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## Original Research Article

## Morphometric analysis of styloid process in human cadavers with clinical implications

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## ABSTRACT

**Background:** Styloid process is a bilateral bony projection of temporal bone related to important neurovascular structures in the head and neck region. Elongated styloid process with length more than 30mm is frequent encounter in multiple imaging techniques in various studies which have been cause of many neurological and vascular signs and symptoms in living. Present study aims at analyzing the morphometric parameters of styloid process in cadavers with clinical correlation.

**Aim and Objective:** The aim of this study is to measure morphometric parameters of styloid process in human cadavers, to estimate the prevalence rate of elongated styloid process and to analyze the clinical effects of elongated styloid process.

**Materials and Methods:** Present study is an observational descriptive study done on styloid processes retrieved from forty human cadavers and fifteen dry skulls from the department of anatomy in the present institution. The morphometric parameters included length and breadth of the styloid process. Spatial orientation of the structures close to styloid process were studied and any deviation was duly documented.

**Results:** A total of 110 styloid processes were studied in which four elongated styloid processes were identified with a prevalence rate of 3.6%. Mean lengths on right and left side measured 16.1mm and 16.07mm respectively with more lengthy styloid process on the right side. Mean breadths of 5.7mm and 5.13mm on right and left sides were measured respectively.

**Conclusions:** Identifying the presence of elongated styloid process is of paramount importance in diagnosing the signs and symptoms manifested in Eagle's syndrome. Expanding knowledge on the morphometry of styloid process is of great advantage to head and neck surgeons and radiologists, which can be enhanced by present study.

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## 1. Introduction

The word styloid process has originated from the word 'STYLOS', the pillar, in Greek. Styloid process can be straight or anteromedially curved.<sup>1</sup> Styloid process is a bilateral bony projection on temporal bone. Its proximal part is called tympanohyal which is ensheathed by tympanic

plate and its distal part is called stylohyal which gives attachment to muscles and ligaments. It is related to important structures such as parotid gland laterally, facial nerve to its base, external carotid artery crossing its tip and the beginning of internal jugular vein medially.<sup>2</sup> Elongated styloid process and calcification of ligaments attached to it are some of the causes for Eagle's syndrome. Eagle syndrome was first reported by W.T. Eagle an otorhinolaryngologist in 1937.<sup>3</sup> Dysphasia, pain over the

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angle of the mandible aggravating on rotation of neck and protrusion of the tongue are the major clinical symptoms of Eagle’s syndrome.<sup>3</sup> Multiple studies have been conducted on the morphometric parameters of styloid process employing varied methods for measurements. Many studies show that the normal length of styloid process ranges from 15.2mm to 47.7mm. More than 30mm long was considered as elongated by many authors in their respective studies. Present study has been conducted to analyze the morphometric parameters of the styloid process and to correlate with studies conducted globally and present the findings of the authors regarding elongated styloid process.

2. Materials and Methods

A cross-sectional observational study was conducted on formalin fixed 40 human cadavers and 15 dry skulls in the department of anatomy in a private medical college in rural Andhra Pradesh. A total of 110 sides (both right and left) have been included in the study with disrupted styloid processes been excluded. Routine dissection was done to expose the styloid process following Cunningham’s manual. The sternocleidomastoid, part of parotid gland and masseter were removed to expose ramus of mandible which was then cut open using a bone cutter. The styloid process from base to tip was then exposed after removing the muscles and soft tissue.

Two points were determined to standardize measurements, which were obtained using a digital vernier calipers.<sup>4</sup>

- 1. Posterior measure: This was obtained by measuring the distance from the tip of the styloid process to base.
- 2. Breadth measure: This was obtained by measuring the breadth of styloid process at the base.
- 3. Relations of neurovascular bundle to styloid process were also observed and noted.

Measurements were recorded in millimeters.

