

# Study of Styloid Process: Anatomical Variations in Length, Angulation and Distance between the Two Styloid Processes

Ajay Rathva<sup>1\*</sup>, Dharati M. Kubavat<sup>2</sup>, Shaileshkumar K. Nagar<sup>3</sup>

{<sup>1</sup>Assistant Professor, <sup>3</sup>Professor} Department of Anatomy, GMERS Medical College & Hospital, Gotri, Vadodara, Gujarat, INDIA.

<sup>2</sup>Associate Professor, Department of Anatomy, M.P.Shah Medical College, Jamnagar, Gujarat, INDIA.

\*Corresponding Address:

[drajayrathva81@yahoo.com](mailto:drajayrathva81@yahoo.com)

## Research Article

**Abstract: Background:** The styloid process is a bony projection, located on the lower surface of the petrous part of the temporal bone just anterior to the stylomastoid foramen. Elongation as well as the anterior and medial angulations of the process may cause various clinical symptoms such as neck and cervicofacial pain, described as Eagle's syndrome. **Objective:** The present study aimed to determine the mean length of the styloid process on 150 dry skulls to investigate the incidence of the elongated styloid process, inter styloid distance, angulation and the relations of the styloid processes to other structures at the base of the skull, highlighting the possible importance in clinical and surgical conditions. **Materials and Methods:** The study was done on both sides of 150 dry skulls were selected from the museum of anatomy department of GMERS Medical College Gotri, Vadodara, and Government Medical College Bhavnagar. The length, inter styloid distance and the angulation of the styloid processes were measured and expressed as Mean  $\pm$  SD. **Results:** The means of length and anterior and medial angles of the elongated styloid process of right side were  $43.76 \pm 11.05$ ,  $38.56 \pm 11.53$ ,  $32.4 \pm 19.54$  and on left side were  $43.53 \pm 10.45$ ,  $38.7 \pm 11.88$ ,  $32.56 \pm 19.78$  respectively. The mean of interstyloid distance were 7.5cm at base, 5cm at midpoint and 2.5cm at tip of styloid process. **Conclusion:** The elongated styloid process was found upto 2% of dry skull. The presence of the elongated styloid process and its angulation, though rare, does highlight the importance of routine examination of the styloid process even in clinical practice.

**Keywords:** Styloid processes; elongated styloid process; inter styloid distance; angulation of styloid process; stylohyoid ligament; Eagle's syndrome.

## Introduction

Styloid process is derived from the Greek word 'Stylos' meaning a pillar. The styloid process is normally a thin cylindrical sharp bony projection which arises from the lower surface of the petrous part of the temporal bone, derivative of a second branchial arch. It lies in front of the stylomastoid foramen and its tip projects anteriorly and inferiorly between internal and external carotid arteries and also laterally to the pharyngeal wall and tonsillar fossa <sup>(1)</sup>. The styloid process has attachments to three muscles and two ligaments. The stylopharyngeus, stylohyoid and styloglossus muscles originate here <sup>(2)</sup>.

The Facial nerve emerges from the stylomastoid foramen posteriorly. The stylohyoid ligament extends from the styloid process to the lesser cornu of the hyoid bone. The stylohyoid process and ligament are derived from the first and second brachial arches, in addition to Reichert's cartilage <sup>(11)</sup>. Important structures surrounding the styloid process include facial and hypoglossal nerves, the occipital artery and the posterior belly of the digastric muscle laterally and the lingual, facial, superficial temporal, maxillary, and internal carotid arteries, internal jugular vein, and the stylomandibular ligament medially <sup>(5)</sup>. The length of the styloid process varies considerably according to several reports. Eagle stated that the normal length of the process was ranged 25 to 30 mm in adults. Palesy et al suggested that the styloid process was generally considered to be elongated, if its length was more than 3 cm. Symptoms associated with an elongated styloid process and/or ossified stylohyoid ligament were first described by Eagle and referred to as "Eagle's syndrome" <sup>(3)</sup>.

## Materials and Methods

The study was conducted after ethical clearance was obtained from the Institutional Ethics committee. A total of 150 dry human skulls with intact styloid processes were selected from the museum of anatomy department of GMERS Medical College Gotri Vadodara and Government Medical College Bhavnagar and from the students. All skulls were regular in shape, without obvious evidences of deformities. The present study focused to determine the mean length and angulations of styloid process and incidence of elongated styloid process in adult dry skulls. The length and angulation of the styloid process were measured directly from the digital images by the image analysis using Adobe Photoshop 7.0 and Image Tool 3.0 Program. The length were measured corresponds to the free part of the styloid process situated on its frontal side and the distance were

measured between the bases, midpoints and the tips of the styloid processes. The measurements of elongated and angulated styloid process of dry skull were done by Towne's X-ray view. Medial angulation was measured on Towne's X-ray. A vertical line passed from the cranial base of the process which was vertical to the line connecting the bases of both the styloid processes. Medial angulation was measured as the angle between the vertical line and the body of the process.



