

Study of Styloid Process in Dry Human Skulls: Identification of Sex from Interstyloid Distance in Central India Region

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| Received: 02.03.2019 | Accepted: 09.03.2019 | Published: 30.03.2019

DOI: [10.21276/sijap.2019.2.3.4](https://doi.org/10.21276/sijap.2019.2.3.4)

Abstract

Introduction: The styloid process is a cylindrical bony projection extending from petrous part of temporal bone. It lies in front of the stylomastoid foramen and projects downwards, forwards, and slightly towards the medial side. Many important neurovascular structures are adjacent to it. Due to morphological variations of styloid process these structures may be compressed. Abnormal elongation of styloid process may pose threat to anaesthetist while performing intubation.

Methods: Study was carried out on 100 (65 males, 35 females) adult dry skulls. The measurements taken ie. styloid process length, and interstyloid distance of the skull between the tip and base. All the parameters were measured using a digital Vernier caliper in millimetres on both the sides. **Results:** We found mean length of styloid process in males on right side 22.70 mm and on left 22.16 mm. In females, it was 22.30 mm on right and 21.28 mm on left side. The interstyloid distances of skull at the base and the tip of the styloid processes were noted. The mean distances at the base and the tip were 75.26 ± 0.3752 mm and 69.14 ± 0.3493 mm respectively in male, those in female were 72.15 ± 0.6525 mm and 67.00 ± 0.5043 mm respectively. The differences between male and female were statistically significant at the base ($P < 0.05$) and at the tip ($P < 0.05$). Although no statistically significant difference was found in length of styloid process between males and females. The occurrence of elongated styloid process was not associated with the gender. By this study it can be said that the styloid process can be utilised for the sex identification by measuring the interstyloid distance at the base or the tip of these processes. **Conclusions:** The results of this study suggested that the styloid process can be utilised for sex identification by measuring the interstyloid distance at both the base and the tip of these processes. Neurovascular structures which lie within the territory of styloid process may be compressed due to its anatomical variation. This data may be useful for clinicians, surgeons, radiologists, anaesthetists and anatomists as an academic interest.

Keywords: Styloid process, Dry skull, interstyloid distance, sex identification.

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INTRODUCTION

Styloid process is derived from the Greek word 'Stylos' meaning a pillar. The styloid process is normally a cylindrical bone which arises from the temporal bone in front of the stylomastoid foramen. The styloid process is a thin, cylindrical, sharp osseous process, from the posterior part of lower surface of the petrous part of temporal bone. The process is directed downwards to the front and slightly medially. The apex of the styloid process is connected with the same sided lesser cornu of hyoid bone via stylohyoid ligament. Embryologically the ligament represents the continuation of the apex of styloid process. All the above entire mentioned features constitute the stylohyoid chain. The whole chain is derived embryologically from four cartilages: tympanohyale, stylohyale, ceratohyale, and hypohyale. The styloid

process originates from the second branchial arch [1]. The length of styloid process averages from 20 to 25 mm. The tip of the process is situated laterally from the pharyngeal wall and immediately behind the tonsillar fossa, and critically between the internal and external carotid arteries. Three muscles and two ligaments are attached to the styloid process. It is considered elongated when it is longer than 30 mm [2]. The elongated styloid process can compress some neurovascular structures of the pharynx. Resulting pains were first described by Eagle and referred as Eagle's syndrome. The Symptoms associated with an Eagle's syndrome are pharyngeal pain, including dysphagia, tinnitus and foreign body sensation in the throat. The symptoms also include changes in the voice and reduction in the range of the mandibular opening [3].

The accuracy of skeletal sex estimation relies on the sexual dimorphism exhibited by the human body. From previous studies, the pelvis and skull have been considered the most reliable for identification of the sex of unknown remains [4]. Additionally, studies on the sex estimation from sternum, clavicle, patella, hand and foot bones have been done. Very few studies have focused on the sex determination using the styloid process. In the present study an attempt has been made to estimate the sexual dimorphism of the styloid process, and to determine the prevalence of the elongated styloid process in the central India region.

MATERIALS AND METHODS

The study was conducted on 100 adult skulls (65 males and 35 females) obtained from the Department of Anatomy, GMC Nagpur, Maharashtra, India as well as the dry skulls available with the first year MBBS medical students of the same college. The styloid process length and the interstyloid distance of the skull between the right and left sides were measured using a digital Vernier caliper. For the length of the

styloid process, the measurement was taken from the base of the skull to the tip of the styloid process (Fig-1). For the interstyloid distance at the base of the skull, the measurement were taken between the bases of right and left styloid process (Fig-2). While the interstyloid distance at the tip was measured as the distance between the tips of right and left styloid process (Fig-3). The parameters were measured by two observers independently with predetermined procedures to prevent inter-observer and intra-observer error. With the help of digital Vernier callipers measurements were taken.