3. Results

A total of 110 styloid processes were measured bilaterally in the present study. A length more than 30mm was considered elongated after thorough review of literature. Four styloid processes in 2 cadavers measured more than 30mm bilaterally with a calculated prevalence rate of 3.6%. The longest and shortest length measured 45.3mm and 5.2mm. The broadest and narrowest breadth measured 6.7mm and 1.7mm. The average length on right side was 16.1mm and on left 16.07mm respectively. The average breadth on right and left side recorded was 5.7, 5.13mm (Tables 1, 2 and 3).

The tip of elongated styloid process in first variant cadaver (cv1) on right side was very close to the facial artery. A common faciolingual trunk arose from external

carotid artery on the same side with facial artery near the elongated styloid process. The origin of styloid muscles was normal in both right and left sides of cv1.

In cv2 the tip of styloid process was very close to internal carotid artery bilaterally. Close approximation of tip of styloid process towards hypoglossal nerve was also observed on both right and left sides of cv2. Origins of styloid muscles was normal on both sides of cv2 (Figures 1, 2, 3, 4 and 5).

Table 1: Showing morphometric parameters of styloid process

Measurement	Longest	Shortest	Mean
Length	45.3mm	5.2mm	16.17mm
	widest	narrowest	mean
Breadth	6.7mm	1.7mm	4.83mm

Table 2: Comparing right and left mean lengths and breadths of styloid process

Mean	Right	Left
Length	16.1mm	16.07mm
Breadth	5.07mm	5.13mm

Table 3: Showing lengths and breadths of styloid processes of variant Cadavers’s

S. No	Length	Breadth at base
Cv1 (right side)	39.1mm	4.9mm
Cv1 (left side)	45.3mm	6.7mm
Cv2 (right side)	32.3mm	3.6mm
Cv2 (left side)	31.9mm	3.3mm

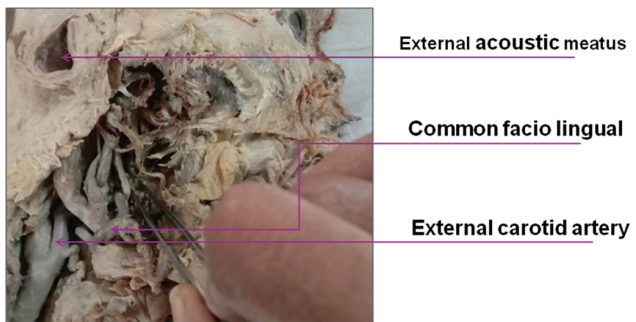
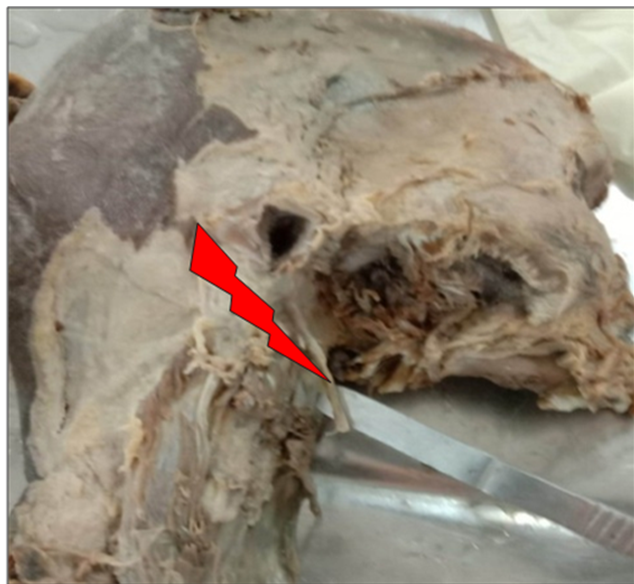


