Original Article

นิพนธ์ต้นฉบับ

Determination of age and sex from the hyoid bone

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Abstract

The skeletonized remains can be assessed for the basic understanding of the human body that is the sex, race, age and stature. The present study was conducted to assess for determination of age from fusion of the greater horns with the body and developed equations for predicting sex in the hyoid bone. The hyoid bones total numbers of 488 samples (266 males and 222 females) were collected from the autopsy cases at the Department of Forensic Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University and Institute of Forensic Medicine, Police General Hospital, Royal Thai Police.

Bilateral fusion of the greater horns with the body was found since 16 years. The mean age of non fusion, unilateral and bilateral fusion in both sexes were 37.20, 51.11 and 54.46 years, respectively. ROC Curve showed that in both sexes over 60 years of age, bilateral fusion was found in 57.98%, if younger than 20 years non fusion was found up to 97.78%. There was no difference between sexes and between right and left sides in the fusion. Bilateral fusion of the lesser horns also found since 16 years but it was not good indicator for determining age. Discriminant function analysis used to develop equations utilizing a combination of measurements that have ability to classify the hyoid bone as either males or females. Three equations ranging in accuracy of 81-95%. The incidence of the shape of the hyoid bone in both sexes was the parabola shape and there was no difference between sexes in shape.

In conclusion determination of age by using the fusion of the hyoid bone is more reliable when combined with the main methods. And this equation for determining sex is good and useful in Thai population.

Keywords: Hyoid bone, Determination of age and sex, Forensic anthropology, Discrimination, Fusion

บทคัดย่อ

โครงกระดูกสามารถประเมินข้อมูลพื้นฐานของร่างกายมนุษย์ คือ เพศ, เชื้อชาติ, อายุ และส่วนสูง ในการศึกษานี้ได้ดำเนินการหาอายุจากการเชื่อมกันระหว่าง greater horns และ body และสร้างสมการเพื่อทำนายเพศจากกระดูกไฮออยด์ ตัวอย่างกระดูกไฮออยด์จำนวน 488 ตัวอย่าง (ผู้ชาย 266 ตัวอย่าง และผู้หญิง 222 ตัวอย่าง) นำมาจากศพที่ถูกนำมาชันสูตรพลิกศพที่ภาควิชานิติเวชศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล มหาวิทยาลัยมหิดลและที่สถาบันนิติเวชวิทยา โรงพยาบาลตำรวจ สำนักงานตำรวจแห่งชาติ

การเชื่อมกันทั้ง 2 ข้างของ greater horns และ body สามารถพบได้ตั้งแต่อายุ 16 ปี โดยอายุเฉลี่ยของการไม่เชื่อมกัน การเชื่อมกันเพียงข้างเดียว และการเชื่อมกันทั้ง 2 ข้างของกระดูก คือ 37.20, 51.11 และ 54.46 ปี ตามลำดับ การวิเคราะห์ ROC Curve แสดงให้เห็นว่า ในทั้ง 2 เพศที่อายุมากกว่า 60 ปี พบว่าเกิดการเชื่อมกันทั้ง 2 ข้าง คิดเป็น 57.98% แต่ถ้าอายุน้อยกว่า 20 ปี พบว่าไม่เกิดการเชื่อมกันของกระดูกถึง 97.78% นอกจากนี้ยังไม่พบความแตกต่างระหว่างเพศและไม่พบความแตกต่างระหว่างการเชื่อมกันของกระดูกทั้งด้านขวาและด้านซ้าย การเชื่อมกันทั้ง 2 ข้างของ lesser horns กับ body ก็พบได้ตั้งแต่อายุ 16 ปีเช่นกัน แต่ว่าเป็นตัวชี้วัดที่ไม่ดีสำหรับการหาเพศ การวิเคราะห์โดยใช้ Discriminant function เพื่อสร้างสมการโดยใช้ประโยชน์จากการวัดซึ่งพบว่ามีประสิทธิภาพในการจำแนกเพศจากกระดูกไฮออยด์ โ ดยทั้ง 3 สมการมีความถูกต้องตั้งแต่ 81-95% และเมื่อทำการวิเคราะห์รูปร่างของกระดูกไฮออยด์พบว่ามีรูปร่างเป็นพาราโบลามากที่สุดในทั้ง 2 เพศ แต่อย่างไรก็ตามก็ไม่พบความแตกต่างระหว่างเพศ