**Figure 1:** Measurement of angle by Towne's view

Anterior angulation was measured on lateral skull X-ray. A vertical line passed from the cranial base of the process, which was vertical to the Frankfort plane (a line passing horizontally from the superior border of external acoustic meatus to the inferior border of orbital rim). Anterior angulation was measured as the angle between this vertical line on lateral skull X-ray and the body of the process.



**Figure 2:** Elongated and Angulated SP (Right side)



**Figure 3:** Elongated and Angulated SP (left side)

## Statistical Analysis

Each measurement was performed for three times and averaged them. All measurements and frequencies of the data were tabulated separately according to normal and elongated styloid process groups. The mean, standard deviation (SD) were assessed.

Epi info 7.0.8.0 Atlanta USA software was used for data analysis.

## Results

Measurements of the length and angulations of the styloid process were compared between normal and elongated styloid process (Table 1&2). It was found that the length of the styloid process was highly varied and ranged from 3 to 68 mm. Out of 150 human dry skulls 30 skulls having elongated styloid process. Their incidence was 2%. 30mm length of styloid process is considered as normal length. The mean length of normal styloid processes investigated in the present study on right side was  $18.06 \pm 7.28$  and on left side  $18.03 \pm 7.35$ . The mean length of elongated styloid processes investigated in the present study on right side was  $43.76 \pm 11.05$  and on left side  $43.53 \pm 10.45$ . The mean length of all styloid processes were on right side  $23.20 \pm 13.13$  and on left side  $23.17 \pm 12.99$  (Table 1).

**Table 1:** Measurements of length of total, normal and elongated styloid processes. Data were expressed as Mean  $\pm$  SD (range)

SP	RL	LL
Normal	$18.06 \pm 7.28$	$18.08 \pm 7.35$
Elongated	$43.76 \pm 11.05$	$43.53 \pm 10.45$
Total	$23.20 \pm 13.13$	$23.17 \pm 12.99$

SP=Styloid process RL=Right length of SP LL=Left length of SP

**Table 2:** Measurements of anterior and medial angulations of the total, normal and elongated styloid processes. Data were expressed as Mean  $\pm$  SD (range)

SP	RAA	RMA	LAA	LMA
Normal	$10.97 \pm 11.59$	$11.49 \pm 13.39$	$10.97 \pm 11.58$	$11.51 \pm 13.41$
Elongated	$38.56 \pm 11.53$	$32.4 \pm 19.54$	$38.7 \pm 11.88$	$32.56 \pm 19.78$
Total	$16.49 \pm 15.99$	$15.67 \pm 16.97$	$16.52 \pm 16.08$	$15.72 \pm 17.06$

RAA=Right anterior angle RMA=Right medial angle  
LAA=Left anterior angle LMA=Left medial angle

The styloid process is usually straight but occasionally curved resulting in the variation of its angulation. In this study, the anterior angle of total groups was ranged from 0 to 57 degrees on right side with the mean of  $16.49 \pm 15.99$  and on left side ranged from 0 to 58 degrees with the mean of  $16.52 \pm 16.08$ . The medial angle of total groups was ranged from 0 to 62 degrees with the mean of  $15.67 \pm 16.97$  degrees and on left side 0 to 64 degree with the mean of  $15.72 \pm 17.06$  (Table:2). Statistically significant difference of length, anterior angulation and

medial angulation was observed between the normal and elongated styloid process ( $p < 0.001$ ).

**Table 3:** Measurement of interstyloid distance (ISD)

ISD(mean)	BASE	MIDPOINT	TIP
Normal	7.5	5.5	3
Elongated	7.5	5	2.5

The interstyloid distance shows that a very limited space was available for accommodating the structures of neck, consisting of the larynx, commencement of the oesophagus, cranial nerves and great vessels.

## Discussion

Embryologically the styloid process, stylohyoid ligament and the lesser cornu of the hyoid bone are developed from the second brachial arch called as the Reichert's cartilage because it is of cartilaginous origin<sup>(1)</sup>. The ligament has the potential to mineralize. Anatomical variation in the length of the styloid process and its stylohyoid chain is of profound anatomical, anthropological as well as clinical importance. Styloid process elongation can occur unilaterally or bilaterally<sup>(15)</sup>. There are investigators claiming that the phenomenon is most common unilaterally but others are contrary to these claims. It has been suspected that an elongated styloid process could be caused by: congenital elongation of the styloid process due to persistence of the cartilaginous analogue of the Styloid, calcification of the stylohyoid ligament by unknown mechanism and growth of osseous tissue at the insertion of the stylohyoid ligament<sup>(21)</sup>. Ossification can take place during childhood and adolescence when the rate of bone growth is increased. After the age of 20 there is a rapid decrease in ossification formation<sup>(19)</sup>. However, other authors support that an inconsistent trend exists toward greater ossification of the stylohyoid ligament with advanced age<sup>(20)</sup>.

