FROM FETUS TO ADULT: SOME MORPHOLOGICAL MEASUREMENTS

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PREFACE

Societies develop with the advancement of science. The studies that contribute to this development emerge with a combination of scientific thinking and scientific research methods. Most of the studies are carried out in the field of health. The importance of anatomy in the field of health is undeniable. Therefore, the widespread use of anatomical and morphological studies sheds light on scientists working in this field.

This book contains various morphological studies and has been prepared to guide scientists who will work in these fields. The studies are based on anatomical measurements suitable, especially, for Turkish society. The book consists of four main parts. The first chapter includes the anthropological measurement features of the condylar and inner-condylar tibia bone. The second part investigated the relations between external genital measurements and morphometric features between 18-52 year-old women. The third chapter examined the relationships between sternum morphometry and other breast measurements in adults. In the fourth section, measurements related to knee development in fetuses during the fetal period were presented. In the fifth chapter, anthropometric measurements of fetuses were continued and information was given about anthropometric measurements of Turkish fetus faces. In the last section, anthropometric analyzes of adult femoral measurements in the Turkish population were explained. All these issues are very important for both anatomists and surgeons or clinicians.

For this reason, we hope that the book we have prepared will be useful for users...

CHAPTER 1

ANTHROPOLOGIC FEATURES OF PROXIMAL END OF THE TIBIA

Assoc. Prof. Dr. Işık TUNCER[1]

INTRODUCTION

Knee replacement surgeries require preciseness. Bone cutting, balancing soft tissues, and covering resected bone are needed to be done carefully (Insall et al., 1989; Kwak et al., 2007) and it is a routine orthopedic procedure for Asian-Pacific populations. Asian subpopulations generally have smaller stature compared with their Western counterparts (Vaidya et al., 2000). And because of this implant sizes do not match correctly on bones in the Asian population. Tibia parts are more likely to have complications among all knee arthroplasty compared with femoral parts (Canale et al., 2013). So it is important to determine the proper size for the prostheses and to cut the surface of the proximal end of the tibia (Incavo et al., 1994; Westrich et al., 1995). There is not enough anthropometric data on the proximal end of the tibia in Asian populations.

Despite that total knee arthroplasty (TKA) has a higher success rate in advanced degenerative or inflammatory diseases of the knee; the proximal tibia cut surface is still an issue. The mismatch has two different types: size and rotation mismatches. Many effects on tibial components were reported to be overhang and underhang (Bonnin et al., 2013; Miyatake et al., 2016; Westrich et al., 1995). Rotational mismatch issues cause patella-femoral congruence followed by dislocation of the patella and anterior knee pain and polyethylene wear of the tibial-bearing insert (Akagi et al., 2004; Nicoll & Rowley, 2010).

Some morphological studies of the proximal tibia were conducted to represent data for matching correctly (Insall et al., 1989; Uehara et al., 2002; Yang et al., 2013).

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Also, sex and race differences in the proximal tibia were included (Uehara et al., 2002; Yang et al., 2013).

Body weight in man is a factor of the extended knee position. The relationship between different weight-bearing scenarios and the anteroposterior and medio-lateral dimensions of diaphysis and epiphysis of the tibia is well stated (Gandhi et al., 2014; Ljunggren, 1976).

When treating knee deformities, having a sense of morphometric traits of the upper end of the tibia is crucial. They may be used for treatment and monitoring purposes on total knee replacement surgeries. Precise and repeatable measurement systems aid in the definition of tibial deformity and improvement of tibial prostheses design (Geil, 2005). Like the other parts of the world, TKA usage is getting higher in Turkey. But there is not much data about the proximal tibia of the Turkish population. So the requirements for a tibial component were not yet successfully fulfilled.

But data about proximal tibia in the Turkish population is not completed and this field requires a lot many studies. For these purposes, this study was conducted to obtain data for the proximal tibia and compare it with the existing data. Material Methods 82 adult human tibia bones were used for this study. The study group comprised 36 right and 46 left bones. This study was approved by the Ethical Committee of Meram Faculty of Medicine, Necmettin Erbakan University according to Copenhagen Criteria (2017/217).

Measurements were performed by using vernier calipers and measuring tape with a sensitivity of 0.01 mm. Following metric parameters were noted:

- Tibia length: The length between the distal-most end of malleolus medialis and vertex point of tibial plato eminentia inter-condylar (Fig-1: AB/Table 1, 2, 3).
- Anteroposterior measurement of the superior articular surface of medial condyle: The maximum distance between anterior and posterior borders of the superior articular surface of medial condyle (Fig-2: CD/ Table 1, 2, 3).
- Transverse measurement of the superior articular surface of medial condyle: The maximum distance between medial and lateral borders of

the superior articular surface of medial condyle (Fig-2: EF/ Table 1, 2, 3).

- Anteroposterior measurements of the superior articular surface of lateral condyle: The maximum distance between anterior and posterior borders of the superior articular surface of lateral condyle (Fig-2: GH / Table 1, 2, 3).
- Transverse measurement of the superior articular surface of lateral condyle: The maximum distance between medial and lateral borders of the superior articular surface of lateral condyle (Fig-2: IJ/Table 1, 2, 3).
- Transverse measurement of the superior articular surface of medio-lateral: The maximum transverse diameter of the superior articular surface of medio-lateral (Fig-3: KL/Table 1, 2, 3).
- The height of tuberculum intercondylar medial: Height between the vertex point of tuberculum intercondylar mediale (Fig-4: MN / Table 1, 2, 3).
- The height of tuberculum intercondylar laterale: Height between the vertex point of tuberculum intercondylar and its base (Fig-4: OP/Table 1, 2, 3).
- Values of this study were entered into the SPSS version 13.0 package program and analyzed. Results were shown as mean, maximum, minimum, and standard deviation. As for the comparison of the parameters, the student- t-test was applied and the spearman test was applied to determine the correlation of parameters. $p<0.05$ value was accepted as a significance level.

Fig 1: Anterior view of the left tibiae. AB; Tibia length

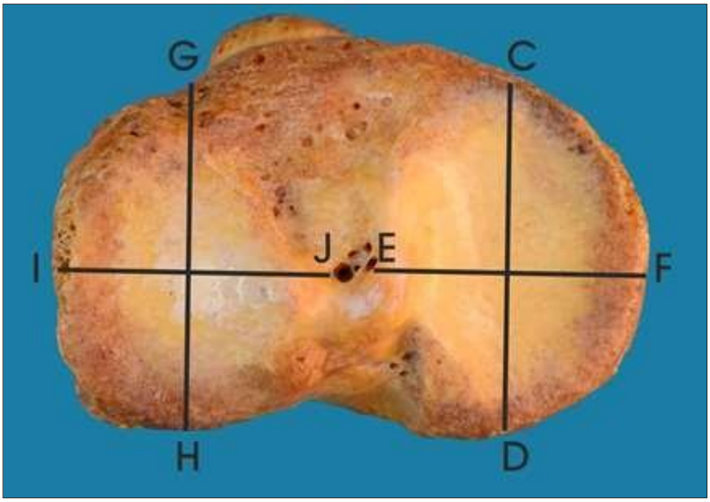

Fig 2: Superior view of the left tibiae. CD-EF; Anteroposterior-transverse measurements of the superior articular surface of the medial condyle. GH-IJ; Anteroposterior-Transverse measurements of the superior articular surface the of the lateral condyle.

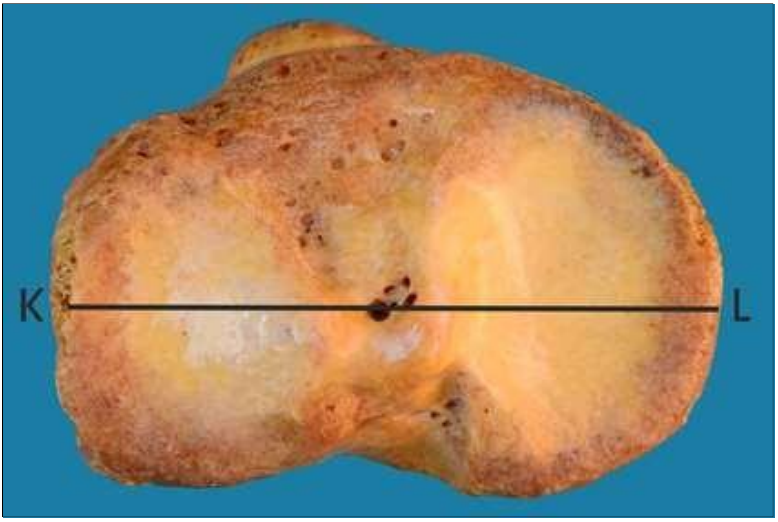

Fig 3: KL; Maximal transverse diameter of the superior articular surface

Fig 4: MN; Height of the tuberculum intercondylar mediale. OP; Height of the tuberculum intercondylar laterale.

1.RESULTS

82 tibia bones (36 right and 46 left) were used for this study. Results from the statistical comparison of the bones were shown in Tables 1, 2, and 3. Standard deviation (SD), minimum and maximum values were given in Table 1.

No significant difference was observed between measurements according to lateralization (p>0.05). Right, and left comparison values of tibial morphometric measurements were shown in the table. Excluding AB, DI, and GJ, all values were higher on left.

Pearson correlation test was applied to determine the significance level of the relation of parameters. Correlation coefficient numbers (r) between tibial measurements were given in Table 3

Table 1: Mean, minimum, maximum, and standard deviation(SD) values of the parameters (mm)

	n	**Minimum**	**Maximum**	**Mean**	**SD**
AB	82	29.0	41.5	32.62	2.23
CD	82	35.0	53.7	45.2	1.55
EF	82	24	49	30.8	3.42
GH	82	29.7	48.6	40.3	3.85
IJ	82	31.0	49.5	40.3	3.79
KL	82	52.3	81.8	70.0	5.82
MN	82	6	12	9.1	1.30
OP	82	7.1	14	10.4	2.01

Table 2: Mean, standard deviation(SD), P, and t values of the bones that were measured in the study according to lateralization

		N	**Mean**	**SD**	**t**	***P***
AB	Right	36	34.6	2.34	0.0060	*0.952*
	Left	46	34.6	2.16		
CD	Right	36	38.1	1.42	-0.604	*0.548*
	Left	46	35.9	1.66		
EF	Right	36	40.1	4.25	-0.342	*0.733*
	Left	46	40.4	3.55		
GH	Right	36	30.6	2.75	-0.252	*0.802*
	Left	46	30.8	3.89		
IJ	Right	36	39.8	3.50	-0.900	*0.371*
	Left	46	40.6	4.01		
KL	Right	36	69.7	6.62	0.155	*0.670*
	Left	46	70.2	5.18		
MN	Right	36	9.2	1.33	0.595	*0.900*
	Left	46	9.1	1.29		
OP	Right	36	10.2	1.77	0.486	*0.860*
	Left	46	9.6	1.36		

Table 3: Correlation between length of the tibia and other parameters of it

TB	AB	CD	EF	GH	IJ	KL	MN	OP
AB	0.234							
CD	0.187	0.164*						
EF	0.538**	0.146	0.503					
GH	0.516**	0.146	0.636**	0.828**				
IJ	0.173	0.133	0.410**	0.613**	0.241*			
KL	0.459**	0.049	0.745**	0.345**	0.305**	0.441**		
MN	0.197	-0.007	0.298**	0.324**	0.562*	3.18	0.525	
OP	0.186	0.005	196	302	196	0.765**	0.867	0.432*

**: significant at 0.05 level according to Pearson Correlation Analysis*
***: significant at 0.001 level according to Pearson Correlation Analysis*

2.DISCUSSION

The biggest finding in the study by Erkocak et al., (Erkocak et al., 2016) was that there was a sex-related significant difference in the proximal tibial plateau of the population. There was also mismatching of the dimensions in tibial components. Their data showed that male individuals had high AP (Antero-posterior plane) and ML (mediolateral plane) and female individuals had higher AR (aspect ratio). Moreover, the samples in their study were more likely to be overhang anteroposteriorly. Also, some female individuals were having tibial anteroposterior diameters smaller than the common tibial components.

However Turkish population has a similar type and stature compared to Western people (Erkocak et al., 2016; Güleç et al., 2009), but they also have their anthropometric differences. Some studies covered the morphology of Asian knees and compared them with that of Western populations (Cheng et al., 2009; Yue et al., 2011). But no present data were found regarding the anthropometry of the proximal tibia among the Turkish population. Therefore, this is one of the first studies in this field.

In their study, Erkocak et al. (Erkocak et al., 2016) reported some results. One of the results was that female individuals were having significantly smaller dimensions at the simulated resection level of the proximal tibia than males. This was not unexpected and resembles previous studies in the field (Kwak et al., 2007; Mensch & Amstutz, 1975; Uehara et al., 2002; Yang et al., 2014). In the study by Erkocak et al. (Erkocak et al., 2016) many of the male individuals (77 in 89 them) were having AP diameter range between 40 and 55 mm, and many of the female individuals had (107 in 138 of them) between 35 and 45 mm.

The ML dimensions of the tibial component may be focused on a length of 65-75 mm for females and 75-85 mm for males because 90% of knees are in this range. As a result, a tibial component with a size variation in the ML length of 65-85 mm and in the AP length of 35-55 mm is suitable for the majority of the Turkish population. Comparing our result data with the previous data in the field it may be seen that AP and ML lengths were smaller than the values of the Western population (Mensch & Amstutz, 1975). In the study, the tibial plateau was also shown to be larger than the lateral tibial plateau in the Turkish population, and sex differences did not affect it. This shows the asymmetric shape of the proximal tibial surface at the simulated resection level and it is also consistent with previous studies in this field (Kwak et al., 2007; Mensch & Amstutz, 1975). But the symmetric or asymmetric tibial components usage in the previous studies does not match. Some studies suggest using the first and others suggest using the latter (Incavo et al., 1994; Kwak et al., 2007). But after all, many studies use symmetric design for tibial components.