กล่าวโดยสรุป คือ การหาอายุจากการเชื่อมกันของกระดูกไฮออยด์จะมีความน่าเชื่อถือมากยิ่งขึ้นหากใช้ร่วมกับวิธีการหาอายุวิธีอื่นๆ และสมการการทำนายเพศสามารถใช้ประโยชน์ได้ดีในประชากรไทย

คำสำคัญ: กระดูกไฮออยด์, การหาอายุและเพศ, นิติมานุษยวิทยา

Introduction

Forensic anthropology is a branch of the forensic medicine and is defined as the application of scientific technique to develop with physical anthropology and human osteology for identification (1). The skeletonized remains can be assessed for the basic understanding of the human body that is the sex, race, age, stature and estimation time of death as well as any pathology to be used in the identification of the bones (2).

The hyoid bone is located at the anterior portion of the neck between the root of the tongue and thyroid cartilage, the shape is like a horse-shoe shaped or U shaped (3-6).

Determination of age from the hyoid bone was studied mainly from the fusion of the body and the greater horns. Many studies have demonstrated that frequency of bony fusion between the body and the greater horns become greater with age (7-12). Fusion was rare in the younger than 20 years (7-14). However, bilateral non fusion was still found in old age of 80-90 years old (9, 15) and the youngest is 18 years (15). No significant difference found between right and left side of fusion (7-10, 16). And there was no statistically significant difference between sexes (8, 11). There are very few studies on age ossification of the lesser horns. Harjeet et al. (2010) found that the lesser horn was not fused until the age of 35 years in males and 40 years in females (9).

Discrimination functions were developed in most sex determination from the hyoid bone. Many studies used indirect method such as radiography and photography. The accuracy of the discrimination function was variable between 69.2-88.5% (10, 17-18). In 2010, Kindschuh et al. examined 398 hyoid bones. The accuracy was 87.3% in male and 81.9% in female on fused hyoid, 82.2% in male and 89.1% in female on unfused hyoid. The functions using the body of the hyoids, the accuracy was 80.6% in male and 85.4% in female.

Due to the problem in the field of forensic science and forensic anthropology, it is not always possible to find all pieces of the bone or sometimes may be incomplete. If we have more data for supporting from many parts of bones we will have higher accuracy and precision for the identification in forensic field. So this present study was conducted with the following aims and objectives:

1. Estimation of the age from fusion of the greater horns and lesser horns with the body of the hyoid bone.
2. To develop a discrimination function or equation for predicting or calculating sex from the hyoid bone.

Materials and methods

Total numbers of 488 specimen of the hyoid bone were collected from autopsy cases performed at Department of Forensic Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University and Institute of Forensic Medicine, Police General Hospital, Royal Thai Police. All 488 hyoid bones were dissected from larynx and surrounding connective tissues, the age, sex, and cause of death were recorded, cases with the old and new fracture of hyoid were excluded. Each hyoid bone was cleaned and stored in the sand or water for 8-10 weeks to remove the attached soft tissue and then air

dried for 2-4 days. For determination of age, visually and manually inspected for the presence or absence of fusion of the greater horns. Then the hyoid was categorized into 5 year age interval and divided into 3 small groups as follows: non-fusion, unilateral fusion and bilateral fusion. For determination of sex, the samples was separated into 2 groups (males and females) and direct measurements were taken for 10 parameters as shown in the following figure by using standard digital sliding calipers (figure 1).