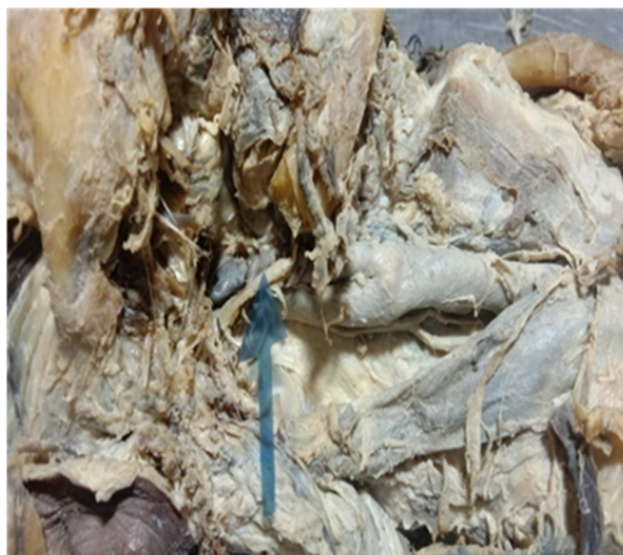
Figure 1: (CV1) Showing right elongated styloid process

4. Discussion

Present study involves the measurement of morphometric parameters of styloid process in human cadavers and analysis of measurements with spatial orientation of anatomical structures with clinical significance. A thorough literature search retrieved multiple studies conducted on morphometry of styloid process using multiple modalities



**Figure 2:** (CV1) Showing right elongated styloid process



**Figure 4:** (CV2) Showing right elongated styloid process arrow showing proximity to internal carotid artery



**Figure 3:** (CV1) Showing left elongated styloid process



**Figure 5:** (CV2) Showing left elongated styloid process

like x-rays, panoramic radiographs, orthopantomography, 3D CT in patients presenting with signs and symptoms related to compression effects of long styloid process.<sup>5</sup> Morphometric studies in dry skulls are useful resources to identify the prevalence rates of elongated styloid process. A wide variation in the prevalence rate of elongated styloid process has been observed globally ranging from 2.7% to 34.2%. The variation can be attributed to the population considered and the resource material utilized for the study. The research conducted by W.T. Eagle on American population, with a prevalence rate of 4% was recorded with

not much clarity on the sample size utilized.<sup>3</sup> Antonio Luis et al., conducted morphometric analysis of styloid process on 15 dry skulls of Brazilian origin, with a prevalence rate of 4%.<sup>4</sup> Vadgaonkar R et al conducted a study on the morphometry with a prevalence rate of elongated styloid process calculated to 4.5% in 110 dry human skulls of Indian origin.<sup>1</sup> The present study is in consonance with the observations of the above studies with a prevalence rate of 3.6%, but the material utilized for morphometric analysis included a mix of cadavers and dry human skulls. Balcioglu et al in their study in Turkish population<sup>6</sup> and Smit et al.,<sup>7</sup> in separate studies have conducted morphometric analysis using mixed resource material as done in present study but did not provide evidence on the prevalence rate of elongated styloid process. Higher prevalence rates were noted by the studies conducted by Natsis in Greek population with 25.2%,<sup>5</sup> Buyuk in Turkish population with 34.2%,<sup>8</sup> Tanaka S et al with a prevalence rate of 29.5% of elongated styloid process in Japanese population<sup>9</sup> and Lengele et al with

29% recorded without the population been specified.<sup>10</sup> A wide variation was also discerned in the prevalence rates of elongated styloid process within the Indian sub-continent, with the studies of Patil et al detecting a prevalence rate of 14%<sup>11</sup> and with Kumar & Kumar recording a stubby prevalence rate of 2.7%.<sup>2</sup>