Successfully matching the tibial component and the proximal tibial cut surface is the most important part of total knee arthroplasty (TKA) (Walker et al., 1981). Many morphological studies of the proximal tibia were conducted to gather data on proper matching (Uehara et al., 2002; Westrich et al., 1995; Yang et al., 2013, 2014) and the usage of computer simulations was also an approach (Chaichankul et al., 2011; Liu et al., 2013; Yang et al., 2013).

Uehara (Uehara et al., 2002) performed some measurements on the proximal tibial cut surface and the anteroposterior dimension was measured at the center of the tibia due to the asymmetrical shape of the proximal tibia

(Incavo et al., 1994; Westrich et al., 1995). In addition, the anatomical morphology of the knee changes by sex and race (Uehara et al., 2002; Yang et al., 2013, 2014). In their study, Miyatake et al. performed measurements on Japanese males and females during TKA and they compared the results with those of TKA systems available in Japan.

In their study, Westrich et al. stated that the proximal tibial surface should be taken as asymmetric (Westrich et al., 1994). Kwak et al. (Kwak et al., 2007) have measured the anteroposterior dimensions of the medial and lateral condyles of the proximal tibia (MAP, LAP) at defined points also with their distance from the central point (C), on the resected proximal tibial surface (CM&CL).

In the same way as the previous studies, the medial tibial condyle was longer anteroposteriorly than the lateral condyle, indicating asymmetry of the proximal tibia (Hitt et al., 2003; Mensch & Amstutz, 1975). By comparing the ML (mediolateral) and AP (anteroposterior) dimensions of the proximal tibia with the conventional tibial prostheses, Kwak et al. (Kwak et al., 2007) reported that the prostheses that fit the smaller AP dimensions of the proximal tibia were undersized in the medio-lateral dimension, and the prostheses that fit the larger AP dimensions of the proximal tibia were oversized in the mediolateral dimension. Of the different implant designs examined, Duracon was the one most closely, however it was not the best match of the proximal tibia morphometric data for Koreans, especially on the female individuals.

A statistical comparison of measurements between Danish and the study by Gandi et al. (Gandhi et al., 2014) in the Indian population reported that the transverse measurements of the intercondylar area at anterior and middle parts were more in the Danish population (35 mm and 11 mm) but that at the posterior end the values were very close (16 mm). Recognizing the significance of anatomical description of the intercondylar area for identifying skeletal structures and soft tissue insertions in radiographs precisely, Jacobsen (Jacobsen, 1974) pointed out that the shape of posterior contours of the tuberculum mediale and laterals may be used to identify the posterior contours of the two tibial condyles, and the posterior contour of the condyles lateralis tibiae may be identified by tracing the posterior curved part of the tuberculum laterale. In his study, the latter contour was found to be the most helpful landmark to measure the “drawer sign” in the knee joint by the radiological procedure of Kennedy and Fowler (Kennedy & Fowler, 1995). The design of prostheses, considering the sex difference, was also a case in the Chinese population according to Cheng et al. (Cheng et al., 2009). Geoffrey (Westrich et al., 1995) stated that asymmetric smaller lateral condylar surface has a better outcome than the symmetrically constructed prostheses. Since the metric parameters of medial and lateral plateau symmetrically have differences concerning each other, it can make it difficult for the medial unicompartmental knee arthroplasty because of unrequired mediolateral overhanging in the attempts of optimal anteroposterior coverage of articular surface (Servien et al., 2008). However, the morphometric analysis of the proximal articular surface of the tibia made in this study may be beneficial in the design of appropriate knee prostheses for unicompartmental and total knee arthroplasty in the Turkish population.

The results obtained in this study reveal anthropometric data on the proximal tibia in the Turkish population, which may be used as a guideline to design a tibial component suitable for Turkish patients. Female individuals of this population tend to have a tibial component with an AP diameter of<38 mm. These values are smaller than the currently available smallest tibial prosthetic sizes. We think that studies like these may help to advancements in arthroplasty technology and so that well-designed individual-specific prosthetic components will help to minimize and/or eliminate mismatch cases in the future.

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CHAPTER 2

THE RELATIONSHIP BETWEEN NORMAL EXTERNAL GENITALIA SIZE OF WOMEN AGED 15-82 AND AGE, HEIGHT, WEIGHT, BMI, PARITY

Assoc. Prof. Dr. Işık TUNCER*

Prof. Dr. Kazım GEZGİNÇ**

INTRODUCTION

Reproducible definitions of the vulva whose 'normal' appearance is currently being debated since an accurate and thorough description of external female genitalia is rarely made. Information on vulvar morphology is limited even in most medical textbooks (Kreklau et al., 2018; Andrikopoulou et al., 2013) Therefore, limited data has been used to define a "normal" appearance since the beginning of the twentieth century.

The theory that belongs to Maria Bonaparte, the first woman who published data about the dimensions of the anatomy of the female genitalia in 1924, was that the distance from the clitoris to the vagina influences the possibility of women experiencing orgasm during sexual intercourse. She wrote her theory of frigidity under the pseudonym A.E. Narjani in a medical journal (Narjani, 1924; Verkauf et al., 1992).

The need for valid standards for describing the size and anatomical relationships of the external female genitalia is obvious in studies published in recent years. Başaran et al. (Basaran et al., 2008) observed a considerable variance in the appearance of female genitalia in a cohort study conducted on pre-and postmenopausal women and stated that more studies on the vulva's "normal" appearance as well as specific definitions are needed.

The anatomy and appearance of the female external genitalia reveal a wide variety of measurements of great concern in aesthetic and cosmetic vulvar surgery (Krissi et al., 2016; Barbara et al., 2015; Goodman, 2011;

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Lloyd et al., 2005; Solanki et al., 2010; Yurteri-Kaplan et al., 2012). Throughout life, the vulva's morphology and physiology change significantly with aging (Basaran et al., 2008).

Female genital cosmetic surgery (FGCS) is performed on women who have functionally undesirable symptoms. Local irritation, issues with personal hygiene during menstruation or after the movements of the bowel, trouble with sexual intercourse, and discomfort when cycling, walking, or sitting are all common reasons for surgical treatment.

Due to the increase in sexually explicit media and the widespread use of genital epilation, women have become more conscious about their genitalia. Women have become more conscious of their genitalia as a result of the abundance of sexually explicit media and the prevalence of genital hair removal, and some women have begun to question if their vulva is normal (Koning et al., 2009). In most cases, esthetic concerns have an impact on the patient's physical and social well-being (Solanki et al., 2010; Maas & Hage, 2000). Moreover, negative perceptions about genitalia might have a negative impact on the sexual well-being of young women (Schick et al., 2010).

A surprising increase in female aesthetic genital surgery has been witnessed in recent years. The reason for the dramatic increase in cosmetic and plastic surgery for female genitalia may be that mass media affect perineal aesthetic trends. However, the fact that accurate and detailed identification of female external genital organs is rare attracts the attention of plastic surgeons. In a previous study, a wide variety of female genital measurements has been observed, but it has not been clarified if the phenomenon is in a homogeneous large-scale group (Lloyd et al., 2005; Cao et al., 2015). For effective surgical approaches and cosmetic results, an understanding of genital anatomy is crucial (Akbiyik & Kutlu, 2010). This question is especially important for plastic and urogynecology surgeons since they often encounter genital restoration problems. One of these major challenges is redistributing the excess tissue in male-to-female transgender operations to create normal female genitalia. Accurate identification of normal female genitalia is the basis of the reconstruction. We aim to define precise and detailed measurements, examine the proportions of the external genitalia of Turkish female adults who present for aesthetic surgery, and determine the significance of age, height, weight, BMI, and marital status variations, and thus provide a morphometric reference for plastic surgery involving male-to-female transgender operations and repairing the genital deformities resulting from traumas and burns.

1.MATERIAL and METHOD

The study consists of 50 nulliparous and 100 multiparous patients. The measurements were performed in millimeters. 150 patients aged 15-84 were included in the study. In the outpatient clinic of Necmettin Erbakan University, Meram Faculty of Medicine, Gynecology Department, all participants were evaluated consecutively. For the study, ethical approval was received from the Ethics Committee of Necmettin Erbakan University (2019/2124).

The patients who have a history of pelvic surgery that includes external and internal genital organs, complaints about the external genital organs, Müllerian anomalies, and previous vaginal deliveries with mediolateral episiotomy were excluded from the study.

Figure 1 shows the results of the measurements. External measurements were performed using a tape caliper in the lithotomy position.

The anatomical measurements (Akbiyik & Kutlu, 2010) (Fig.1) are defined as:

- Clitoris length: the distance between the point at which crura clitoridis fuse and the commissura labiorum anterior.
- Clitoris Width: the widest horizontal diameter of clitoridis.
- Labia Majora Length: the distance from the commissura labiorum anterior to the commissura labiorum posterior.
- Labia Minora Length: the distance from the lower border of the glans clitoridis to the frenulum labiorum pudenda.
- Labia Minora Width: the widest distance from the sulcus nymphohymenalis to the edge of the labium minus.
- The distance from the clitoris to the urethra: the distance between the base of the glans and the urethral orifice (central).
- The distance of the urethra to the vagina: the distance from the urethral orifice to the vaginal orifice.
- Gynecological perineum: the vertical distance from the commissura labiorum posterior to the anus (central).

1.1. Statistical Analysis:

The results of the measurements were carefully entered into MS Office Excel (2016) as the dataset. SPSS 20.0 was used to conduct the statistical analysis (IBM Inc, IL, USA) software. The descriptive statistics were expressed as mean and SD. The comparison of the groups was carried out by the Independent Sample Student t-test since the distribution of the measurements was normal by the Kolmogorov-Smirnov test. The relation between the measurements, age, and parity was searched by the Pearson Correlation Coefficient test. In all analyses, $P<0.05$ value was considered statistically significant.

2.RESULTS

The measurements carried out on female external genitalia were statistically analyzed. The average age of the patients was 39.36±14.06 years in a very wide range from 16 to 72 years. The average height was 1.60±0.07 m and could be considered proportionally short. The weight of the patients was at the medium level (70.53±15.53 kg). However, BMI values indicated that the patients were overweight generally since the average BMI was 27.57±6.40 kg/m^2 ranging from 18.26 to 43.03 kg/m^2 (Table 1). Demographical characteristics and most of the measurements of female genitalia were found significantly different between the parity groups ($P<0.05$). Only the distance from the urethra to the vagina and the right labia minora length were not found different ($P=0.844$ and $P=0.086$ respectively) (Table 2). No statistically significant correlation was observed between the distance urethra to vagina and demographical characteristics. The age was positively correlated with the external genitalia measurements and negatively correlated with the perineum. The height of the patients had a low correlation level with some measurements. However, a positive, strong correlation was found between the measurements and the weight and BMI values except for the distance from the urethra to the vagina and perineum (Table 3).

3.DISCUSSION

This study indicated wide disparities in all-female external genitalia parameters that were evaluated. This diversity was not associated with sexual function. Wide variations in the dimensions of the clitoris, perineum, and labia minora were also observed. These and other genitalia measurements were slightly shorter than those previously determined by Lloyd et al. (Lloyd et al., 2005). No difference was found in vaginal length when parous and nulliparous women were compared. In the study of Krissi et al. (Krissi et al., 2016), the right and left labia minora lengths were found to be 3.47±1.42 cm range (1-6 cm) and 3.82±1.33 cm (range 2-6 cm), respectively. Rovzier et al. (Rouzier et al., 2000) defined the maximum distance of more than 4 cm from the base of the labia minora to its margin as a hypertrophic distance requiring corrective surgery. No subjects (according to exclusion criteria) stated any personal difficulties or requested cosmetic surgical modifications.

Few definitions related to normal female genitalia are present in the medical literature. Some reports are available on the length of the vagina and the size of the clitoris, but there is little information on the labial size (Lloyd et al., 2005). Although the anatomical relationship of the urethra and clitoris has been discussed in one report, as shown in post-mortem dissections, the emphasis has not been on the external appearance of the female genitalia (O'Connell et al., 1998).

In many areas of expertise, including gynecology, diagnostic radiology, and urology, understanding the changes in the anatomy of female genitalia thoroughly in the post-menopause period is essential for practice and study. Surprisingly, there are few studies about the definition of "normality" for the anatomy of external female genitalia, few reports on clitoral size (Verkauf et al., 1992; Oberfield et al., 1989) and vaginal length (Verkauf et al., 1992), and there is very little information related to labium majus, minus, and perineum size (Lloyd et al., 2005). Furthermore, objective measurements of the anatomy of postmenopausal external genitalia in females have not been well defined. The term vaginal atrophy is commonly used in literature for a clinical picture with signs and symptoms, including vaginal dryness, itching, irritation, and painful intercourse, with little to no focus on anatomical changes (Goldstein & Alexander, 2005; Suckling et al., 2003; Berman et al., 1999).

Collagen component increases due to estrogens (Castelo-Branco et al., 1992). Collagen level and skin thickness begin to decrease owing to aging and estrogen deficiency (Brincat et al., 1987). As a result, the skin becomes thinner and loosened (Brincat et al., 1987). Flattening of the rugae, atrophy of the epithelium, and a decrease in vaginal length and elasticity are observed in the vagina. Epidermal thickness and subcutaneous adipose tissue decrease in the vulva with age.