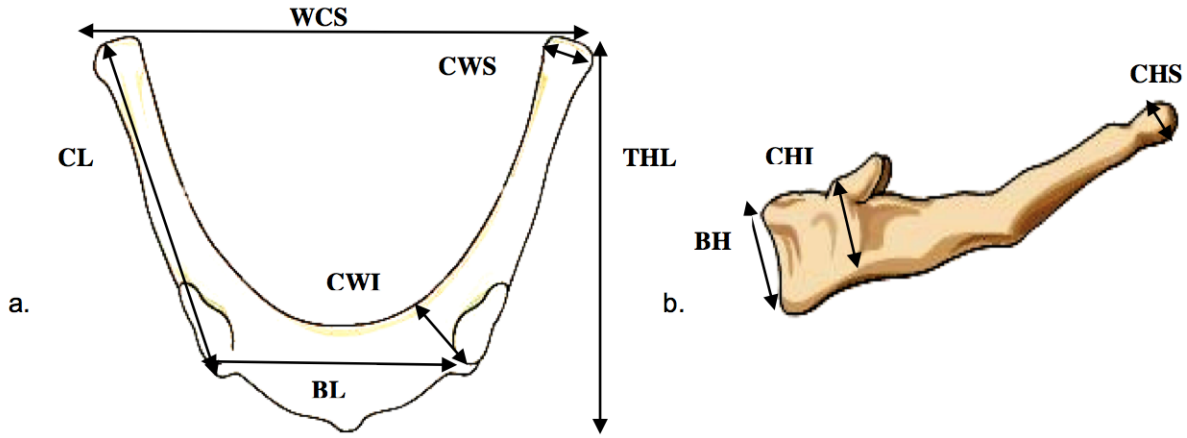

Figure 1 Parameter for measurement of the hyoid bone.

a = superior view, b = lateral view

Parameter	Description
BL	Maximum length of body
BH	Maximum height of body
CWI	Width of greater horn at fusion point with body (Rt. And Lt.)
CHI	Height of greater horn at fusion point with body (Rt. And Lt.)
CL	Maximum length of greater horn (Rt. And Lt.)
CWS	Greatest width of distal end of greater horn (Rt. And Lt.)
CHS	Greatest height of distal end of greater horn (Rt. And Lt.)
THL	Total hyoid length, from anterior surface of the body to the distal ends of greater horns (fused hyoids only)
THW	Total hyoid width – maximum distance between the widest points of the greater horns (not pictured; fused hyoids only)
WCS	Total width between the distal ends of the right and left greater horns (fused hyoids only)

Table 1 Description of the parameter

Statistic method

1. Descriptive statistic for calculated frequency, mean, S.D., S.E.

2. Multiple comparisons: scheffe's test for comparing age and fusion.

3. Paired sample t-test used to test the difference in measurements between the right and left sides of the same hyoid.

4. Independent t-test to compare mean between 2 groups i.e. to compare difference between sex and parameter.

5. ROC curve for predicting cut off point.

6. Discriminant function analysis to develop equations utilizing a combination of measurements that have ability to classify the hyoid bone as either males or females

All data used in the calculation of the program SPSS 19.0.

Results

In this present study, all 488 samples were collected. 266 samples (55.5%) were males, mean age was 44.64 years. 222 samples (45.5%) were females and mean age was 46.05 years.

1. Determination of age from the hyoid bone

1.1 Fusion of the greater horns

In males younger than 19 years, non fusion was mostly found in 95.7% and tends to decrease with increasing age, and only 5% found in males over the age of 70 years. The bilateral fusion was not found in males younger than 19 years and tends to increase with advancing age, if was found in males over the age of 70 years for 70%.

In females, the incidence of fusion was similar to males. In females younger than 19 years, non fusion was found in 93.3%. And in the age group of 60-64 years, non fusion was not found and bilateral fusion was found in 88.2% (Table 2).

The trend decreased in non fusion and increased in bilateral fusion. So it can be concluded that the fusion of the greater horn and hyoid bone increases with age in both males and females.