A normal range of the length of the styloid process differs among the studies in the literature. Eagle *et al* reported the normal length of the styloid process as 2.5 cm. other authors measured the length as 3 cm. It has been reported that it is probably symptomatic when the length exceeds 4cm<sup>(3)</sup>. In the present study, Elongated styloid process was ranging from 30 mm to 68 mm and bilaterally. Some authors say that length of styloid process ranges between 15.2mm & 47.7mm considered being normal. Studies of other authors consider length of styloid process over 30 mm. As elongated styloid process<sup>(24)</sup>. Few have considered 40mm of length of styloid process. In some rare cases there is very long styloid process measuring 73mm<sup>(21, 24)</sup>.

The stylohyoid chain extends between the temporal bone and hyoid bones and is divided into 4 sections;

1) Tympanohyal: This forms the base of the styloid Process

2) Stylohyal: This forms major portion of the styloid Process

3) Ceratohyal: This forms the stylohyoid ligament

4) Hypohyal: This forms the minor horn of the hyoid Bone

The first two sections form the stylohyoid process. The cartilage that is embryologically located at the stylohyoid ligament may undergo calcification of varying degrees which causes variations. The stylohyoid ligament may undergo ossification due to trauma like tonsillectomy<sup>(4)</sup>. There is coexistence of ossified stylohyoid ligament with other conditions such as: Cervical osteophytes and cervical spondylosis, anomalies in the Atlantic section of the vertebral artery<sup>(16)</sup> and fracture of the ossified ligament. Cervical spondylosis yet very common in elderly population, may have similar clinical signs with Eagles syndrome<sup>(18)</sup>, but could be differential diagnosed by palpation of tonsillar fossa. Arterial anomalies should be cleared up because it is likely to coexist with stylohyoid ossification<sup>(15, 17)</sup>. As a result of advancements in examinations methods stylohyoid chain variations are more frequently diagnosed among the general population and an elongated styloid process is the most common variation amongst them. Kouladouros *et al.* (2009) reported that aetiology can be explained by a genetic alteration or according to three different theories. (1) The first theory, the hyperplastic reaction, suggests that the styloid process had been stimulated by a pharyngeal trauma leading to the ossification of the styloid ligament. (2) The second theory, metaplastic reaction, also includes a traumatic stimulus causing multiples metaplastic alterations in the cells of the styloid ligament, which results in its total or partial ossification. (3) The third theory, anatomic variation, suggests that the styloid process and the styloid ligament are not usually ossified, but rather, an anatomic variation<sup>(8,12)</sup>. Ilguy *et al* described a variety of factors that causes symptoms of Eagle's syndrome, including the length and width of the styloid process, the angle and direction of its deviation and the degree of ossification<sup>(9)</sup>. Several studies reported that the direction and angulation of the elongated styloid process probably were responsible for the irritation of a number of anatomical structures traversing the parapharyngeal space. For example, medial deviation could impinge the tonsillar fossa and anterior angulation might result in mucosal irritation and pressure over vital structures in the tonsillar fossa<sup>(7)</sup>. Jackson *et al* also reported that an elongated styloid process deviating slightly from its normal direction could impinge the internal or external carotid artery, and causes pain during artery's palpation because it stimulates the sympathetic nerve plexus accompanying the artery and that correlates hypertension in elongated styloid process<sup>(6, 10)</sup>. The



elongation of styloid process is considered an anomaly which can be accompanied by a series of symptoms such as dysphasia, odynophagia, facial pain, ear pain, headache, tinnitus and trismus. This set of symptoms associated with the elongated styloid process is called Eagle's syndrome (Lages et al., 2006)<sup>(22)</sup>. Several other symptoms are attributed to the syndrome, including: neck pain, foreign body sensation in the throat, pain on the rotation of the head, and pain when swallowing (Guimaraes et al)<sup>(23)</sup>.

## Conclusion

Summarizing the above facts diagnosis can usually be made on physical examination by digital palpation of the styloid process in the tonsillar fossa which exacerbates the pain. Diagnosis can also be made by plain radiography include antero-posterior and lateral skull films, orthopantomogram and CT scan. Injection Of local anaesthetic solution into tonsillar fossa relieves pain. The styloid process can be shortened through an intraoral or external approach<sup>(13)</sup>. The radiological picture of the anomalous styloid process may be beneficial for the surgeons, neurologists and radiologists in daily clinical practice. Anomalies related to styloid process may help in arriving at a correct diagnosis and help in avoiding erroneous interpretation of radiographs.

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