We were able to find the correlation based on our analysis of the appearance and the size of the external female genitalia. Thus, the correlation between the length of the labia majora and the BMI of the patient that was stated by Cao et al. (Cao et al., 2015) 2015 is confirmed by these results. This supports the belief that uniform thresholds for vulva size are not appropriate for diagnosing vulvar diseases. In making a diagnosis, the external female genitalia measurements are of great importance but should be considered individually rather than being used as irrefutable diagnostic criteria. The finding of the fact that vaginal delivery, the introitus length, and the labia majora length are positively correlated emphasizes this as well. It is fundamental for measurements to be standardized and used with caution, as previous studies have shown very different means of vulvar structures, indicating a population-based on the observer-based bias (Basaran et al., 2008; Lloyd et al., 2005). To establish a broad homogeneous group of females without ethnic diversity, we deliberately chose white heritage as an inclusion criterion.

Reporting the values obtained as a result of the measurements of female genitalia of patients applying for cosmetic gynecological surgery is the key topic of this study. To conduct genital reconstruction and plastic surgery, we must gain a detailed understanding of female vulvovaginal anatomy and its physiological changes. The first definition of female genital anatomy dates back to 1899 when Waldeyer indicated that the measurement of normal labia minora was 2.5 to 3.5 cm in width (Weijenborg, 2006). Several studies have been conducted on anthropometric measurements of the external genital anatomy of girls in their prepubertal period (Akbiyik & Kutlu, 2010) and women (Cao et al., 2015; Schober et al., 2004; Seitz et al., 2010). Lloyd et al. made the measurements of 50 premenopausal women and found no statistically significant relationship between external measurements and age, parity, or sexual activity history(Lloyd et al., 2005). Seitz et al., evaluating mons pubis measurements of 28 normal-weight women, stated that the data were dependent on body size/weight and age (Seitz et al., 2010). This is, to our knowledge, the first study to examine genital appearance in the Turkish population. This study was able to analyze only Turkish female adults, which limits our generalization of the results to other races but provides information for the studies to be conducted in the future. We are not sure whether there are racial variations in the measurements of the external genitalia, but this issue regarding labia minora has been raised before (Ajayi, 2012). Therefore, the assessment of genital variations between different races and ethnicities requires multicenter cooperation.

The clitoris, the homolog of the penis, is a cylindrical, erectile organ, consisting of three parts: the glans, corpus or body, and the crura. The glans can be seen between the labia minora, which bifurcates forming the upper prepuce and lower frenulum. Dividing into two crura, which attach to the undersurface of the symphysis pubis, the clitoral body extends under the skin (Verkauf et al., 1992).

Masters and Johnson suggested that clitoral structure is highly variable (Masters & Johnson, 1976). They characterized women with a long, thin shaft surmounted by a relatively small glans, and the ones with a short, thick shaft with a rather large glans, with many variations and combinations.

The measurement of total clitoral length (glans and corpus) is complicated as the exact location at which the crura is inserted under the symphysis is difficult to determine. Glans measurements are obtained more easily and reproducibly and applied more commonly to the evaluation of clinical problems. We observed that measurements of both total clitoral length and clitoral width are facilitated by the use of the calipers, but this measurement can be performed with a measuring tape or a flat ruler.

4. CONCLUSION

This cross-sectional study provides the largest cohort of demographic data related to the normal size of the external female genitalia. Although these data belong to white women only, it is believed that this study will contribute to further studies publishing data on different ethnicities and heterogeneous groups of women all over the world.

With our results, however, we form a basis for the normal appearance of the white vulva and set standards for indications for gynecological cosmetic surgery and other applications. These results, along with vulvar measurements in patients diagnosed with vulvar diseases, can create valid international guidelines.

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Table 1: Demographical characteristics and measurements of female external genitalia

Parameters	**N**	**Mean**	**SD**	**Minimum**	**Maximum**
Age (year)	150	39.36	14.06	16.00	72.00
Height (m)	150	1.60	0.08	1.43	1.78
Weight (kg)	150	70.53	15.54	40.00	110.00
BMI (kg/m^2)	150	27.57	6.41	18.26	43.03
Clitlength (mm)	150	6.61	1.37	4.00	9.90
Clitwidth (mm)	150	3.92	0.71	2.80	5.40
Cliturethra (mm)	150	19.59	3.70	12.00	27.00
Uretvagina (mm)	150	3.74	0.67	2.50	5.30
Perine (mm)	150	23.82	6.16	12.00	36.00
Lmajlengthright (mm)	150	62.41	6.25	51.00	78.00
Lmajwidthrihgt (mm)	150	33.97	3.06	25.00	42.00
Lmajlengthleft (mm)	150	62.44	6.28	50.00	78.00
Lmajwidthleft (mm)	150	33.97	3.08	24.00	42.00
Lminlengthright (mm)	150	43.07	7.94	28.00	62.00
Lminwidthright (mm)	150	17.32	6.62	7.00	34.00
Lminlengthleft (mm)	150	42.99	8.00	28.00	62.00
Lminwidthleft (mm)	150	17.45	6.71	7.00	34.00

Table 2: Comparison of demographical characteristics and measurements between the groups

Demographical charactersitics and measurements	**Nulliparous (n=50)**	**Multiparous (n=100)**	
	Mean±SD	**Mean±SD**	***p***
Age (year)	31.12±11.01	43.36±13.67	*<0.001**
Height (m)	1.64±0.07	1.59±0.07	*<0.001**
Weight (kg)	62.12±9.81	74.61±16.19	*<0.001**
BMI (kg/m^2)	23.35±4.45	29.62±6.22	*<0.001**
Clitlength (mm)	5.98±1.19	6.92±1.35	*<0.001**
Clitwidth (mm)	3.55±0.64	4.1±0.68	*<0.001**
Cliturethra (mm)	16.53±2.57	21.07±3.23	*<0.001**
Uretvagina (mm)	3.75±0.58	3.73±0.72	*0.844*
Perine (mm)	26.53±5.66	22.5±5.98	*<0.001**
Lmajlengthright (mm)	59.41±5.54	63.87±6.07	*<0.001**
Lmajwidthrihgt (mm)	32.43±2.51	34.72±3.04	*<0.001**
Lmajlengthleft (mm)	59.39±5.47	63.92±6.13	*<0.001**
Lmajwidthleft (mm)	32.43±2.51	34.72±3.07	*<0.001**
Lminlengthright (mm)	41.47±7.81	43.85±7.93	*0.086*
Lminwidthright (mm)	15.41±6.54	18.25±6.48	*0.013**
Lminlengthleft (mm)	41.45±7.89	43.74±7.98	*0.014**
Lminwidthleft (mm)	15.39±6.6	18.46±6.57	*0.008**

**: significant at 0.05 level according to Student t-test*

Table 3: Correlations between female genitalia parameters and physical characteristics

Parameters	Height	Weight	BMI	Age
Clitlength	-0.149	0.366**	0.405**	0.341**
Clitwidth	-0.191*	0.469**	0.526**	0.319**
Cliturethra	-0.182*	0.550	0.591**	0.495**
Uretvagina	0.095	0.089	0.052	-0.047
Perine	0.169*	-0.090	-0.090	-0.238**
Lmajlengthright	-0.206*	0.591**	0.647**	0.400**
Lmajwidthrihgt	-0.131	0.757**	0.774**	0.304**
Lmajlengthleft	-0.211*	0.591**	0.649**	0.402**
Lmajwidthleft	-0.133	0.753**	0.771**	0.303**
Lminlengthright	-0.206*	0.314**	0.393**	0.274**
Lminwidthright	-0.073	0.421**	0.445**	0.222**
Lminlengthleft	-0.202*	0.314**	0.391**	0.263**
Lminwidthleft	-0.082	0.425**	0.452**	0.244**

**: significant at 0.05 level according to Pearson Correlation Analysis*
***: significant at 0.001 level according to Pearson Correlation Analysis*

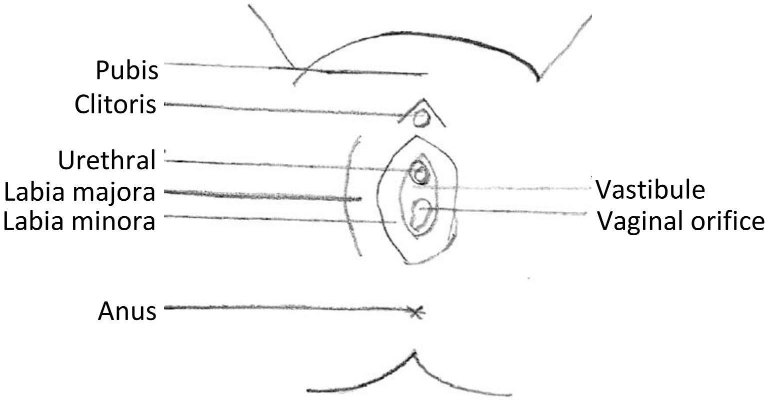

Figure 1: Female external genitalia measurements obtained from H. Krissi et al (2016).

CHAPTER 3

STERNAL MORPHOMETRY COMPARISON TO CHEST MEASUREMENTS AND USING ROENTGENOGRAPHY

Assoc. Prof. Dr. Işık TUNCER*

INTRODUCTION

Anthropometric studies of skeletal structures have provided important information for identification procedures. Postmortem examinations of various skeletal elements provide crucial data for estimating gender. Morphometric examinations, particularly of the pelvic and craniofacial region, are widely utilized procedures in cases of advanced destruction of skeletal remains (Ekizoglu, Hocaoglu, et al., 2014; Krogman & İşcan, 1986; Byers, 2002; Bass, 2005; Spradley & Jantz, 2011; Haglund & Sorg, 2002; Phenice, 1969). There are many factors affecting the integrity of skeletal remains. Explosions, putrefaction, severe injury, and geographical conditions can all obstruct pelvic and cranial bone studies. In addition, several investigations have found that the pelvis and skull bones are less useful for determining gender (Byers, 2002; Bass, 2005; Spradley & Jantz, 2011; Haglund & Sorg, 2002). Even in extensive skeletal destruction, the structure of the sternum might be conserved. According to Bongiovanni and Spradley (Bongiovanni & Spradley, 2012), the manubrium and sternum's good condition levels were above 59% in the Forensic Anthropology Data Bank. Wenzel (Ashley, 1956a) obtained data regarding sexual dimorphism in the manubrium and sternum and concluded that the manubrium was nearly similar in length in both genders, but males had a longer mesosternum. Following that, the description that "The female sternum's manubrium is more than half the length of the body, whereas the male sternum's body is at least twice as long as the manubrium. " became known as Hyrtl law (Dwight, 1881).

During the post-mortem period, morphometric examinations of the sternum can be conducted using dry bone direct measurements and radiographic approaches (Macaluso, 2010; Hunnargi et al., 2008;

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Mukhopadhyay, 2010; Singh et al., 2012; Singh & Pathak, 2013; Menezes et al., 2009; Dahiphale et al., 2002; Fernández et al., 2007; Marinho et al., 2012; Macaluso & Lucena, 2014; Torwalt & Hoppa, 2005). Several radiological and morphometric tests were carried out on living subjects (Uysal Ramadan et al., 2010; Franklin, Flavel, et al., 2012; Franklin, Cardini, et al., 2012; Osunwoke et al., 2010). Some parameters, including the manubrium, mesosternum, total sternum length, manubrium, sternabra 1, and sternabra 3 widths, sternal area, and the sternal index (SI) were all used in these studies. Despite some methodological differences among studies, morphometric evaluations of the sternum generally produce an accuracy of 80% or higher (Bongiovanni & Spradley, 2012; Ashley, 1956a; Dwight, 1881; Macaluso, 2010; Hunnargi et al., 2008; Mukhopadhyay, 2010; Singh et al., 2012; Singh & Pathak, 2013; Menezes et al., 2009; Dahiphale et al., 2002; Fernández et al., 2007; Marinho et al., 2012; Macaluso & Lucena, 2014; Torwalt & Hoppa, 2005; Uysal Ramadan et al., 2010; Franklin, Flavel, et al., 2012; Franklin, Cardini, et al., 2012).

Jit et al. (Jit et al., 1980) revealed that dry human sternums of the same heterogeneous group studied in the study more than three decades ago showed sexual dimorphism. The standards that Jit et al. (Jit et al., 1980) proposed are deemed obsolete today owing to secular trends and altered environmental or dietary circumstances, and hence are no longer appropriate to the current population of this region. Since Jit et al., the study sample has experienced several nutritional, environmental, and climatic changes, in addition to changes in body proportions (Jit et al., 1980). This study aims to look into secular changes in sternal dimensions and sexing efficacy since 1980, as well as to add to population data on the subject. Jit et al. (Jit et al., 1980) considered the sample gathered from multiple states as a single population sample because of their similar body proportions and morphometric physical dimensions (Jit et al., 1980; Bowles, 1977) and dietary patterns.

1. MATERIAL AND METHOD

The study consists of 75 adult Turkish individuals applied to Necmettin Erbakan University, Meram Faculty of Medicine, Radio-Diagnosis Department for radiological investigations. Patients who had the chest wall with pathological, congenital, or traumatic lesions were not included in the study. Patients were chosen at random, and all patients submitted their informed consent before the study.

Before scanning, the height and weight of the subjects were additionally collected by the expert on forensic age estimation responsible for the study.

Before scanning, the specialist in forensic age estimation who was in charge of the study also measured the subjects' height and weight. Seventy-five virtual chests were analyzed on the anterior view to detect the following:

- Sternal length: The length between the upper end of the sternum and the lower end.
- Chest circumference: Measuring the chest circumference by passing through the nipples.
- Chest anterior-posterior diameter: Maximum anteroposterior diameter of the chest.
- Lung width: The width of the lung measured from the widest part.
- Lung length: Maximum lung length.

1.1. Statistical Analysis

Statistical Package for Social Sciences (SPSS/version 17) software was employed to perform statistical analysis after the collection of data. The results were expressed via arithmetic mean and standard deviation. Pearson Correlation Coefficient test was performed for the relationship between parameters.