Age group	Male			Female			Total		
	Non fusion	Unilateral fusion	Bilateral fusion	Non fusion	Unilateral fusion	Bilateral fusion	Non fusion	Unilateral fusion	Bilateral fusion
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
<19	22 (95.7%)	1 (4.3%)	0 (0%)	14 (93.3%)	0 (0%)	1 (6.7%)	36 (94.7%)	1 (2.6%)	1 (2.6%)
20-24	17 (81.0%)	0 (0%)	4 (19.0%)	16 (88.9%)	1 (5.6%)	1 (5.6%)	33 (84.6%)	1 (2.6%)	5 (12.8%)
25-29	15(62.5 %)	4 (16.7%)	5 (20.8%)	10 (76.9%)	0(0%)	3 (23.1%)	6 (75 . 6%)	4 (10.8%)	8 (21.6%)
30-34	15 (75.0%)	2 (10.0%)	3 (15.0%)	13 (72.2%)	2 (11.1%)	3 (16.7%)	28 (73.7%)	4 (10.5%)	6 (15.8%)
35-39	10 (50.0%)	4 (20.0%)	6 (30.0%)	14 (66.7%)	4 (19.0%)	3 (14.3%)	24 (58.5%)	8 (19.5%)	9 (22.0%)
40-44	14 (51.9%)	5 (18.5%)	8 (29.6%)	7 (30.4%)	7 (30.4%)	9 (39.1%)	21 (42.0%)	12 (24.0%)	17 (34.0%)
45-49	12 (57.1%)	6 (28.6%)	3 (14.3%)	10 (45.5%)	1 (4.5%)	11 (50.0%)	22 (51.2%)	7 (16.3%)	14(32.6 %)
50-54	7 (30.4%)	5 (21.7%)	11 (47.8%)	9 (47.4%)	3 (15.8%)	7 (36.8%)	16 (38.1%)	8 (19.0%)	18 (42.9%)
55-59	10 (43.5%)	4 (17.4%)	9 (39.1%)	4 (22.2%)	2 (11.1%)	12 (66.7%)	14 (34.1%)	6 (14.6%)	21 (51.2%)
60-64	8 (36.4%)	5 (22.7%)	9(40.9%)	0 (0%)	2 (11.8%)	15 (88.2%)	8 (20.5%)	7 (17.9%)	24 (61.5%)
65-69	5 (22.7%)	4 (18.2%)	13 (59.1%)	6 (40.0%)	1 (6.7%)	8 (53.3%)	11 (29.7%)	5 (13.5%)	21 (56.8%)
>70	1 (5.0%)	5 (25.0%)	14 (70.0%)	6 (26.1%)	7 (30.4%)	10 (43.5%)	7 (16.3%)	12 (27.9%)	24 (55.8%)
Total	136 (51.1%)	45 (16.9%)	85 (32.0%)	109 (49.1%)	30 (13.5%)	83 (37.4%)	245 (50.2%)	75 (15.4%)	168 (34.4%)

Table 2 Fusion of the greater horn with the body of the hyoid bone

There was no difference in right side and left side of unilateral fusion in both sexes (p>0.05).

Degree of fusion	No.	Mean age (years)	SD	Minimum	Maximum
Non fusion	245	37.20	16.26	12	91
Unilateral fusion	75	51.11	16.01	16	87
Bilateral fusion	168	54.46	15.76	16	93
Total	488	45.28	17.99	12	93

And no difference between sex was found in the fusion of the greater horn (p=0.359)

* *p<0.001* when compared with non bilateral fusion

p>0.05 when compared with unilateral fusion

Table 3 Mean age of the greater horn fusion in both sexes

The mean age in both sexes of non fusion was 37.2 years showing statistically significant difference compared to the mean age of unilateral fusion 51.11 years and bilateral fusion 54.46 years (p<0.001). But the mean age of unilateral fusion showed no difference compared to the mean age of bilateral fusion (p =0.324) (Table 3).

1.2 Fusion of the lesser horns

Table 4 showed that for lesser horn fusion, non fusion was found in majority of all age range and there was no difference between sex found in the fusion of the lesser horn (p=0.210)

The mean age in both sexes of non fusion was 43.49 years revealing statistically significant difference compared to the mean age of unilateral fusion 50.68 years and bilateral fusion 50.20 years (p=0.008). But the mean age of unilateral fusion showed no difference compared to the mean age of bilateral fusion (p =0.989) (Table 5).