Statistical Analysis

The values were analysed using Graph pad prism 6. The mean, SD, and range for each of the measurements were assessed. A Comparison of the values of all measurements was made in terms of the sides in each subject, as well as between sexes. The data was analysed using student's t-test and p values less than 0.01 was accepted as statistically significant.



Fig-1:



Fig-2:



Fig-3:

RESULTS

Table-1: Sex comparison of length and interstyloid distance of styloid process

Parameter	SEX				P value
	Male (N=65)		Female (N=35)		
	Range (Min-Max)	Mean ± SD	Range (Min-Max)	Mean ± SD	
Length of right styloid process	9.750 - 40.56	22.70 ± 0.8602	10.00 - 35.12	22.16 ± 1.213	0.8868
Length of left styloid process	10.00 - 38.78	22.30 ± 0.8075	10.48 - 34.67	21.28 ± 1.143	0.7090
Interstyloid distance at base of styloid process	70.34 - 82.87	75.26 ± 0.3752	64.66 - 79.56	72.15 ± 0.652	0.0001**
Interstyloid distance at tip of styloid process	63.67 - 76.45	69.14 ± 0.3493	63.56 - 74.33	67.00 ± 0.5043	0.0001**

Table-2: Sex incidence of the elongated styloid process

Sex	Normal styloid process	Elongated styloid process
Male (n=65)	54 (83.07%)	11 (16.92%)
Female (n=35)	27 (77.14%)	8 (22.85%)

Table-3: sex prevalence of elongated styloid process

Sex	Elongated styloid process	
	Bilateral	unilateral
Male	4	7
Female	5	3

Table-4: Sex prevalence of unilateral elongated styloid process

Sex	Unilateral elongated styloid process	
	Right	Left
Male	3	4
Female	2	1

Out of total 100 specimens, the length of the styloid process highly varied from 9.75 mm as the shortest to 40.56 mm as the longest (Table-1). The mean values of the length were 22.70 ± 0.8602 mm and

22.30 ± 0.8075 mm on the right side and 22.16 ± 1.213 mm and 21.28 ± 1.143 mm on the left side in male and female respectively. However, the differences of the styloid process length were statistically non-significant

between males and females on both right and left sides ($P > 0.05$). The interstyloid distances of the skull at the base and the tip of the styloid processes were represented in Table-1. The mean of the distances at the base and the tip were 75.26 ± 0.3752 mm and 69.14 ± 0.3493 mm respectively in male, those in female were 72.15 ± 0.6525 mm and 67.00 ± 0.5043 mm respectively. These differences between male and female were statistically significant at the base ($P < 0.05$) and at the tip ($P < 0.05$).

Table 2 and 3 shows the sex incidences and prevalence of the elongated styloid process. Of the total 100 specimens, 19 skulls (19 %) had elongated styloid processes with 11 out of 65 skulls (16.92%) in male and 8 out of 35 skulls (22.85%) in female. Bilateral elongated styloid processes were found in 4 (4 %) of the 11 male skulls and 5 (5%) of the total 8 female skulls. As for the unilateral elongated styloid processes, the elongated were found in 3 skulls (3 %) in male and 2 skulls (2%) in female on the right side and in 4 skulls (4%) in male and 1(1%) skulls in female on the left side.

DISCUSSION

The styloid process arises developmentally from the Reichert cartilage of the second branchial arch. It is a long and thin outgrowth at the base of the temporal bone, immediately in front of the stylomastoid foramen, posterior to the apex of mastoid process. It serves as a point of attachment for the stylomandibular ligament as well as the styloglossus, stylohyoid, and stylopharyngeus muscles. Elongation of styloid process is a poorly understood process. Commonly admitted theories about the actual cause of the elongation of the styloid process are defined as congenital elongation of the styloid process, calcification of the stylohyoid ligament by an unknown process, and growth of osseous tissue where the stylohyoid ligament inserts [5, 6].

Eagle [7] defined the length of a normal styloid process is 2.5-3 cm. The normal length of the styloid process varies greatly as follows:

- From 1.52 cm to 4.77 cm, according to Moffat *et al.*, [8].
- Less than 3 cm, according to Kaufman *et al.*, [9].
- From 2 cm to 3 cm, according to Lindeman [10].