2. RESULTS

The study consisted of 75 adult Turkish patients aged between 18 and 83, equally divided into both genders. Male patients between the ages of 18 to 83, with a mean of 46.51 16.91 years, while female patients between the ages of 20 to 74, with a mean of 45.11 12.74 years. With t = 0.52 and P = 0.75, no significant difference according to age was found between genders.

Table 1 demonstrates that males had significantly higher sternal measurements, and sternum length (physical and radiograph) than females, with P=0.001 in all examined measurements.

It was seen that all values were higher in males except for the anterior-posterior diameter of the chest, chest circumference, right lung-width, and left lung length, as in Table 1.

The mean and standard deviation (SD), minimum and maximum values of the measurements are shown in Table 2.

The Correlation Coefficient test performed to indicate the relationship between the measurements. Correlation values of the variables were shown in Table 3.

3. DISCUSSION

The main anthropological alternatives for gender estimation are morphometric examinations of specific bones through direct measurements from radiological procedures or skeletal remains. The major obstacles to getting bones with high integrity include trauma, putrefaction, and loss for various reasons (Byers, 2002; Bass, 2005; Spradley & Jantz, 2011; Haglund & Sorg, 2002). In these situations, data from a single bone could be critical for gender estimation. Pelvic studies in the literature produced 95% accuracy for gender estimation (Phenice, 1969; Bongiovanni & Spradley, 2012; Ashley, 1956a; Dwight, 1881; Macaluso, 2010; Hunnargi et al., 2008; Mukhopadhyay, 2010; Singh et al., 2012; Singh & Pathak, 2013; Menezes et al., 2009; Dahiphale et al., 2002; Fernández et al., 2007; Marinho et al., 2012; Macaluso & Lucena, 2014; Torwalt & Hoppa, 2005; Uysal Ramadan et al., 2010; Franklin, Flavel, et al., 2012; Franklin, Cardini, et al., 2012; Bowles, 1977; Sutherland & Suchey, 1991). Morphometric parameters of the craniofacial region yielded accurate results (Ekizoglu, Inci, et al., 2014; Cameriere et al., 2005; Emirzeoglu et al., 2007; Fernandes, 2004; Deshmukh & Deversh, 2006). For the morphometric examination of maxillary sinuses in the Turkish population, the accuracy was 80% for females and 74.3% for males, and the overall level was 77.15% (Ekizoglu, Inci, et al., 2014). Terrorist blasts, in particular, have the potential to kill a large number of people. In these circumstances, the speed of the identification process is crucial. Furthermore, when mass grave investigations are considered, a single bone piece preserved in disintegrated skeletons enables a quick categorization of disaster victims' identification (DVI) (Morgan, 2006; Sidler et al., 2007).

Preserved integrity of the sternum with a robust structure is an important bony structural benefit. As can be seen in our study, the sternum provides a gender discrimination property of over 80%. Fast and easy CT scanning of single bony parts, which were preserved, “like sternum” may offer an effective identification approach for researchers (Sidler et al., 2007).

Discrimination analysis of sternal measurement parameters is an effective technique for estimating gender. For measurement data, direct discrimination analysis and different combinations of analysis methods were employed in previous studies. Maculoso and Lucena (Macaluso & Lucena, 2014) conducted a stepwise analysis of five linear dimensions on a Spanish population. a gender classification accuracy of 89.7% was obtained by ML (corpus sterni length), manubrium width, CSWS1 (corpus sterni width at first sternebra), and CSWS3 (corpus sterni width at third sternebra). For the manubrium, both length and width measurements were chosen in the stepwise analysis, which yields a gender estimation accuracy of 87.1%. In the Western Australia study of Franklin et al. (Franklin, Flavel, et al., 2012), the length of the manubrium, body, and corpus sterni width at the first sternebra were combined, and the accuracy of gender classification was found to be 84.5%. Morphometric dry bone or sternum imaging studies revealed 80% to 90% accuracies through combined analyses of multiple parameters (Bongiovanni & Spradley, 2012; Macaluso, 2010; Hunnargi et al., 2008; Mukhopadhyay, 2010; Macaluso & Lucena, 2014; Torwalt & Hoppa, 2005; Uysal Ramadan et al., 2010; Franklin, Flavel, et al., 2012; Franklin, Cardini, et al., 2012). Our stepwise 1 (ML, MSL, SIW, S3W) discrimination analysis yielded the highest accuracy rate; 86.1% for females and 83.8% for males, and accuracy was higher than 80% after three step-wise discrimination analyses for both genders. We employed six different combinations, just like the report by Ramadan et al. (Uysal Ramadan et al., 2010) who indicated 81.8% to 88.2% accuracies. The accuracies were similar for Turkish populations in both studies although there were differences between the combinations.

Direct measurement analyses can be carried out on skeletal remains, which may not always be possible (Krogman & İşcan, 1986; Byers, 2002; Bass, 2005; Spradley & Jantz, 2011; Haglund & Sorg, 2002). With the increasing clinical diagnostic role of radiological technologies, A great number of images have been obtained. CT and MRI are high-resolution systems that can provide three-dimensional images. The properties can provide detailed information for morphometric studies. In comparison to 2004/2005, the Royal College of Radiologists noted a 26.5% rise in the number of radiological images in 2012. The usage of CT and MRI modalities increased by 86% and 125%, respectively ("The Royal College of Radiologists", 2012). Based on the growing number of radiology-based investigations and suitable analyses, we conclude that other bones like the sternum can be employed for forensic anthropologic assessments.

Despite extensive study of sexual dimorphism in human sternum using its metric and non-metric features (Bongiovanni & Spradley, 2012; Macaluso, 2010; Hunnargi et al., 2008; Mukhopadhyay, 2010; Dahiphale et al., 2002; Uysal Ramadan et al., 2010; Franklin, Flavel, et al., 2012; Osunwoke et al., 2010; Jit et al., 1980; McCormick et al., 1985; Torwalt & Hoppa, 2005; Ashley, 1956b; Rother et al., 1975; Selthofer et al., 2006; Atal et al., 2008; Atal et al., 2009; Hunnargi et al., 2009; Mahajan et al., 2009; Sun et al., 1995), the metric analysis is preferred since it is more objective, reproducible/duplicable, statistically analyzable, and it enables reliable identification of the deceased even from fragmentary remains (McCormick et al., 1985; Uysal Ramadan et al., 2010; Dibennardo & Taylor, 1983; Gapert et al., 2009). For gender determination, while the individual or the combined length/s of the sternum (as a rule) have been used by some researchers, demarking and limiting points have been devised or discriminant functions or regression equations based on the metric measurements of sternum have been calculated by the others. To take measurements, different criteria and variables have been used selectively and arbitrarily by different researchers, directly on the bone specimens or indirectly on the radiographic or computed-tomographic images of the thoracic region housing the sternum. Macaluso (Macaluso, 2010) and Bongiovanni and Spradley (Bongiovanni & Spradley, 2012) examined the sternums of prominent bone collections. The results of Singh et al. were based on direct measurements of freshly collected wet sternums, while Franklin et al. (Franklin, Flavel, et al., 2012) and other Indian researchers (Hunnargi et al., 2008; Mukhopadhyay, 2010; Dahiphale et al., 2002; Jit et al., 1980; Atal et al., 2008; Atal et al., 2009; Hunnargi et al., 2009;

Mahajan et al., 2009) examined dried sternums collected from autopsied subjects.

The sternal area and the combined length were revealed to be slightly better parameters for gender determination based on two discriminating points (demarking and limiting points), since the values of most of the sternal parameters (especially the two indices) were found to be lying in the gray/overlapped zone. Therefore, in this study, these points, particularly demarking points, were not deemed reliable for gender determination. Slightly better classification rates were obtained by the limiting points than the demarking points. These findings were in line with the earlier research findings (Hunnargi et al., 2008; Dahiphale et al., 2002; Ashley, 1956b; Atal et al., 2008; Mahajan et al., 2009). Sexing efficacy of limiting point was found comparable with an Indian (Maharash-trian) sample (Hunnargi et al., 2008). Singh et al. (Singh & Pathak, 2013) indicated that 93% of male and 69% of female sternums were accurately sexed from the limiting point of the sternal area, while about 87% of male and 79% of female sternums were accurately sexed from the limiting point of combined length. The maximum gender bias was noticed for manubrio-corpus index (-39.0), then the sternal area (23.5), and the first sternubrial width (12.5). The combined length of the sternum's limiting points was considered to be a better gender discriminating variable than that of the individual manubrial or mesosternal values, which is inconsistent with the study of Hunnargi et al. (Hunnargi et al., 2008).

In a North Indian heterogeneous population, Jit et al. (Jit et al., 1980) found that 85% of males and 89% of females could be accurately sexed using a multivariate discriminant function analysis (DFA) of seven sternal dimensions and indices. All of the parameters had an overall accuracy of 84.8% (81.7% males and 93.4% females) and 89.8% (94.0% males and 78% females) in stepwise multivariate DFA and logistic regression analysis (LRA) analyses, respectively. Although these findings are in parallel with those of Jit et al. (Jit et al., 1980), in various sternal measurements and their sexing efficacy they reveal secular trends. In each multivariate function where mesosternal length was entered as a variable, more than 80% of sternums were accurately classified (Functions III-5). Similarly, more than 80% of sternums were classified accurately in all the multivariate logistic regression functions. The 'major' sternal lengths (M.B. and MBL) accurately classified 83.7% (81.3% males and 90.1% females) of the sternum from DFA and LRA, respectively. The transverse manubrial or sternubrial widths provided the least reliable gender estimation. 88% of male and 80% of female sternums were sexed accurately by using LRA in a recent Turkish sample (Uysal Ramadan et al., 2010). In the study conducted by The Macaluso (Macaluso, 2010), an overall accuracy of about 86% and 90.8% was reported from the stepwise discriminant function analysis and LRA, respectively (with gender biases that range from 4.7% to 13.8%). The accuracy levels of Singh et al. (Singh & Pathak, 2013) were consistent with those reported in other studies (Bongiovanni & Spradley, 2012; Macaluso, 2010; Hunnargi et al., 2008; Mukhopadhyay, 2010; Dahiphale et al., 2002; Uysal Ramadan et al., 2010; Franklin, Flavel, et al., 2012; Jit et al., 1980; McCormick et al., 1985; Torwalt & Hoppa, 2005; Atal et al., 2008; Atal et al., 2009; Hunnargi et al., 2009; Mahajan et al., 2009) and the functions/measurements stated here are sufficient for determining the gender of unknown specimens. Therefore, sternum can be a useful aid to determine the gender of sternums of the Chandigarh region of North India with maximum accuracy levels ranging from 90% to 85% from multivariate DFA and LRA of sternal measurements, respectively. According to the studies by Singh, DFA had a gender bias in favor of the males while it was biased toward the females in LRA, which could be owing to the difference in the sample size of the two genders. Univariate functions had higher gender biases than the multivariate ones, which is in line with the previous research (Macaluso, 2010; Uysal Ramadan et al., 2010). As the statistical standards/techniques with unacceptable higher gender biases have limited forensic significance (Franklin, Flavel, et al., 2012), multivariate analyses with the least sex biases are recommended for reliable accuracy rates of gender estimation.

Researchers benefit from the increasing number of morphometric studies, particularly those involving various populations. CT is used to perform morphometric analyses of living subjects or found bones. Forensic specialists and anthropologists can use the sternum to estimate gender accurately if skeletal parts like the pelvis or skull are lost or damaged.

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Table 1: Comparison of sternum measurements by gender (female-male) (mean-sd, n: 53 male, n: 21 female), (cm).

Parameter	**Male**			**Female**			**T**	***P***
	n	**Mean**	**SD**	**n**	**Mean**	**SD**		
Image measurement	54	21.05	1.78	21	9.47	1.74	0.001	*0.999*
Direct (Real) measurement	54	20.59	2.39	21	20.02	2.44	0.369	*0.824*
Front-rear	54	22.97	2.55	21	25.33	3.60	0.010	*0.147*
Chest Circumference	54	94.16	7.68	21	96.76	10.54	0.244	*0.531*
Right acc. Width	54	11.17	1.55	21	13.11	1.83	0.001	*0.732*
Right acc. Length	54	23.12	2.35	21	21.01	2.76	0.361	*0.814*
Left acc. Width	54	9.80	1.18	21	19.01	2.18	0.003	*0.201*
Left acc. Length	54	22.01	24.01	21	22.04	2.83	0.313	*0.312*

Table 2: Mean-sd, minimum and maximum values of sternum-related parameters (n: 54 male, n: 21 female) (cm)

Parameter	n	Mean	Std. Dev.	Minimum	Maximum
Direct (Real) measurement	74	20.43	2.40	15.50	26.50
Image measurement	74	20.61	1.90	16.00	25.00
Age	74	49.00	17.12	17.00	83.00
Weight	74	70.20	12.60	39.00	99.00
Length	74	162.37	29.57	16.00	190.00
Chest Circumference	74	94.89	8.60	74.00	116.00
Antero-Posterior Diameter	74	23.64	3.06	17.00	32.00
Right Acc. Width	74	10.78	2.07	7.00	24.00
Right Acc. Length	74	21.86	3.17	11.50	30.50
Left Acc. Width	74	9.61	2.03	8.29	22.15
Left Acc. Length	74	19.18	2.01	10.25	28.50

Table 3: Correlation coefficient ® between the sternal anthropometric measurements

	Physical	**Film**	**Age**	**Weight**	**Length**	**Chest Circumference**	**Antero-Posterior Diameter**	**Right Acc. Width**	**Right Acc. Length**	**Left Acc. Width**
Image measurement	0.319									
Age	0.190	0.171								
Weight	0.002	0.130	0.055							
Length	0.140	0.063	-0.215	0.106						
Chest Circumference	-0.084	0.195	0.241	0.694**	-0.174					
Antero-Posterior Diameter	0.035	0.064	0.335	0.449**	-0.245	0.796**				
Right Acc. Width	0.124	-0.012	0.062	-0.017	0.125	-0.070	-0.056			
Right Acc. Length	0.423	0.494**	-0.247	-0.003	0.370	-0.191	-0.318	0.002		
Left Acc. Width	0.121	-0.011	0.055	-0.002	0.122	0.060	-0.043	0.001	0.003	
Left Acc. Length	0.324	0.322	-0.216	0.001	0.261	0.180	-0.224	0.002	0.002	0.001

***: Significant at <0.001 level according to Pearson Correlation*

CHAPTER 4

THE MORPHOMETRIC DEVELOPMENT OF THE FETAL KNEE DURING THE FETAL PERIOD

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INTRODUCTION

Knee-joint is the biggest joint in the body. The cartilage, ligaments, and capsule elements of the joint development in the gaps of the central mesenchyme concentration build the long bones of the extremities. This central layer of ligament tissues forms the interior elements of the joint. Concentrating proximally and distally, they produce the synovia that later covers the joint gap. Meniscus and closed joint ligaments are formed by the central zone (i.e; cruciate knee ligaments) (Moore, 1993; Sadler, 2010).