Age group	Male			Female			Total		
	Non fusion	Unilateral fusion	Bilateral fusion	Non fusion	Unilateral fusion	Bilateral fusion	Non fusion	Unilateral fusion	Bilateral fusion
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
<19	23 (100%)	0 (0%)	0 (0%)	13 (86.7%)	0 (0%)	2 (13.3%)	36 (94.7%)	0 (0%)	2 (5.3%)
20-24	19 (90.5%)	1 (4.8%)	1 (4.8%)	15 (83.3%)	2 (11.1%)	1 (5.6%)	34 (87.2%)	3 (7.7%)	2 (5.1%)
25-29	16 (66.7%)	6 (25.0%)	2 (8.3%)	12 (92.3%)	1(7.7%)	0 (0%)	28 (75 . 7%)	7 (18.9%)	2 (5.4%)
30-34	17 (85.0%)	2 (10.0%)	1 (5.0%)	17 (94.4%)	1 (5.6%)	0 (0%)	34 (89.5%)	3 (7.9%)	1 (2.6%)
35-39	14 (70.0%)	4 (20.0%)	2 (10.0%)	16 (76.2%)	1 (4.8%)	4 (19%)	30 (73.2%)	5 (12.2%)	6 (14.6%)
40-44	18 (66.7%)	5 (18.5%)	4 (14.8%)	16 (69.6%)	2 (8.7%)	5 (21.7%)	34 (68.0%)	7 (14.0%)	9 (18.0%)
45-49	15 (71.4%)	4 (19.0%)	2 (9.5%)	17 (77.3%)	5 (22.7%)	0 (0%)	32 (74.4%)	9 (20.9%)	2 (4.7%)
50-54	15 (65.2%)	4 (17.4%)	4 (17.4%)	15 (78.9%)	3 (15.8%)	1 (5.3%)	30 (71.4%)	7 (16.7%)	5 (11.9%)
55-59	13 (56.5%)	5 (21.7%)	5 (21.7%)	14 (77.8%)	1 (5.6%)	3 (16.7%)	27 (65.9%)	6 (14.6%)	8 (19.5%)
60-64	13 (59.1%)	6 (27.3%)	3 (13.6%)	14 (82.4%)	0 (0%)	3 (17.6%)	27 (69.5%)	6 (15.4%)	6 (15.4%)
65-69	16 (72.7%)	2 (9.1%)	4 (18.2%)	8 (53.3%)	5 (33.3%)	2 (8.7%)	24 (64.9%)	7 (18.9%)	6 (16.2%)
>70	11 (55.0%)	6 (30.0%)	3 (15.0%)	16 (69.9%)	5 (21.7%)	2 (8.7%)	27 (62.8%)	11 (25.6%)	5 (11.6%)
Total	190 (71.4%)	45 (16.9%)	31 (11.7%)	173 (77.9%)	26 (11.7%)	23 (10.4%)	363 (74.4%)	71 (14.5%)	54 (11.1%)

Table 4 Fusion of the lesser horn with the body of the hyoid bone

Degree of fusion	No.	Mean age (years)	SD	Minimum	Maximum
Non fusion	363	43.49	18.42	12	91
Unilateral fusion	71	50.68	15.96	23	83
Bilateral fusion	54	50.20	15.31	16	75
Total	488	45.28	17.99	12	93

Table 5 Mean age of the lesser horn fusion in both sexes

* $p<0.05$ when compared with non fusion

$p>0.05$ when compared with unilateral fusion

2. Determination of sex from the hyoid bone

The 12 parameters of non fusion revealed that the greatest width of distal end of greater horn (CWS) (right and left) and the greatest height of distal end of greater horn (CHS) (left) showed no difference between sexes.

The 15 parameters of fusion revealed that the greatest height of distal end of greater horn (CHS) (right and left) showed no difference between sexes.

Parameter	Sex	No.	Minimum	Maximum	Mean±SD
BL	M	266	15.86	34.95	23.85±2.66
	F	222	14.81	27.35	19.99±2.10
BH	M	266	6.79	14.01	10.35±1.23
	F	222	5.49	12.22	9.29±1.13
CWIR	M	266	2.56	7.1	4.52±0.83
	F	222	2.65	6.48	3.93±0.60
CHIR	M	266	4.39	9.43	6.81±0.93
	F	222	4.03	8.89	5.65±0.80
CLR	M	266	23.34	41.66	32.91±3.24
	F	222	23.06	37.96	29.45±2.71
CWSR	M	266	1.39	5.05	2.90±0 .95
	F	222	1.73	5	3.06±0.50
CHSR	M	266	2.12	7.75	4.63±0.95
	F	222	2.74	6.35	4.43±0.69
CWIL	M	266	2.4	7.41	4.49±0.87
	F	222	2.31	5.79	3.88±0.57
CHIL	M	266	4.53	9.29	6.89±0.92
	F	222	4.03	8.53	5.69±0.74
CLL	M	266	23.28	41.63	32.68±3.19
	F	222	23.31	40.48	29.24±2.62
CWSL	M	266	1.56	4.9	2.95±0.60
	F	222	1.74	4.25	3.04±0.51
CHSL	M	266	2.73	7.1	4.52±2.53
	F	222	2.39	6.36	4.46±0.70
THL	M	84	34.41	44.66	40.17±2.53
	F	82	28.78	38.93	34.47±2.13
THW	M	84	35.3	62.57	46.81±5.35
	F	82	31.13	50.01	40.89±4.12
WCS	M	84	33.57	67.98	46.77±6.00
	F	82	31.13	50.01	40.89±4.12