Styloid process is considered normal when it is shorter than 2.5 cm and elongated when it is longer than 4 cm. Several theories have been proposed to explain the elongation of the SP in Eagle's syndrome [11]. An elongated SP occurs in about 4% of the general population. Only small percentages (between 4% and 10.3%) of these patients are symptomatic with a female to male predominance of 3:1.17. Incidence seems to range from 1.4 to 84.4% of population, that or anatomic (cadaveric or dry) specimen, ethnic variability and predominance of unilateral to bilateral occurrence [12,

13]. The elongated SP syndrome is often observed in third and fourth decades of life and in women more frequently than in men. [14] The identification of the sex of skeletal remains is important in the execution of the forensic anthropological examination. For this purpose, the information on sexual dimorphism of human skeleton is useful in terms of the morphology differences as well as the larger size of male [4]. In this regard, Krogman & Iscan have stated that the identification of sex with 100 % accuracy is possible when the whole skeleton is utilized, while 98 % accuracy is possible by using the pelvis and the skull, 95 % accuracy by the pelvis alone, and 92 % by the skull alone. Furthermore, there have been studies to estimate the value for sex identification of various parts of the skeleton such as patella, mastoid process, scapula and clavicle, and first rib. However, very few studies have been done on sex estimation from the styloid process. According to previous reports, the normal length of the styloid process varies in different geological regions, such as 2.50 - 3.00 mm in Europe [28] and 24.12 ± 7.28 mm in Thai [15]. With regard to the sexual dimorphism, Hussain *et al.*, [16] have reported that its length in male is larger than that in female at both right and left sides with a statistically significance. In the present study, however, no statistical significance was found in the sex difference in the length of the styloid process. The styloid process with its length larger than 30 mm is generally regarded as the elongated styloid process and a representative of Eagle's syndrome [17]. Although the skeletal growth is a complex biological phenomenon influenced by many factors such as genotype, hormones, nutrition, ecology, energy levels and medical care. The commonly accepted cause of the styloid process elongation is a congenital elongation and ossification of the stylohyoid ligament. The Eagle's syndrome characterized by the elongated styloid process was first described by Eagle [28] and it is a rare disease in which the elongated process compresses neurovascular structures surrounding it. This syndrome is classified into 2 types; one of the two, termed the classical type is characterized by a persistent pain in the throat and ear, and a foreign body sensation in the throat. The other type is characterized by dizziness and headache probably due to the compression of the carotid artery by the elongated processes. For differential diagnosis of Eagle's syndrome, attention should be paid to oral and dental diseases, temporomandibular disorders, and tumors in the oropharynx and laryngopharynx [29]. Some authors have reported that an abnormal angulations of the styloid process may be responsible for the compression of the nearby structures rather than the elongation itself of this process [18].

With regard to the occurrence frequency of the elongated styloid process, the present value of 19 % in central Indian population is lower than that of Brazilian reported by Vieira *et al.*, [19] and de Andrade *et al.*, [20] as 76 %, Rizzatti-Barbosa *et al.*, [21] as 20

% . And Leite *et al.*, [22] as 19.56 % and Thai population [26] as 26.47%. The present study values of elongated styloid process closely resemble Leite *et al.*, [22].

Regarding gender, the elongated styloid process or Eagle's syndrome occurred more frequently in females [23]. In contrast [24] reported that styloid processes were elongated more in males than females. Present study found no relationship of gender to an Eagle's syndrome in agreement with Ilgüy *et al.*, [25]. Although the elongated styloid process can occur unilaterally or bilaterally. It has been previously reported that elongation styloid process were bilateral more than unilateral [24, 25]. We found that the unilateral elongated styloid process was more frequently found on the left in males and in females the unilateral styloid process was frequently found on the right side.

Previous study done by [26] on styloid process for sex determination showed statistically significant differences of the interstyloid distance at both the base and the tip of the processes. ($p < 0.05$). The present study findings coincides with the study conducted by [26].

The skull being one of the most accurate bones for sex differentiation [4]. In fact, the styloid process is an elongated bony projection from the petrous portion of the temporal bone [3]. Therefore, the results of this study indicate that it is possible to use the interstyloid distance at both the base and the tip of the processes for sex estimation.

Taken together these findings may help surgeons to consider the SP whether its length and direction could be the factors that obstruct the surgical approach through the entrance of the infratemporal fossa [27]. Our study is an attempt to provide some data about different parameters of SP in Indian population. Detail study of the morphology of SP and its relations with adjacent neurovascular structures should be performed by using new imaging techniques which will throw light on this.

CONCLUSION

Many important anatomical structures are in close proximity with the SP. These structures may be compressed or irritated because of variations in the morphology of SP. Our study may be helpful for maxillofacial surgeons, dentists, radiologists, and anesthetists to reach the proper diagnosis by doing pre-operative evaluation.

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