In the early stages of pregnancy, the detection of congenital anomalies that emerged from external causes such as genetic diseases, intrauterine infections, and teratogenic agents is critical for prenatal diagnosis. Following the fetal development involves all structural parameters of the fetus. Fetal growth curves can be formed for parametric evaluations according to fetal age for all ethnic groups and may set the normal standards of the fetal growth of a population. Both invasive and non-invasive techniques are used for prenatal diagnosis. Fetal ultrasonography (USG) mostly used as a non-invasive procedure has the benefit of demonstrating all fetal formations. To evaluate all stages of embryogenesis via USG, fetal morphometric anatomy should be known for every week of gestation.

Fetal femur length has been one of the standards employed as a morphometric evaluation of fetal development in second and third-trimester fetuses. Crown-rump length (Dubowitz et al., 1970; Gibson et al., 1992; Hesinger, 1992; McBride et al., 1984; Ziylan & Murshid, 2003), biparietal diameter, head, and body circumference, and cephalic index standards were used for the same purpose (Hadlock et al., 1982; Kurtz et al., 1980; Seeds &

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Cefalo, 1982). Skeletal growth disturbances (Abramowicz et al., 1989; Bromley et al., 1993; Deter et al., 1981; O'Brien & Queenan, 1982), estimation of fetal gestational age (Hadlock, Harrist, et al., 1982; Seeds & Cefalo, 1982; Shalev et al., 1985; Yeh et al., 1982), developmental abnormality and identification of certain fetal congenital anomalies (Biagiotti et al., 1994; McBride et al., 1984; Shah et al., 1990), and detection of population growth features (Deter et al., 1987; O'Brien & Queenan, 1981) were the goals of various studies. Graphs were created on the correlation of fetal growth with gestational age (Iffy et al., 1975; Shepard et al., 1964) and the relationship between body and organ weight (Tanimura et al., 1971).

Comprehensive morphological data on the patella and the patellar ligament are crucial to understanding the normal mechanics of the knee joint, the pathogenesis of disorders involving the knee, and surgical management, including reconstructive procedures (Koyuncu et al., 2011; Miller et al., 1996; Yoo et al., 2007). The anatomical position of the patella is a critical factor in the natural history of disorders of the patellofemoral joint (White et al., 2009; Andrikoula et al., 2006; Schlenzka & Schwesinger, 1990). An abnormally superior patellar position may lead to pain owing to either patellar instability or because a patellar with chondromalacia may create abnormal contact stress (Biedert & Albrecht, 2006). The patella may have diverse shapes, some of which are associated with patellar instability. Previous studies suggested that morphological differences such as a narrow medial articular surface of the patella have a function in the pathogenesis of certain pathologies (Biedert & Albrecht, 2006; Fucentese et al., 2006).

Moreover, morphological and morphometric features of certain bones display gender differences (Introna et al., 1998; Mahfouz et al., 2007; Scheuer, 2002). As a result of analyzing both the patella and patellar ligament in adults, they were identified to exhibit such differences (Biedert & Albrecht, 2006; Grelsamer & Meadows, 1992; Introna et al., 1998; Mahfouz et al., 2007; Miller et al., 1996; Yoo et al., 2007). These data are fundamental to completely understanding knee biomechanics and may be connected to forensic science and anthropology (Kemkes-Grottenthaler, 2005; Mahfouz et al., 2007).

The purpose of this study was to establish the normal dimensions of the distal part of the femur, the proximal part of the tibia, the patella, and the anterior and posterior cruciate ligaments of the knee in human fetuses.

1.METHODS

This study was carried out on spontaneously aborted 50 fetuses (24 males and 26 females) (6 first trimester, 31 second trimester, and 13 third trimester) with no observable congenital malformations or maternal history of risky pregnancy which were obtained from Selcuk University, Meram Faculty of Medicine, Gynaecology Department, and Dr. Faruk Sükan Maternity Hospital (Konya, Turkey) between 2005 and 2010. The ages of the fetuses were determined to be between the 11th and 37th postmenstrual weeks depending on the crown-rump length (CRL) measurements (Hesinger, 1992). Written consent from the families and approval from the Ethics Board of Necmettin Erbakan University, Meram Faculty of Medicine were received before the study began. The cases were classified according to gestational age: Group 1 (1st trimester), Group 2 (2nd trimester), and Group 3 (3 rd trimester) consisted of fetuses whose gestational ages were less than 12 weeks, between 13 to 25 weeks, and between 26 to 37 weeks, respectively. The cases that have an anomaly or pathology of the distal part of the femur, the proximal part of the tibia, the patella, and anterior and posterior cruciate ligaments were not involved in the study. The tools such as a caliper, measuring tape, plastic ruler, or compass were used for the measurements. The immersion technique was used to fix the fetuses in %10 formalin. In the knee region, the skin, regional surrounding soft tissues and the upper end of the muscle tibialis anterior m, and the lower ends of the musculus quadriceps femoris m, sartorius m, gracilis m were fully removed. The patellar ligament, lateral collateral ligament, medial collateral ligament, arcuate popliteal ligament, and oblique popliteal ligament were taken apart and analyzed under the microscope. Then, the lower end of the quadriceps femoris m left its place and was pulled anteriorly to some extent, and hence, the exposed part of the capsule clinging to the femur was isolated from the bone. In the end, when the lower end of quadriceps femoris m, patella, and patellar ligament was laid anteriorly altogether, the joint gap was accessible. In this gap, it was easy to see anterior and posterior cruciate ligaments that cross each other in the space between the condyles of the femur.

Measurements were obtained from each knee (Figs 1-7) to enable comparatively slight changes after keeping in formalin.

Parameters for femur are as follows;

- Proximal breath: The distance between superior margins of lateral and medial condyles (A).
- Distal breath: The maximal distance between external margins of lateral and medial condyles (B).
- Maximal breath: The distance between external margins of the inferior articular surface of lateral and medial condyles (C).
- The maximum width of the intercondylar notch (D)
- The maximal height of the lateral condyle (G)
- The maximal height of the medial condyle (H) For Tibia
- The maximal anteroposterior width of the condyles (K)
- The maximal anteroposterior width of the condyles medialis (J)
- The maximal distance between external margins of lateral and medial condylus (I)
- The maximal anteroposterior width of the median line (T) For Patella
- The maximal transverse width (M)
- The maximal vertical height (N)
- The thickness of the patella (L) For Lig Cruciatum Anterior
- The length of the anterior cruciate ligament (LACL)
- The thickness of anterior cruciate ligament (TACL) For Lig Cruciatum Posterior
- The length of the posterior cruciate ligament (LCPL)
- The thickness of posterior cruciate ligament (TPCL)

Characterization of the aspect ratio (the medial-lateral dimension divided by the anterior-posterior dimensionx100) was performed for the tibia and femur.

The measured data were analyzed by using a Student t-test (Statistical Package for Social Sciences Version 10.0 for Windows software) about gender and trimester. The difference between these groups reached a significant p-value of less than 0.05. The results were presented as the mean ± standard deviation in tables.

FAR: Femur aspect ratio

TAR: Tibia aspect ratio

2.RESULTS

After dissecting the knee and reaching the femur, tibia, and patella, they were checked for any gross anomaly; then, the location of the knee and their connection with surrounding structures were identified. There were no pathologies in the tibialis posterior m, quadriceps femoris m, sartorius m, or gracilis m and they were all in their usual position.

In a preliminary study, the parameters of interest were measured in 10 cases by three researchers. Each researcher was blind to the others' measurements. The student's t-test was used to compare the results of each rater. There were no significant differences between the measurements ($p>0.05$). Pearson's correlation test was also used to compare the results of raters and significant correlations were observed between each rater (0.001). All the measurements of the actual study were carried out by a single researcher.

No differences were identified in general external features between genders ($p>0.05$). The number of cases and means of the measurements related to gender are shown in Table 1. Gender or laterality differences were not observed in the knee joint, the distal part of the femur, the proximal part of the tibia, and the patella separate for both knee joints ($p>0.05$). Means of parameters and standard deviation of the parameters of the trimesters are presented in Table 2.

A significant relation was found between all parameters and trimesters ($p<0.001$).

The means of femur aspect ratio and tibia aspect ratio were detected from the right and left knee joints. Separate femur aspect ratio and tibia aspect ratio for both knee joints showed differences in gender and laterality ($p<0.005$). The femur aspect ratio was found to be larger on the right in females than in males, and larger on the left in males than females. In contrast, the tibia aspect ratio was larger on the right in males than females, and larger on the left in females than males (Table 1, Table 2). A significant relationship was identified between femur aspect ratio, tibia aspect ratio, and trimesters ($p<0.05$) (Table2).

In our study, positive correlations were observed between general external features (BPD, CRL, and femur and foot lengths) that were signs of gestational age and knee joint parameters ($p<0.05$) (Table 2).

Table 1: The descriptive statistics of measurements of both sides according to gender

	Right			Left		
	Male (n=24)	Female (n=26)		Male (n=24)	Female (n=26)	
	Mean±SD		*p*	Mean±SD		*p*
A	7.78±3.56	7.35±2.75	*0.631*	7.41±3.38	7.17±2.72	*0.789*
B	14.76±6.68	14.22±5.03	*0.748*	14.58±7.03	14.19±5.08	*0.820*
C	13.86±5.75	13.95±4.82	*0.954*	14.32±6.08	13.88±4.43	*0.774*
D	6.54±2.25	6.38±2.06	*0.795*	6.47±2.41	6.20±2.15	*0.677*
G	10.62±4.62	10.07±3.2	*0.621*	10.34±4.81	10.35±3.63	*0.992*
H	9.72±4.22	9.44±3.26	*0.795*	10.00±4.75	10.08±3.47	*0.945*
J	8.49±3.76	8.53±2.96	*0.798*	7.90±3.45	8.27±3.18	*0.702*
I	14.56±6.76	14.28±4.99	*0.867*	14.85±7.00	14.63±5.00	*0.900*
K	7.90±3.42	7.67±2.63	*0.793*	7.76±3.50	8.09±3.05	*0.726*
T	7.69±3.11	8.11±3.03	*0.630*	7.93±3.81	7.92±2.95	*0.985*
L	3.06±1.89	2.93±1.45	*0.790*	3.37±1.82	3.30±1.29	*0.874*
M	8.89±3.78	8.80±3.02	*0.925*	8.50±3.67	8.65±2.70	*0.862*
N	7.44±3.06	7.57±2.44	*0.865*	7.32±2.88	7.39±2.12	*0.925*
LACL	4.39±2.18	4.65±1.75	*0.643*	4.85±2.37	5.40±2.05	*0.387*
TACL	2.17±0.93	1.80±0.62	*0.109*	2.35±1.03	2.65±0.88	*0.271*
LPCL	4.92±2.32	5.20±2.16	*0.657*	4.68±2.49	4.74±1.77	*0.918*
TPCL	2.29±1.01	2.48±0.93	*0.487*	2.39±1.12	2.48±0.86	*0.753*
FAR	144.62±19.43	150.89±15.99	*0.217*	145.23±13.58	140.04±13.52	*0.183*
TAR	175.65±37.06	172.11±33.09	*0.723*	186.88±27.46	187.52±26.12	*0.932*

Table 2: The descriptive statistics of measurements of right side according to trimester period

Right	**1st trimester (n=6)**	**2nd trimester (n=31)**	**3rd trimester (n=13)**	
		Mean±SD		***p***
A	3.92±1.38	6.63±2.16	11.46±1.57	***<0.001****
B	7.72±2.52	12.59±3.45	22.11±3.34	***<0.001****
C	8.05±2.26	12.14±3.07	20.83±2.99	***<0.001****
D	4.08±1.35	5.90±1.45	8.90±1.56	***<0.001****
G	6.13±1.41	8.94±2.00	15.58±2.82	***<0.001****
H	5.25±1.65	8.31±2.12	14.58±1.88	***<0.001****
J	5.18±1.18 [a]	7.34±2.22 [a]	12.85±1.75	***<0.001****
I	8.02±2.85	12.7±3.97	21.46±3.85	***<0.001****
K	4.72±1.32 [b]	6.93±2.40 [b]	11.23±1.55	***<0.001****
T	4.35±0.87	7.57±2.54	10.36±2.88	***<0.001****
L	1.43±0.66 [c]	2.34±0.96 [c]	5.27±0.95	***<0.001****
M	4.65±1.56	7.75±1.97	13.38±1.23	***<0.001****
N	4.12±1.43	6.69±1.68	11.02±1.25	***<0.001****
LACL	2.32±0.60	4.08±1.54	6.61±1.37	***<0.001****
TACL	1.38±0.48 [d]	1.82±0.76 [d]	2.63±0.59	***0.001****
LPCL	2.78±1.19	4.33±1.34	7.88±1.56	***<0.001****
TPCL	1.32±0.52	2.14±0.74	3.48±0.53	***<0.001****
FAR	147.85±20.68	146.43±20.66	151.35±5.79	*0.714*
TAR	181.89±39.31	164.86±32.45	191.41±32.78	*0.054*