Most studies revealed lengthy right side styloid processes compared to left. Present study has similar observations as that of the studies conducted by G Rath & Anand, who have conducted measurements on 232 dry human skulls of Indian origin with mean lengths of 25.5mm and 25mm on right and left sides respectively.<sup>12</sup> Apurba Patra et al., conducted morphometric study with radiological evaluation on 50 dry skulls and calculated a mean length of 21.90 mm and 20.80 mm on right and left sides.<sup>13</sup> A mean length of 24.7mm and 28.3mm was measured on either side in 149 dry human skulls by Natsis et al in Greek population.<sup>5</sup> Kumar & Kumar analyzed the mean lengths of styloid processes in 73 dry human skulls as 21.9 mm and 20.8 mm on right and left sides respectively.<sup>2</sup> Present study nearly correlates with the measurements of Vadgaonkar R et al with mean length of 18.2mm on right and 17.8mm on left side in 110 dry human skulls<sup>1</sup> and with the study conducted by Saritha & Surekha on 70 dry human skulls with mean measurements of length 17.8 mm on right side and 15.4 mm on left side.<sup>14</sup> All the above studies showed a right-side dominance in lengths of styloid process.

The mean measurement of base of styloid process in various studies ranged from 3.41mm to 5.41mm.<sup>2</sup> Studies which are in conformity with the measurement of breadth or thickness of base of styloid process with present study in which the measured breadth was 4.77mm are that of Apurba Patra et al., with mean breadth of base of styloid process measuring 4.30mm,<sup>13</sup> Saritha & Surekha measured and calculated a mean breadth of 4.53mm,<sup>14</sup> Vadgaonkar R et al measuring 4.4 mm<sup>1</sup> and Kumar & Kumar calculated a mean breadth of 4.34mm.<sup>2</sup> Many studies of Indian origin indicated that increased thickness at the proximal base would compress facial nerve. Styloid process thickness is a factor that influences signs and symptoms of nerve compression.

Elongated styloid processes in present study measured with a range 31.9–45.3mm observed bilaterally which were in proximity with studies conducted by Vadgaonkar R et al., who reported length of elongated styloid process to be 30–50mm.<sup>1</sup> Patil et al., observed elongated styloid processes measuring 30.8–32.7mm in dry human skulls<sup>11</sup> and Apurba Patra recorded 35–53mm of long styloid processes bilaterally.<sup>13</sup> Lengthiest styloid processes were reported by Natsis et al with 50.2–70.2mm, in Greek population.<sup>5</sup> Tanaka S et al also detected elongated styloid processes ranging from 47–55mm in Japanese population.<sup>9</sup> Embryologically styloid process develops from the cartilage of 2nd pharyngeal arch referred to as Reichert's cartilage. This cartilage consists of four segments: tympanohyal,

stylohyal, ceratohyal and hypohyal. The proximal and distal parts of styloid process are derived from tympanohyal and stylohyal. Ceratohyal gives rise to stylohyoid ligament.<sup>10</sup> An elongated styloid process occur in about 4% of general population, only a small percentage (between 4% and 10.3%) of these patients is symptomatic with a female to male predominance of 3:1.<sup>15</sup> The elongated styloid process syndrome is often observed in 3<sup>rd</sup> and 4<sup>th</sup> decades of life and in women more frequently than in men.<sup>16</sup> Eagle described the syndrome complex into two categories. The classical type is presented as foreign body sensation in the throat, pain in the throat and the earache. The other type is the styloid process compressing the carotid arterial system and presenting as dizziness and headache. A variety of head and neck signs and symptoms are related to the elongated styloid process and its stylohyoid chain component.<sup>1</sup> Present study the authors have identified two variant cadavers with elongated styloid process bilaterally. The criteria of length more than 30mm was considered as elongated in the studies mentioned above.

## 5. Conclusion

Variation of morphometric parameters provides knowledge to head and neck surgeons, radiologists and anesthetists to perform image guided block dissections and nerve blocks. A sound knowledge of clinical relevance of elongated styloid process and its relations is of paramount importance while performing major head and neck surgeries. Comprehending the spatial orientation structures around the styloid process is key for identifying and diagnosing the signs and symptoms manifested in Eagle's syndrome.

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None.

## 7. Conflict of Interest

None.

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