Table 6 Average parameters in millimeter of sexual dimorphism of the hyoid bone

Parameter	Mean age	Accuracy
BL	≥ 23.85	M = 94.89%
	< 23.85	F = 61.26%
THL	≥ 40.17	M = 100%
	< 40.17	F = 63.68%

Table 7 Cut off point of parameters to sexual dimorphism

Table 7 showed that the maximum length of body (BL) greater than 23.85 mm. will be males for 94.89%, if the value less than 23.85 mm. will be females for 61.26%. And the total hyoid length (THL) greater than 40.17 mm. will be males for 100%, if the value less than 23.85 mm. will be females for 63.68%.

Paired samples t-tests comparing right and left sides of fusion and non fusion in males and females showed maximum length of greater horn (CL) which is the only one statistically significant difference ($p<0.05$).

Table 8 showed the 3 functions of the condition of the hyoid.

Function	Hyoid conditon	Discriminant function	Cut off point	Total accuracy	Accuracy of sexes
1	Fusion	D= (0.167)BL + (0.344)CHIR + (-0.541)CWSR + (0.361)CWIL + (0.377)CHIL + (0.248)THL - 17.710	-0.00546	95.20%	M = 92.9% F = 97.6%
2	Non fusion	D= (0.206)BL + (0.294)CHIR + (-0.658)CWSR+ (0.302)CHIL + (0.121)CLL - 9.969	-0.24367	85.90%	M = 85.6% F = 86.3%
3	Body	D= (0.368)BL + (0.204)BH - 10.146	-0.16694	81.80%	M = 83.1% F = 80.2%

Table 8 Discriminant functions for determining sex

3 Shape of the hyoid bone

Parabola shape is the most common type found in both sexes. 57 of 83 females were of parabola shape (68.7%) while 45 of 85 males were of parabola shape(52.9%)

There was no shape difference between sexes (p=0.06) (Figure 2).

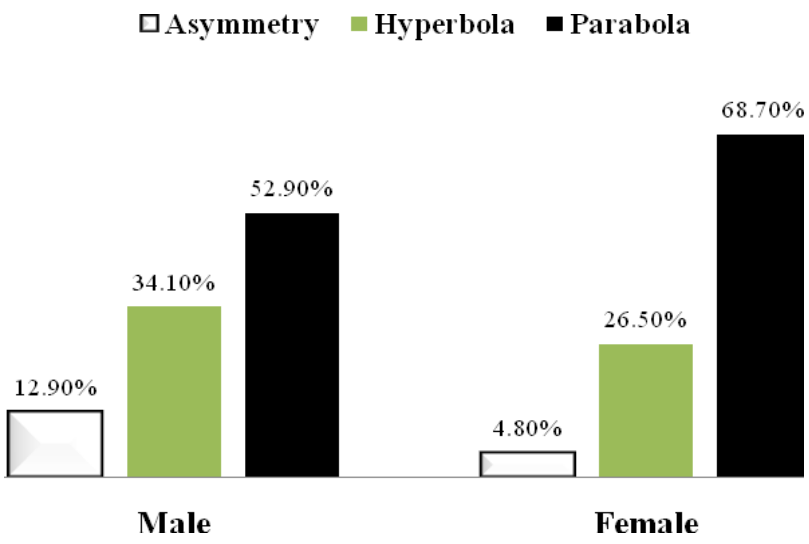

Figure 2 statistical incidence of hyoid morphological types

Discussion

This research demonstrated the results of determination of age and sex from the hyoid bones by studying the fusion between the body and the greater horns or lesser horns and predicting sex from the discrimination function analysis. This study was carried out on 488 samples of the hyoid bone, age range from 12 to 93 years in Thai populations.