***:** *significant at 0.05 level in bold characters*
[a, b, c, d] superscript letters denote the significance of the pairwise group

Table 3: The descriptive statistics of measurements of left side according to trimester period

Left	1st trimester (n=6)	2nd trimester (n=31)	3rd trimester (n=13)	
		Mean±SD		*p*
A	3.70±1.37	6.31±1.91	11.27±1.18	***<0.001****
B	7.10±2.75	12.58±3.75	22.02±3.54	***<0.001****
C	8.12±2.45	12.47±3.35	20.72±3.02	***<0.001****
D	3.70±1.40	5.66±1.49	9.12±1.23	***<0.001****
G	5.88±1.95	9.06±2.98	15.46±2.30	***<0.001****
H	5.82±2.44	8.67±2.59	15.28±2.33	***<0.001****
J	4.23±1.54	7.17±2.31	12.07±1.72	***<0.001****
I	7.92±2.92	12.97±4.16	22.08±3.05	***<0.001****
K	4.50±1.07	6.88±2.17	12.02±1.97	***<0.001****
T	4.50±1.31	6.86±2.33	12.03±2.13	***<0.001****
L	1.65±0.82	2.85±0.92	5.25±1.17	***<0.001****
M	4.75±1.91	7.62±1.98	12.63±1.46	***<0.001****
N	4.77±1.17	6.63±1.64	10.28±1.99	***<0.001****
LACL	2.40±0.96	4.66±1.74	7.55±1.10	***<0.001****
TACL	1.28±0.48	2.35±0.79	3.43±0.58	***<0.001****
LPCL	2.38±0.88	4.22±1.57	6.95±1.77	***<0.001****
TPCL	1.33±0.60	2.19±0.72	3.53±0.68	***<0.001****
FAR	123.18±7.72	145.57±12.77[a]	144.21±10.74[a]	***<0.001****
TAR	174.34±23.65	190.88±23.9	184.42±32.86	*0.348*

***: significant at 0.05 level in bold characters*

[a] *superscript letter denotes the significance of the pairwise group*

Table 4: The comparison between the right and left sides

(n=50)	**Right**	**Left**	
		Mean±SD	***p***
A	7.56±3.14	7.29±3.03	*0.064*
B	14.48±5.83	14.38±6.04	*0.459*
C	13.91±5.23	14.09±5.24	*0.344*
D	6.46±2.13	6.33±2.26	*0.326*
G	10.33±3.91	10.34±4.19	*0.957*
H	9.58±3.72	10.05±4.09	***0.008****
J	8.51±3.33	8.09±3.28	***0.018****
I	14.42±5.85	14.73±5.98	*0.231*
K	7.78±3.01	7.93±3.24	*0.488*
T	7.91±3.04	7.92±3.35	*0.970*
L	3.00±1.66	3.33±1.55	***0.001****
M	8.84±3.37	8.58±3.17	*0.069*
N	7.51±2.73	7.36±2.49	*0.419*
LACL	4.53±1.96	5.14±2.20	***0.001****
TACL	1.98±0.79	2.51±0.95	***<0.001****
LPCL	5.07±2.22	4.71±2.13	*0.115*
TPCL	2.39±0.97	2.44±0.98	*0.633*
FAR	147.88±17.82	142.53±13.66	*0.104*
TAR	173.81±34.74	187.21±26.5	***0.045****

***: *significant at 0.05 level in bold characters.*

Table 5: The correlation between gestational age and all measurements according to trimester periods in males

	Gestational age (week)							
Male	**2.trimester (right)**		**2.trimester (left)**		**3.trimester (right)**		**3.trimester (left)**	
	Rho	***p***	**Rho**	***p***	**Rho**	***p***	**Rho**	***p***
A	0.830	***<0.001****	0.845	***<0.001****	0.440	*0.276*	0.707	*0.050*
B	0.983	***<0.001****	0.983	***<0.001****	0.886	***0.003****	0.970	***<0.001****
C	0.910	***<0.001****	0.981	***<0.001****	0.874	***0.005****	0.898	***0.002****
D	0.760	***0.003****	0.934	***<0.001****	0.934	***0.001****	0.623	*0.099*
G	0.904	***<0.001****	0.934	***<0.001****	0.910	***0.002****	0.934	***0.001****
H	0.954	***<0.001****	0.981	***<0.001****	0.826	***0.011****	0.620	*0.101*
J	0.964	***<0.001****	0.933	***<0.001****	0.608	*0.109*	0.958	***<0.001****
I	0.903	***<0.001****	0.979	***<0.001****	0.874	***0.005****	0.970	***<0.001****
K	0.911	***<0.001****	0.967	***<0.001****	0.494	*0.213*	0.443	*0.272*
T	0.770	***0.002****	0.960	***<0.001****	-0.295	*0.479*	0.455	*0.257*
L	0.544	***0.055****	0.864	***<0.001****	0.758	***0.029****	0.897	***0.003****
M	0.935	***<0.001****	0.958	***<0.001****	0.813	***0.014****	0.790	***0.020****
N	0.927	***<0.001****	0.849	***<0.001****	0.247	*0.555*	0.527	*0.180*
LACL	0.701	***0.008****	0.914	***<0.001****	0.635	*0.091*	0.458	*0.254*
TACL	0.592	***0.033****	0.854	***<0.001****	0.687	*0.060*	-0.373	*0.362*
LPCL	0.280	*0.355*	0.898	***<0.001****	0.479	*0.230*	0.467	*0.243*
TPCL	0.157	*0.609*	0.795	***0.001****	0.862	***0.006****	0.568	*0.142*
FAR	0.233	*0.444*	-0.416	*0.158*	0.766	***0.027****	0.683	*0.062*
TAR	0.357	*0.231*	-0.014	*0.964*	0.707	*0.050*	-0.371	*0.365*

***: significant at 0.05 level in bold characters*

Table 6: The correlation between gestational age and all measurements according to trimester periods in females

	Gestational age (week)							
Female	**2.trimester (right)**		**2.trimester (left)**		**3.trimester (right)**		**3.trimester (left)**	
	Rho	***p***	**Rho**	***p***	**Rho**	***p***	**Rho**	***p***
A	0.951	***<0.001****	0.928	***<0.001****	0.667	*0.219*	-0.553	*0.334*
B	0.917	***<0.001****	0.952	***<0.001****	0.718	*0.172*	-0.500	*0.391*
C	0.934	***<0.001****	0.935	***<0.001****	-0.154	*0.805*	0.500	*0.391*
D	0.700	***0.001****	0.871	***<0.001****	0.500	*0.391*	-0.103	*0.870*
G	0.894	***<0.001****	0.951	***<0.001****	0.821	*0.089*	-0.205	*0.741*
H	0.898	***<0.001****	0.850	***<0.001****	0.895	***0.040****	0.574	*0.312*
J	0.845	***<0.001****	0.951	***<0.001****	0.667	*0.219*	0.462	*0.434*
I	0.893	***<0.001****	0.940	***<0.001****	0.718	*0.172*	-0.462	*0.434*
K	0.810	***<0.001****	0.915	***<0.001****	-0.616	*0.269*	0.526	*0.362*
T	0.812	***<0.001****	0.953	***<0.001****	0.205	*0.741*	-0.667	*0.219*
L	0.647	***0.004****	0.884	***<0.001****	-0.051	*0.935*	-0.051	*0.935*
M	0.858	***<0.001****	0.933	***<0.001****	0.718	*0.172*	0.289	*0.637*
N	0.784	***<0.001****	0.754	***<0.001****	0.289	*0.637*	0.410	*0.493*
LACL	0.744	***<0.001****	0.706	***0.001****	-0.410	*0.493*	0.667	*0.219*
TACL	0.444	*0.065*	0.801	***<0.001****	-0.263	*0.669*	-0.205	*0.741*
LPCL	0.734	***0.001****	0.776	***<0.001****	-0.205	*0.741*	-0.051	*0.935*
TPCL	0.658	***0.003****	0.725	***0.001****	0.359	*0.553*	-0.359	*0.553*
FAR	0.212	*0.399*	0.245	*0.327*	-0.154	*0.805*	-0.763	*0.133*
TAR	0.141	*0.576*	-0.372	*0.128*	0.872	*0.054*	0.359	*0.553*

***: significant at 0.05 level in bold characters*

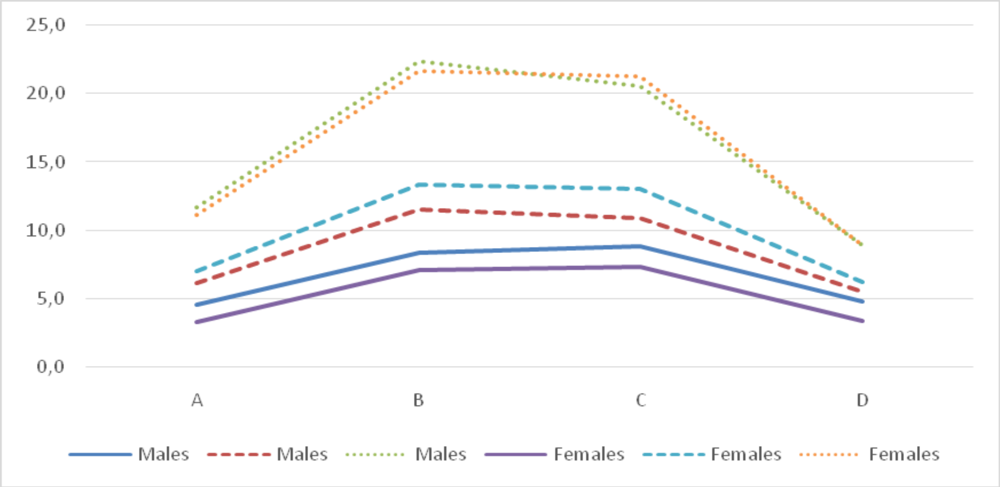

Figure 1: The means of A, B, C, and D measurements according to gestational age in genders

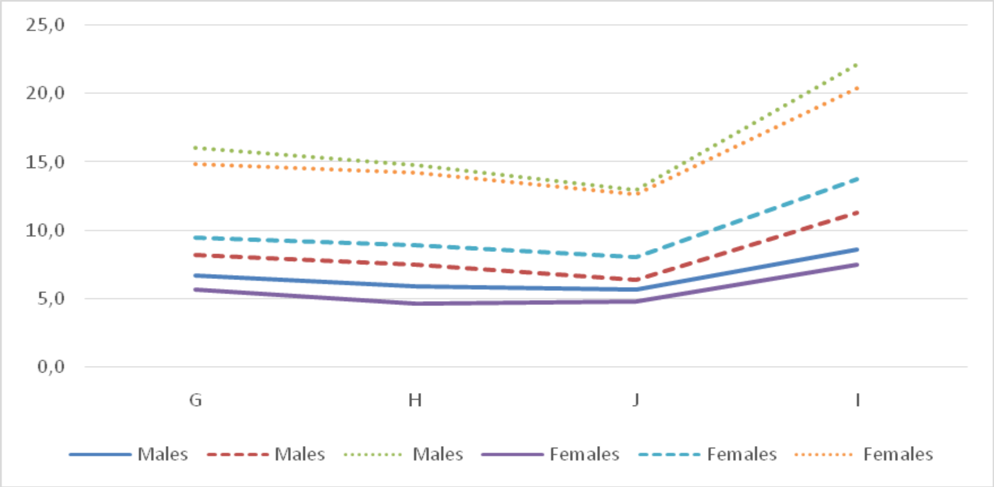

Figure 2: The means of G, H, J, and I measurements according to gestational age in genders

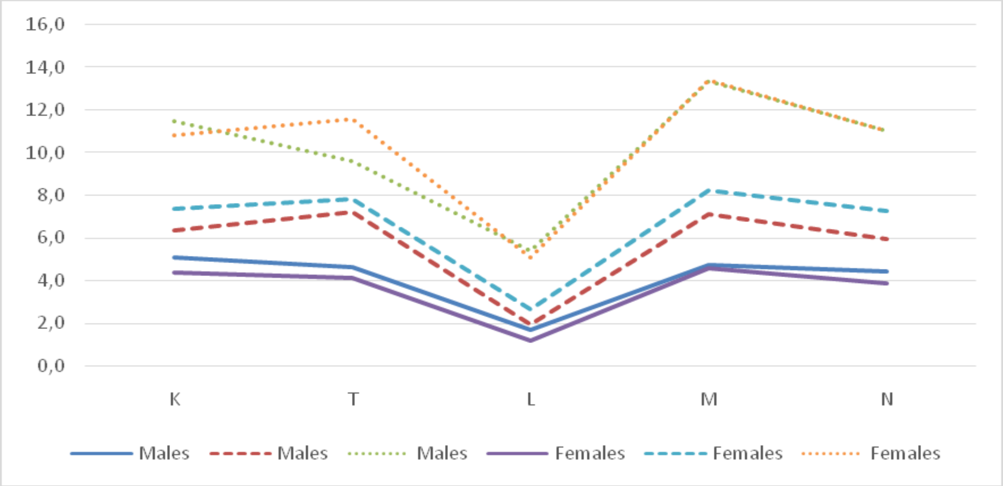

Figure 3: The means of K, T, L, M, and N measurements according to gestational age in genders

