

Sexual Dimorphism Using the Interstyloid Distances and Clinical Implication for Elongated Styloid Process in Northeastern Thailand

Dimorfismo Sexual Usando la Distancia Inter-Estiloide y la Implicación
Clínica del Proceso Estiloides Elongado en el Noreste de Tailandia

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SUMMARY: Skeletal remains are crucial in forensic identification of the sex, especially human skulls including the styloid process, a bony projection from the skull. Hence, the objectives of the present study were undertaken to assess the value of the styloid process for the sex identification of unknown skulls and also to investigate the prevalence of elongated styloid process in 102 human dry skulls from the northeast Thai population. As a result, the interstyloid distances at both base and tip of the styloid processes were found to be significantly different between male and female specimens, although no significant difference was found in the length of the styloid process between males and females. In addition, the occurrence of the elongated styloid process was not associated with the gender, although its prevalent laterality on the left was recognized. It is suggested that the styloid process can be applied to the sex identification by measuring the interstyloid distance at the base or the tip of these processes.

KEY WORDS: Styloid process; Elongated styloid process; Interstyloid distance; Sex identification.

INTRODUCTION

The sex estimation is one of the most important steps in identification of the biological profile of the dismembered and skeletal remains. 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 (Krogman & Iscan, 1986). Additionally, studies on the sex estimation have been conducted on various skeletal elements such as the scapula, sternum, clavicle, patella, hand and foot bones (Vasiliki *et al.*, 2012; Singh *et al.*, 2012; Smith, 1996; Wiwatpinyo *et al.*, 2014). However, no studies have been focused on the sex estimation using the styloid process.

The styloid process is a cylindrical bony projection extending from the petrous portion of the temporal bone. It lies in front of the stylomastoid foramen and projects downwards, forwards, and slightly towards the medial side.

The location of the apex of the styloid process is clinically important, which is located between internal carotid and external carotid arteries, posterolateral to the tonsillar fossa and laterally from the pharyngeal wall. There are many structures surrounding the styloid process, such as the facial nerve crosses to the base and external carotid artery crosses its apex of this process before embedded in the parotid gland. In addition, three muscles and two ligaments are attached to the styloid process. Stylopharyngeus, stylohyoid and styloglossus muscles are attached to the base, middle part and tip of the styloid process, respectively. The stylohyoid and stylomandibular ligaments extend from the tip of the styloid process to the hyoid bone and the angle of mandible, respectively (Standing, 2008).

The normal adult styloid process is approximately 20-30 mm in length. The styloid process is generally regarded as elongated when it is longer than 30 mm (Eagle, 1962).

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The elongated styloid process can compress some neural or vascular structures of the pharynx. Resulting pains were first described by Eagle and referred as Engle's syndrome. Symptoms associated with an Engle's syndrome, in addition to such as pharyngeal pain, include dysphagia, tinnitus and foreign body sensation in the throat. The symptoms also include changes in the voice and reduces in the range of the mandibular opening (Dinkar & Amonkar, 2003).

The purposes of this study are: 1) to estimate the sexual dimorphism of the styloid process, and 2) to investigate the prevalence of the elongated styloid process in a Thai population living in the northeast region.

MATERIAL AND METHOD

A total of 102 adult dry human skulls with intact styloid processes (50 males and 52 females) were derived from donated cadavers in the Department of Anatomy, Faculty of Medicine, Khon kean University, Thailand. 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 was done on the distance between the bases of 2 styloid processes (Fig. 2). While the interstyloid distance at the tip of the skull was measured the distance between the tips of 2 styloid processes.



Fig. 1. Length of the styloid process from the base to the apex of the process.



Fig. 2. The interstyloid distance at the base of two styloid processes.

Each measurement was performed three times and averaged them. The values were statistically analyzed with the statistical package for social science (SPSS) version 17.0 (SPSS Inc., Chicago, Illinois, USA). The data were analyzed using the student t-test and P values less than 0.05 were accepted as statistically significant.

RESULTS

Among the total 102 specimens, the length of the styloid process was highly varied from 8.75 mm as the shortest to 42.02 mm as the longest (Table I). The mean values of the length were 24.79 ± 6.80 mm and 24.53 ± 6.20 mm on the right side and 24.54 ± 6.58 mm and 24.92 ± 6.04 mm on the left side in male and female, respectively. While its mean values on the right side in female seems to be greater than that in male, its value on the left side greater in females. 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 II. Whereas the means of the distances at the base and the tip

Table I. Sex comparison of the styloid process lengths.

Locations	Sex	Range in mm	Mean in mm	SD	P-value
Right	Male	8.75 - 42.02	24.79	6.80	0.84
	Female	9.50 - 34.49	24.53	6.20	
Left	Male	10.89 - 37.46	24.54	6.58	0.76
	Female	10.13 - 40.20	24.92	6.04	

Table II. Sex comparison of the interstyloid distances

Locations	Sex	Mean in mm	SD	P-value
Interstyloid distance at base of the styloid processes	Male	80.24	4.00	0.001*
	Female	77.24	5.12	
Interstyloid distance at tip of the styloid processes	Male	68.46	5.80	0.002*
	Female	64.66	6.08	

Table III. Sex incidence of the elongated styloid process.

Sex	Normal styloid process	Elongated styloid process
Male	38 (37.25%)	14 (13.73%)
Female	37 (36.27%)	13 (12.75%)

Table IV. Sex prevalence of the elongated styloid process.

Sex	Elongated styloid process	
	Bilateral	Unilateral
Male	6 (5.88%)	8 (7.84%)
Female	4 (3.92%)	9 (8.82%)

Table V. Sex prevalence of unilateral elongated styloid process.