The present study found one case which the age less than 19 years that had bilateral fusion. The youngest sample in whom bilateral fusion occurred was females 16 years of age. This observation differed from the previous studies which found none of the cases less than 19 years with bilateral fusion (7-11, 13-14).

The present study found a mean age of 54.46 years for bilateral fusion. This is higher than in the previous studies. The reason for this difference in mean age of bilateral fusion is that the majority of cases in the previous studies were less than 40 years (7-8, 16) while ages in most of cases in present study is almost equally distributed in most age range. Gupta et al. (2008) found that the unilateral fusion occurred about 10 years earlier than bilateral fusion in females and 15 years earlier than bilateral fusion in males but in this study this relationship was not found. Previous studies found the bilateral fusion occurred in females earlier than males (9, 16) but it is also not consistent with other studies (7, 11). There was no difference in right side and left side of unilateral fusion in both sexes and there is no specific pattern to show that one side fuses earlier than the other which correspond with previous studies (8-10, 13, 16). We did not find a statistically significant difference in fusion between sexes. This observation is accord with the previous studies (8, 10). Therefore, the fusion in the hyoid bone cannot be applied as a sex indicator.

Very little information is available on the determination of age by the lesser horns. The present study found 2 cases with the age less than 19 years having bilateral fusion of the lesser horns. The youngest sample in whom bilateral fusion occurred was females 16 years of age. This observation differed from the previous study which found none of the cases until the age of 35 years in both sexes (9). Finally, we found that the fusion of the lesser horns cannot be used to determine age. We consider the fusion in the hyoid bone to be relatively immune to some of the individualistic factors like genetics, lifestyle, health, nutrition, hormone, etc.

In determination of sex, this study showed statistically significant sex differences in many measurements. The width, length and height of the hyoid bones were statistically significant greater in males than in females except for the greatest width of distal end of greater horn (CWS) (right and left) for which the females is greater than males. This study suggested the total hyoid length (THL) as a sex indicator which contradicts with the other studies. The other studies suggested the distal end of the greater horns and the length of the greater horns for being sex indicators (10, 21).

The two functions developed for use on both non fusion and fusion hyoids classify females with higher accuracy than males but in the study of Kindschuh et al. showed that the fusion hyoids classify males with higher accuracy than females. And the function using the hyoid body classifies males better than females that contradicted too (19). In addition, the function to be used on fusion hyoid has an overall accuracy of greater than 90% which is significantly higher than the majority of previously developed discriminant functions (10, 18-21). This may be because there were no common measurements used as discriminant variables and the main reason was the different in races among the literature. But anyway we believe that our discriminant function is more statistically useful than those of others to date.

The present study consisted of direct measurement in autopsy cases. We believe this to be more accurate and reliable than the other studies which were studied on radiography and digital photographs (10, 12, 18). Namely, those methods allow dimensional distortion depending on the angle that was taken, the presence of soft tissue and bone tissue density where bone parts of extremely low or high density are not clearly displayed on radiograph and digital photograph (19, 22).

Morphologically, the bone shape was classified into three groups: parabola, hyperbola and asymmetric shape. In males, the incidence of asymmetrical shape is considerably higher than in the females while the incidence of parabola shape is lower, which is in agreement with Papadopoulos et al. (23) but contradicts with Leksan et al. (22). In this study, we found the parabolic shape to be the most common in males and females, 52.90% and 68.70%, respectively. On the contrary, the previous

studies found the parabolic shape to be the most common form in males and the hyperbolic shape to be the leading form in females. And there was no shape difference between sexes (23).

Conclusion

In the study of fusion of the hyoid bone, it was found that there was the relationship between age group and fusion but no difference between sexes. We also found a high degree of variation in the age of fusion which implies that the hyoid bone is not a good indicator for estimating age by the lesser horn fusion but age estimation from the greater horn fusion is better than the lesser horn fusion. However, it can be made more useful when combined with other methods of age estimation in adults.

This will provide the physical anthropologist with the opportunity to make use of every skeletal element present when assessing the age of an individual.

This study showed statistically significant sex differences in many parameters. We recommends using the maximum length of body (BL) and the total hyoid length (THL). And then we developed three discriminant functions which provide the better result. Thus, the total accuracy was up to 90% from the hyoid bone that is useful for sex determination in Thai population and will prove helpful in distinguishing them from other population groups.

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