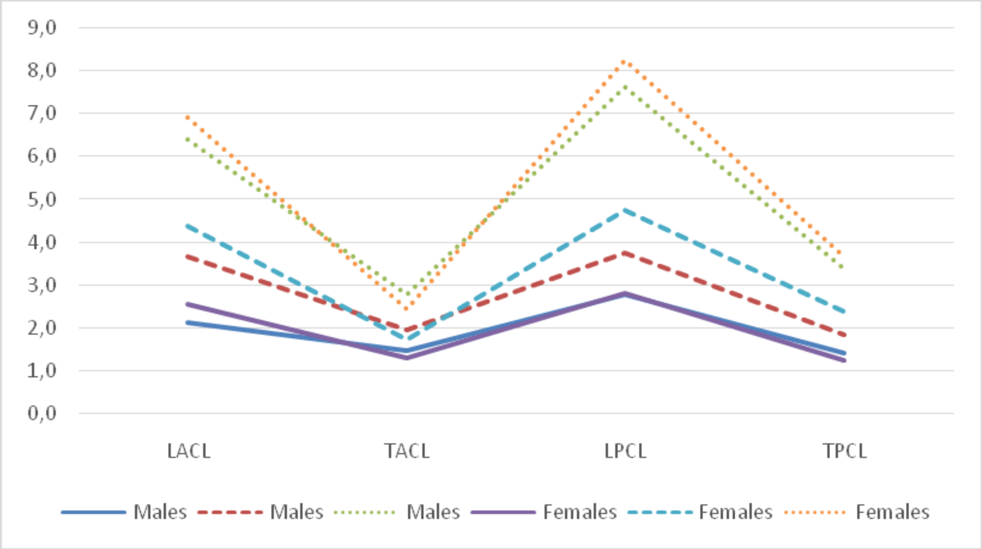

Figure 4: The means of LACL, TACL, LPCL, and TPCL measurements according to gestational age in genders

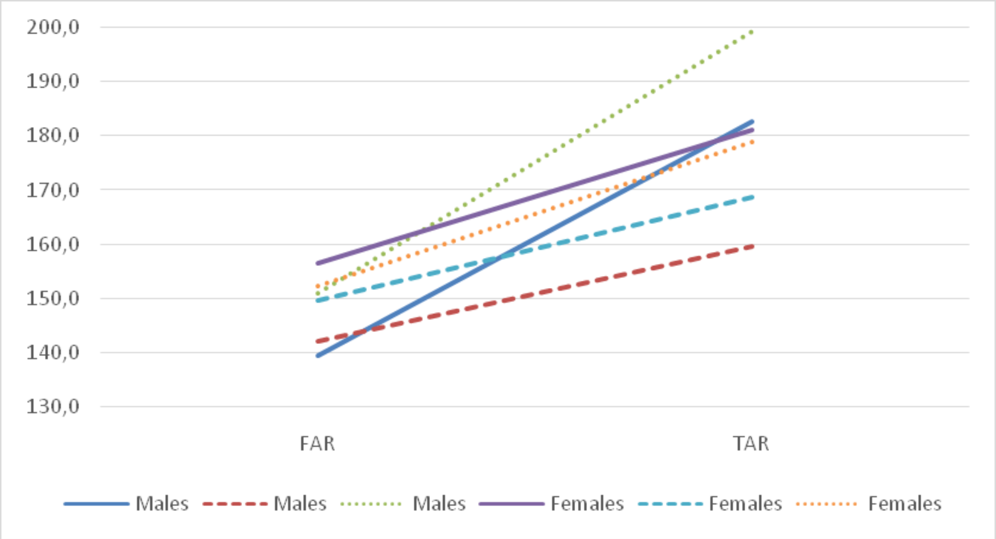

Figure 5: The means of FAR and TAR measurements according to gestational age in genders

3. DISCUSSION

Precise linear measurements of the fetus enable a full profile of the fetus and bring a new dimension to the measurement of its growth. In the current study, no significant gender and sides difference regarding knee joints and its component during fetal life was found. Ziylan and Murshed (Ziylan & Murshid, 2003) reported that the epicondylar widths were 14.92 mm in females, 14.78 mm in males in the 2nd trimester, and 20.83 mm in females, 20.81 mm in males during the 3rd trimester. These significant differences between males and females were in line with our findings related to the epicondylar width. Moreover, the results of the study revealed that the medial condylar width and lateral condylar width of men were significantly greater than that of women.

Racial differences in the population should be taken into consideration; hence, we felt that using a heterogeneous population was more appropriate rather than separating into different racial groups. This should provide a more universally applicable growth curve (O'Brien & Queenan, 1981). We suggest that a comfortable size chart for fetal parameters be created for the Turkish population, which has a wide range of study samples. Although CRL can be used to determine the gestational age of the fetus (Hesinger, 1992; Singer et al., 1991), this standard was found to assess the gestational age in the first trimester accurately (Hadlock et al., 1982; Deter et al., 1987; Robinson, 1975).

The difficulties faced while imaging the knee joint and its components, especially during 1st and 2nd trimesters have been reported by previous ultrasound studies including those with 3D ultrasound. In this study, the knee joint and its components between 11-37 weeks of gestation were measured and a significant relationship was determined between the knee joint and its components and gestational age during this period ($p<0.001$). The data obtained in this study contains detailed information on the intrauterine development of the fetal extremities, especially knee joints and their components.

No significant gender differences related to the knee joint and its components during fetal life were observed in previous studies. Yet, in adults, a gender difference was found between the lateral tibial condyle and medial tibial condyle (Mc Fadden et al, 2002). In most males, the lateral tibial condyle is smaller than the medial tibial condyle. In our study, no laterality differences were found in the knee joint and its components between gender or sides ($p>0.05$). When the knee joint and its components among trimester groups were compared, a significant difference was found in the medial plateau and lateral plateau of the tibial anterior-posterior measurements among all groups.

In the present study, the length and width of the patella were observed to increase with gestational age and this increase was statistically significant ($P<0.05$; Table 2). The increases in the length and width also showed a linear relationship throughout the fetal period. In addition, positive correlations were found between the length and width of the patella and body weight-CRL ($p<0.05$). In terms of gender, the mean length of the patella was larger in females, which was not statistically significant.

It is important to know the thickness of the patella in adults and no studies have been conducted on this topic. However, to our knowledge, there are no studies on this structure and fetal period (Yoo et al., 2007; Sulaiman et al., 2005). In addition, the thickness of the patella showed a significant correlation with the height and weight of patients (Sulaiman et al., 2005). In our study on fetal specimens, there were positive correlations between the thickness of the patella and body weight-CRL, and the thickness was observed to increase with gestational age (Table 2). These results demonstrate that the thickness of the patella, body weight, and CRL all increase at the same ratio before the lower extremities bear and load.

A gender difference was seen in the femur aspect ratio and tibia aspect ratio ($p<0.05$) (Table 1, Table 2). Femur aspect ratio, tibia aspect ratio on the right; 144.62, 175.64, 150.89, 172.10, on the left 145.22, 186.87, 140.04, 187.52, male and female, respectively. There were significant differences between trimesters ($p<0.05$) (Table 2).

4. CONCLUSION

In this study, morphologic variations were more frequent on the right side in females. In terms of the average length of the right and left knees, there was no statistically significant difference between males and females ($p>0.05$). The measurements of the knees were determined to be able to be used as a parameter for fetal body development since they correlated with CRL. In this study, the general morphologic features, variations, and morphometric evaluations of the elements involved in the knee formation and knee structures of human fetuses were obtained. The materials used in this study taken from aborted fetus collection were considered morphologically normal. Nevertheless, both the factors affecting the growing process of the intrauterine period and the possible relation with the negative effects of the causes of abortion on growth should be taken into consideration. Since there are no studies directly related to the study of fetuses in the literature, this study was compared with similar neonatal period studies and a limited number of cadaver studies. It is believed that this clinically important area can be analyzed morphologically better when similar studies are conducted on adult cadavers. We hope that the data obtained in this study will facilitate other studies on the diagnosis and treatment of such conditions carried out in obstetric, perinatology, forensic medicine, and fetal pathology departments in addition to the anomalies, pathologies, and variations of the knee joint and its components.

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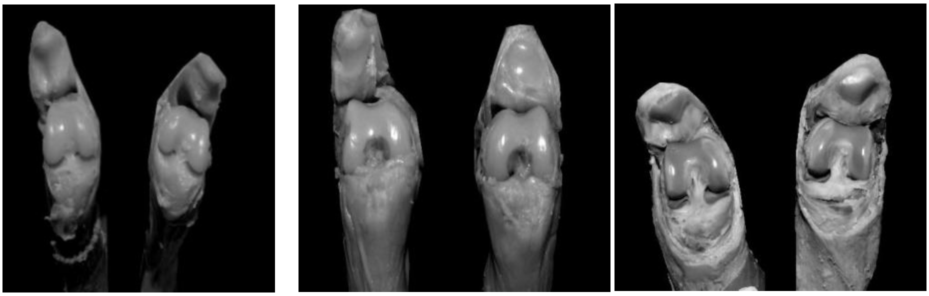

K1 K2 K3

Figure 6. Knees of 1st trimester (K1), 2nd trimester (K2) and 3rd trimester (K3) in fetuses.

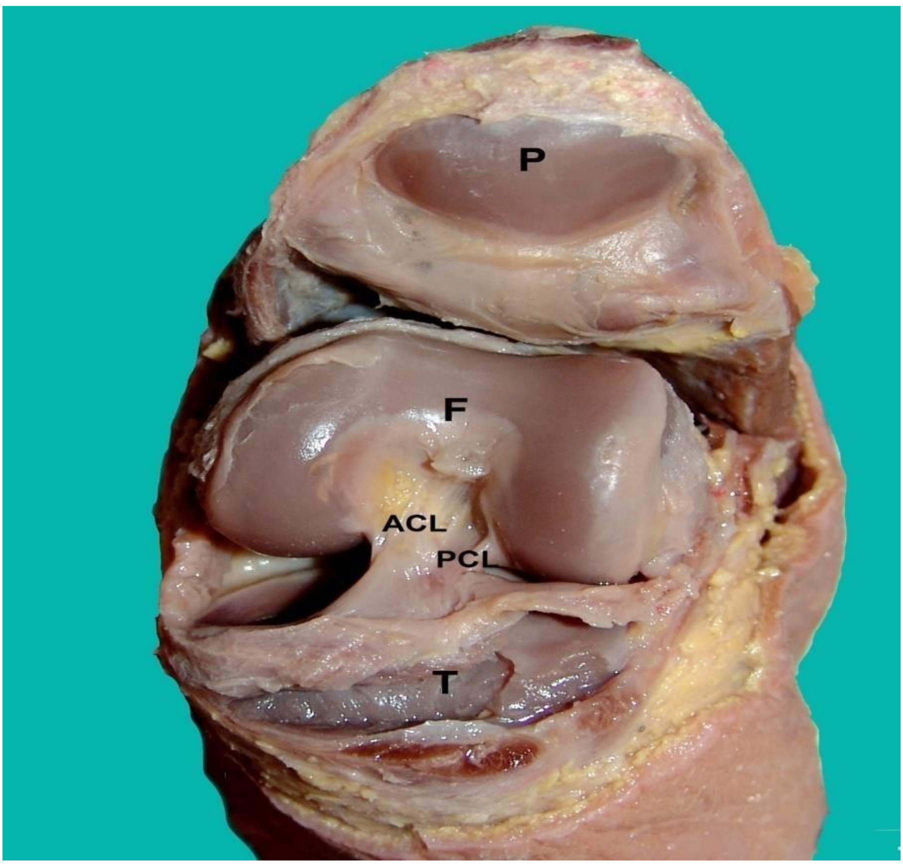

Figure 7. The anterior appearance of the knee from one of the examined fetuses in the third trimester after dissection and during measurements.
P: Patella, F: Femur, T: Tibia, ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament.

CHAPTER 5

ANTHROPOMETRIC ANALYSIS OF TURKISH FETUSES' FACE

Assoc. Prof. Dr. Işık TUNCER[1]

INTRODUCTION

Chantal index and circumference-interorbital index, which are acquired from the measured parameters, are valuable for anatomists and cranio facial surgeons (Evereklioglu et al., 2001; Lakshminarayana et al., 1991). A single gene, gene groups or environmental factors can be used to determine craniofacial dimensions (Poswillo, 1975). Many clinicians, geneticists and maxillofacial surgeons take into consideration abnormal facial features such as telechantus, ocular hypertelorism or hypotelorism while diagnosing certain anomalies and syndromes. When it reaches adult levels in the mid-to-late twenties, the measurement becomes stable (Fledelius & Stubgaard, 1986; Pryor, 1969). The anatomical interpupillary distance is primarily expressed through visual impression. However, this expression is insufficient owing to variation in facial features such as a wide nasal bridge, epicanthus, and telecanthus. When comparing normative population values, the groups must be matched by age, gender and race. This is especially important in the early years.

The face is composed of three parts; upper, middle and lower thirds. Lips create the basic aesthetic characteristic of the lower third, the upper lip, in particular, has a considerable impact on the aesthetic assessment of the face (Bisson et al., 2004). Individual, gender and ethnic variations determine the size and curvature of the exposed red lip surface (Berkovitz et al., 2005). These measurements slightly change as people get older. Lips and their relationship with the position of anterior teeth have a major effect on smile and overall facial aesthetics (Ferrario et al., 2001). As individuals get older, the lips get thinner, the wet line moves caudally and oral commissure begins to downturn (Daniel, 2008; Franklin et al., 2012). After the fifth or sixth decade of life, almost all measurements show a downward trend (Singal & Sidhu, 1986).

The lack of a comprehensive study on facial morphometric measurements has enabled this study to be carried out. The study aims to benefit forensic dentists, plastic surgeons and forensic experts with useful information. In addition, it can serve cosmetic correction and identification.