Sex	Unilateral elongated styloid process	
	Right	Left
Male	3 (2.94%)	5 (4.90%)
Female	4 (3.92%)	5 (4.90%)

were 80.24 ± 4.00 mm and 68.46 ± 5.80 , respectively, in male, those in female were 77.24 ± 5.12 mm and 64.66 ± 6.08 , respectively. These differences between male and female were statistically significant differences both at the base ($P < 0.05$) and the tip ($P < 0.05$).

Tables III, IV and V shows the incidences of the elongated styloid process. Of the total 102 specimens, 27 skulls (26.47 %) had elongated styloid processes with 14 out of 52 skulls (13.73 %) in male and 13 out of 50 skulls (12.75 %) in female. Bilateral elongated styloid processes were found in 6 (5.88 %) of the 14 male skulls and 4 (3.92 %) of the total 13 female skulls. As for the laterality of unilateral elongated styloid processes, the elongated were found in 3 skulls (2.94 %) in male and 4 skulls (3.92 %) in female at the right side.

DISCUSSION

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 (Krogman & Iscan). In this regard, Krogman & Iscan have stated that the sex identification with 100 % accuracy is possible when the whole skeleton is utilized, while the 98 % accuracy is possible

by using the pelvis and the skull, the 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 (Introna *et al.*, 1998; Vasiliki *et al.*, 2012; Kubicka & Piontek, 2016). However, no estimation of the value has so far been done about the styloid process.

According to previous reports, the normal length of the styloid process is varying in different geological regions, such as 2.50-3.00 mm in Europe (Eagle, 1962) and 24.12 ± 7.28 mm in Thai (Promthale *et al.*, 2012). With regard to the sex dimorphism, Hussain *et al.* (2011) 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. Although some differences seemed to be present in terms of the laterality.

The styloid process with its length larger than 30 mm is generally regarded as the elongated styloid process and a representative of Engle's syndrome (Balbuena *et al.*, 1997). Although the skeletal growth is a complex biological phenomenon influenced by many factors such as genotype, hormones, nutrition, ecology, energy levels and medical care (Charisi *et al.*, 2011; Raghavendra Babu *et al.*, 2012) The commonly accepted cause of the styloid process elongation is a congenital elongation and ossification of the stylohyoid ligament. The Engle's syndrome characterized by the elongated styloid process was first described by Eagle (1962) 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 diagnoses of Engle's syndrome, attention should be paid to oral and dental diseases, temporomandibular disorders, and tumors in the oropharynx and laryngopharynx (Eagle, 1948). Some authors have reported that an abnormal angulation of the styloid process may be responsible for the compression of the nearby structures rather than the elongation itself of this process (Rathva *et al.*, 2013).

With regard to the occurrence frequency of the elongated styloid process, the present value of 26.47 % in north east Thai population is lower than that of Brazilian reported by Vieira *et al.* (2015) and de Andrade *et al.* (2012) as 76 %. However it was slightly upper than the reported of Rizzatti-Barbosa *et al.* (2005) and Leite *et al.* (1988), as 20 % and 19.56 %, respectively.

Regarding gender, the elongated styloid process or Eagle's syndrome occurred more frequently in females (Woolery, 1990). In contrast, reported that styloid processes were elongated more in males than females (Bozkir *et al.*, 1999). Our study found no relationship of gender to an Engle's syndrome in agreement with Ilgüy *et al.* (2005). Although the elongated styloid process can occur unilaterally or bilaterally. It has been previously reported that elongation styloid process were bilateral more than unilateral (Bozkir *et al.*; Ilgüy *et al.*). We found that the unilateral elongated styloid process was more frequently found on the left than the right side in both males and females.

To the best of our knowledge this study is the first to be conducted styloid process for sex determination. We found the statistically significant differences of the interstyloid distance at both the base ($P < 0.05$) and the tip ($P < 0.05$) of the processes. The skull being one of the most accurate bones for sex differentiation (Krogman & Iscan). In fact, the styloid process is an elongated bony projection from the petrous portion of the temporal bone (Dinkar & Amonkar). 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.

The results of this study indicated that the styloid process has a good potential for sex identification. By measuring the interstyloid distance at both the base and the tip of these processes. The knowledge length of the styloid process and prevalence of the elongated styloid process are important and useful to the anatomists, anthropologists, radiologists, and clinicians.

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RESUMEN: Los restos óseos son cruciales para la identificación forense del sexo, especialmente en los cráneos humanos, incluyendo el proceso estiloides, una proyección ósea del cráneo. Por lo tanto, los objetivos del presente estudio consistieron en evaluar el valor del proceso estiloides en la identificación del sexo de cráneos desconocidos y también para investigar la prevalencia del proceso estiloides elongado en 102 cráneos secos humanos de la población del Noreste de Tailandia. Como resultado, se encontró que las distancias inter-estiloides tanto en la base y la punta de los procesos estiloides eran significativamente diferentes entre las muestras de hombres y mujeres, aunque no se encontró diferencia significativa en la presencia del proceso estiloides entre ambos. Además, la aparición del proceso estiloides elongado no se asoció con el sexo, aún cuando se observó su prevalencia en el lado izquierdo. Sugerimos que el proceso estiloides se puede utilizar en la identificación del sexo mediante la medición de la distancia inter-estiloide en la base o en la punta de estos procesos.

PALABRAS CLAVE: Proceso estiloides; Proceso estiloides elongado; Distancia inter-estiloide Identificación del sexo.

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