Datta AK. Essentials of human anatomy: Head and neck. 6th ed. Kolkata: Current Books International; 2017. p.21.
7. Camarda AJ, Deschamps C. Stylohyoid chain ossification: a discussion of etiology. Oral Surg Oral Med Oral Pathol. 1989;67:515-20.
8. Eagle WW. Symptomatic elongated styloid process; report of two cases of styloid process-carotid artery syndrome with operation. Arch Otolaryngol. 1949;49:490 503.
9. More CB, Asrani MK. Evaluation of the styloid process on digital panoramic radiographs. Indian J Radiol Imaging. 2010;20(4):261-5
10. Balcioglu HA, Kilic C, Akyol M, Ozan H, Kokten G. Length of the styloid process and anatomical implications for Eagle’s syndrome. Folia Morphol (Warsz). 2009;68(4):265-70.
11. Kosar MI, Atalar MH, Sabanclogullari V, Tetiker H, Erdil FH, Cimen M, Otag I. Evaluation of the length and angulation of the styloid process in the patient with pre-diagnosis of Eagle syndrome. Folia Morphol. 2011;70(4):295-9.
12. Oztunc H, Evlice B, Tatli U, Evlice A. Cone-beam computed tomographic evaluation of styloid process: a retrospective study of 208 patients with orofacial pain. Oral Radiol. 2014;30(1):43-7.
13. 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.
14. Margam SR, Jadhav SD. Morphometric study of styloid process

- of temporal bone in Indian adult dry skull. *Int J Res Med Sci.* 2015 Jun;3(6):1348-52
15. Shayganfar A, Golbidi D, Yahay M, Nouri S, Sirus S. Radiological evaluation of the styloid process length using 64-row multidetector computed tomography scan. *Adv Biomed Res.* 2018;7:85.
 16. Dursun A, Öztürk K, Şenel FA, Ayyildiz VA. A different perspective on the styloid process morphometry. *Eur J Anat.* 2021;25(3):301-10.
 17. Tanaka S, Yamashita Y, Katsube T, Izumi M, Fujimiya M. A gross anatomical study of the styloid process of the temporal bone in Japanese cadavers. *Anat Sci Int.* 2021;96(2):173-181
 18. Kapur E, Voljevic A, Šahinović M, Šahinović A, Arapović A. Styloid process length variations: an osteological study. *Acta Med Acad.* 2022;51(1):46-51.
 19. Priyadharshini S, Gopal KS, Srinivasan S. Cone-beam computed tomography evaluation of morphology and orientation of styloid process and prevalence of its elongation in age and gender: An institutional-based retrospective study – A dentist perspective. *Indian J Otol.* 2022;28(2):119-25.
 20. Maradi N, Beesanahalli YS, Pawar A, Jadhav T, Deshpande S. An unusual case of excessive angulation of styloid process and ossified stylohyoid complex causing Eagle's syndrome: a case report. *Egypt J Otolaryngol.* 2023;39:178.
 21. Kang YJ, Sung SM, Cho HJ, Lee TH. Carotid artery dissection caused by an elongated styloid process: a case report. *J Neurosonol Neuroimag.* 2024;16(1):21-3.
 22. de Ruiter RD, Treurniet S, Bravenboer N, Busse B, Hendrickx JJ, Jansen JC, Dubois L, Schreuder WH, Micha D, Teunissen BP, Raijmakers PGHM, Eekhoff EMW, von Brackel FN. Eagle syndrome: tissue characteristics and structure of the styloid process. *JBMR Plus.* 2024;8(10):ziae115.
 23. Yang Z, Yuzi J, Beibei L. Cone-beam computed tomographic evaluation of styloid process: a retrospective study of 498 patients with maxillofacial diseases. *BMC Med Imaging.* 2024;24:333.
 24. Bagga MB, Kumar CA, Yeluri G. Clinicoradiologic evaluation of styloid process calcification. *Imaging Sci Dent.* 2012;42(3):155-61.
 25. Koshy JM, Narayan M, Narayanan S, Priya BS, Sumathy G. Elongated styloid process: A study. *J Pharm Bioall Sci.* 2015;7(Suppl 1):S131-3.
 26. Baykan AH, Doğan Z, Özcan G. A computed tomography-based morphometric study of the styloid process. *Folia Morphol (Warsz).* 2020;79(1):120-6.
 27. George Triantafyllou, George Botis, Katerina Vassiou, Marianna Vlychou, George Tsakotos, Theodosios Kalamatianos, George Matsopoulos, Maria Piagkou, The styloid process length and the stylohyoid chain ossification affect its relationship with the carotid arteries, *Annals of Anatomy - Anatomischer Anzeiger*, Volume 257, 2025, 152342, ISSN 0940-9602,
 28. Batarfi M, Alghamdi KA, Asery YA, Alsaif MA, Nahhas NK, Alharthi MA, Khawaji B, Alali A, Alraddadi AS. Anatomical variations and elongation patterns of the styloid process: a CT-based study. *Folia Morphol (Warsz).* 2025.