1.MATERIAL AND METHOD

This study includes human fetuses between 7 and 37 weeks of gestation (crown rump length [CRL]). The measurements were performed on 97 fetuses. An approval was provided from the Ethics Board of Necmettin Erbakan University Meram Faculty of Medicine before the study began (2016/171). The fetuses were detected via immersion method using %10 formalin in the fetus collection of Necmettin Erbakan University, Meram Faculty of Medicine, Anatomy Department in 2016-2017.

The fetuses were divided into three groups based on their gestational ages: Group 1 (first trimester) involved fetuses aged 7-12 weeks, group 2 (second trimester) involved fetuses aged 13-25 weeks, and group 3 (third trimester) involved fetuses aged 26-37 weeks. The measurements were conducted by using a digital compass sensitive to 0.01 mm.

The following are the vertical measurements: (Farkas, 1981) (Figure 1):

The head:

- Height of calvaria (vertex-trichion) (v-tr),
- Forehead height I (trichion-glabella) (tr-g),
- Forehead height II (trichion-nasion) (tr-n),

- Special head height(vertex-endocanthion) (v-en),

The face:

- Special face height (endocanthion-gnathion) (en-gn),
- Special upper face height(glabella- subnasale) (g-sn),
- Lower face height (subnasale-gnathion) (sn-gn),

The ear:

- Ear length (supraaurale-subaurale) (sa-sba),
- The horizontal measurements are as follow (Figure 2):

The orbits:

- Left eye fissure length (exocanthion-endocanthion) (ex-en),
- Intercanthal distance (endocanthion-endocanthion) (en-en),

The nose:

- Nose width (alare-alare) (al-al),
- The labio-oral region:
- Mouth width cheilion-cheilion) (ch-ch).

1.1. Statistical Analysis

SPSS 20.0 (IBM Inc., Chicago, IL, USA) software was used for the analyses of the study. Descriptive statistics were presented as frequencies and percentages for categorical variables and mean±SD for numerical variables in addition to percentile values. Kolmogorov-Smirnov method was used to examine continuous variables for normality, student t-test for two independent samples and the analysis of variance for several independent samples. Pearson correlation coefficients were calculated between measurements and gestational age. $P<0.05$ was considered statistically significant as 5% Type-I error.

2. RESULTS

The study involved a total of 98 fetuses. The gender ratios were close to one another, with males accounting for 51 percent of the sample (n = 50). In fetuses, second trimester rate was 64.3%, third trimester rate was 24.5% and first trimester rate was 11.2%, respectively. Their gestational age ranged from 8 to 28 weeks. Mean age was 19.67 ± 7.29 weeks in male fetuses, 16.66 ± 5.85 weeks in female fetuses and 18.18 ± 6.75 weeks in general.

Values measured were compared between male and female fetuses. En_gen ($p = 0.013$) and tr_r ($p = 0.012$) differed significantly between genders. Both measured values were significantly higher in male fetuses than in females. However, male fetuses had higher r_sn measurement result while the difference between genders was not statistically significant ($p = 0.115$). Male fetuses had also significantly higher Sn_gn, tr_g, g_sn and ex_en measurement results. The results of Sa_sba, en_en, al_al and ch_ch measurements were not found to differ significantly between gender groups (Table.1).

Comparisons of measurement for trimester periods are shown in Table 2. All measurements were significantly different between periods ($p <0.001$). All measurements increased in parallel to the trimester period (Figure 3). When all measurements were compared according to trimesters in terms of gender difference, it was seen that all mean values between periods were significantly different. In both male and female fetuses, facial measurement values increased as trimester periods progressed (p0.001). Table 3 includes the mean, minimum, maximum, and quartile (25th, 50th, and 75th percentile) values for all morphometric measurements by gender difference. In terms of gender difference, all morphometric measurement values were found to correlate positively and significantly with gestational age (week). The highest correlation in male fetuses belonged to sa_sba (r=0.973) and the lowest correlation was found between al_al and gestational week (r=0.746) while in female fetuses, the highest correlation was found to be r_0903 with en_gn and the lowest correlation was r=0.750 with al_al measurements.

3. DISCUSSION

Body sizes differ depending on age, gender, race, climate, and regional factors. Face is the most important part of this variation. Eyes are the parts of the face with the most distinguishing features. Many physicians, geneticists, and plastic surgeons use eye-related parameters in the diagnosis and treatment of specific anomalies, syndromes, and abnormal appearance such as hypertelorism, hypotelorism and telecanthus as well as in the production of eyeglasses and the establishment of physical anthropologic standards (Evereklioglu et al., 2002; Onizuka & Iwanami, 1984).

Geneticists, opticians, anthropologists, forensic medicine experts, and reconstructive surgeons have all benefited from craniofacial anthropometry in recent years. Direk et al. performed measurements in orbital region and detected a significant decrease in the nasoprontal angle with age (Direk et al., 2016). When the findings on different races were examined, the narrowest nasofrontal angle was found to be 134.3 in North American Caucasians, whereas the widest nasofrontal angle was found to be 149.2 in the study of Direk et al (Choe et al., 2004; Husein et al., 2010; Wei, 2009).

The external nose, head, and face, like other parts of the body, grow fast during adolescence. Knowing the pattern of growth and maturity is critical for determining the ideal time for nasal deformity reconstruction. (Farkas, 1981) indicated that the width and height of the nose completed growth at the age of 12 in women and 14 or 15 in men, and that the size and form of the external nose altered less after maturity. We conducted an anthropometric study on selected normal young Han Chinese between the ages of 17 and 24 so as to provide reliable reference data during reconstruction of secondary nasal deformity after cheiloplasty, nasal reconstruction and repair of nasal defects and rhinoplasty in adults for the Chinese population.

According to anthropologists, different nasal forms and sizes emerged as a result of the nose's evolutionary adaptation to climate. Negus has stated that populations adapted to arid climates have external noses that are wide and protruding, nostrils that point downward, and skeletal apertures that are smaller (Negus, 1958). These characteristics are thought to induce turbulence in nasal airflow, allowing for better filtration and humidification of air within the nasal passages. The populations with smaller and flatter external nares, more anteriorly oriented nares, and shorter pyriform apertures, on the other hand, are more adapted to humid climates. These results are also consistent with our study on individuals from West India that mostly involve Rajasthani subjects with large external nares with downwardly directed nasal tips and Himalayan subjects with flatter noses, more anteriorly directed nares and shorter nasal apertures.

Systematic anthropometric methods for measuring the soft tissue of the external nose before surgery are routinely employed to examine objective aspects in external nose reconstruction. Preoperative evaluation and surgical planning should be based on the shapes of the face, mouth, eyes and body, refer to the measurement values of the normal population of the same gender and ethnicity to determine the degree of reconstruction and the morphology of implant and guide the real surgery objectively (Rohrich & Bolden, 2010).

Faces with four equal sections of the profile canon were not detected in neither of the groups. Among the variations of this canon, the height of the calvaria was lower than the upper and lower face heights in the majority of the other study group (Farkas et al., 1985). However, in our group, the calvarium height was lower than the upper face height but higher than the lower face height. In both groups, the upper face height was lower than the lower face height. The most noticeable distinction was that in high percentages of the other data, the forehead height I was lower than the upper and lower face heights. (Farkas et al., 1985). Even though the forehead height I was lower than the lower face height, it was higher than the upper face height in our measurements. The last vertical canon was found to be equal in 2.9% and 2.2% of our women and men respectively. Our findings match those found in the literature (Farkas et al., 1985). The nose length being shorter than the ear length was the most commonly reported variation in both groups.

The evaluation of reference anthropometric data of the orbital region is a necessary step in the quantitative description of normal people and can also be useful in diagnostic procedures (treatment of traumas, chromosomal, and single gene alterations, teratogenically induced conditions such as fetal alcohol syndrome) (Barretto & Mathog, 1999; Pivnick et al., 1999; Strömland et al., 1999). In fact, measurements are essential for distinguishing between different pathologies and morphological variances in individuals.

In terms of anatomic and anthropologic perspective, as well as oral and maxillofacial surgery, the fetus' facial growth is critical. It is crucial especially in lower jaw surgery and intervention. Knowing the facial position will enable to identify chromosomal deviations, hereditary disorders and other facial deformities and ensure the realization of anesthesia applied in in the lower jaw intervention and surgical interventions.

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Table 1: Measurement results according to gender

Measurements		**Male (n=50)**	**Female (n=48)**	
		Mean±SS		***p***
en_gn	*mm*	29.15±12.36	23.79±8.33	***0.013****
tr_r	*mm*	22.58±9.79	17.97±7.42	***0.012****
r_sn	*mm*	15.05±6.0	13.26±5.58	*0.115*
sn_gn	*mm*	20.46±7.93	16.8±5.25	***0.008****
tr_g	*mm*	19.17±7.87	14.77±5.8	***0.002****
g_sn	*mm*	16.59±6.1	14.11±5.68	***0.041****
sa_sba	*mm*	17.58±9.07	15.13±6.31	*0.109*
ex_en	*mm*	13.08±5.88	10.67±3.87	***0.020****
en_en	*mm*	13.29±5.12	11.6±4.15	*0.076*
al_al	*mm*	12.98±4.99	11.53±5.09	*0.140*
ch_ch	*mm*	16.03±5.98	14.58±5.65	*0.231*

*: *significant at 0.05 level according to Independent Sample t-test*

Table 2: Measurement results for Trimester periods

	1st trimester (n=11)	**2nd trimester (n=63)**	**3rd trimester (n=24)**	
		Mean±SS		***p***
en_gn	12.31±2.81	23.76±5.25	40.31±10.23	***<0.001****
tr_r	10.14±1.97	18.18±5.7	30.6±8.83	***<0.001****
r_sn	5.6±1.42	13.2±3.92	20.67±4.42	***<0.001****
sn_gn	9.38±2.25	17.23±3.94	26.7±6.81	***<0.001****
tr_g	8.78±1.59	15.25±4.6	25.43±6.96	***<0.001****
g_sn	5.99±1.9	14.47±3.85	22.05±4.4	***<0.001****
sa_sba	7.35±1.69	14.15±4.56	26.39±6.96	***<0.001****
ex_en	5.48±1.05	10.87±2.6	17.53±6.0	***<0.001****
en_en	7.02±1.55	11.37±3.16	17.81±4.34	***<0.001****
al_al	4.75±1.27	11.77±3.98	17.03±3.66	***<0.001****
ch_ch	7.43±1.61	14.33±3.62	21.34±5.64	***<0.001****

**: significant at 0.05 level according to One-way ANOVA test with Tukey HSD post-hoc test showing that every trimester period is significantly different from others*

Table 3: Descriptive measures according to trimester periods according to gender

	1st trimester	**2nd trimester**	**3rd trimester**			
Male		**Mean±SS**		***p***	**Min-Max**	**P_{25}-P_{50}-P_{75}**
en_gn	9.95±0.92	23.18±5.0	43.51±10.11	***<0.001****	9.3- 56.7	20.47-26.6-36.8
tr_r	11.7±0.42	18.14±5.17	32.8±9.43	***<0.001****	11.0- 50.5	14.97-20.4-28.8
r_sn	6.15±1.2	12.37±3.64	21.54±4.38	***<0.001****	5.3- 26.6	10.02-13.6-20.27
sn_gn	7.4±0.57	16.84±3.64	29.34±6.58	***<0.001****	7.0- 38.7	14.7-19.4-24.2
tr_g	10.1±1.13	15.42±4.0	27.8±6.98	***<0.001****	7.0- 39.3	13.0-18.55-22.9
g_sn	6.95±0.07	13.97±3.7	23.03±4.7	***<0.001****	6.9- 28.6	11.35-15.85-20.02
sa_sba	7.05±0.07	13.13±4.44	27.8±7.73	***<0.001****	6.7- 39.1	10.92-15.0-22.47
ex_en	5.8±0.57	10.64±2.09	18.86±6.96	***<0.001****	5.4- 31.0	9.3-11.9-14.5
en_en	7.35±0.49	11.12±3.18	18.38±4.73	***<0.001****	6.7- 24.1	9.5-12.5-17.0
al_al	5.5±1.13	11.01±3.45	17.86±3.93	***<0.001****	4.7- 23.7	8.97-11.8-16.8
ch_ch	8.4±1.7	13.37±3.24	21.97±5.65	***<0.001****	7.2- 32.0	12.1-14.75-18.7
Female						
en_gn	12.83±2.84	24.35±5.51	33.9±7.36	***<0.001****	8.9- 47.1	17.47-24.4-28.02
tr_r	9.79±2.02	18.23±6.28	26.19±5.71	***<0.001****	5.8- 37.6	12.3-15.8-22.3
r_sn	5.48±1.49	14.06±4.08	18.91±4.21	***<0.001****	3.6- 28.9	9.05-12.8-17
sn_gn	9.82±2.25	17.63±4.25	21.43±3.44	***<0.001****	6.6- 26.2	12.45-16.0-21.82
tr_g	8.49±1.57	15.07±5.21	20.68±4.02	***<0.001****	6.0- 29.0	9.52-13.0-17.95
g_sn	5.78±2.06	14.99±4.0	20.1±3.1	***<0.001****	3.4- 26.0	10.1-14.8-18.2
sa_sba	7.41±1.89	15.19±4.51	23.58±4.2	***<0.001****	4.9- 32.3	10.0-14.6-21.3
ex_en	5.41±1.15	11.11±3.06	14.89±1.56	***<0.001****	4.0- 17.9	7.1-10.55-14.2
en_en	6.94±1.71	11.64±3.18	16.65±3.43	***<0.001****	4.0- 19.7	8.55-11.2-14.3
al_al	4.59±1.3	12.55±4.37	15.39±2.51	***<0.001****	2.4- 21.2	7.65-11.8-14.7
ch_ch	7.21±1.61	15.4±3.77	20.09±5.79	***<0.001****	5.0- 29.0	10.0-14.45-17.85

**: significant at 0.05 level according to One-way ANOVA test with Tukey HSD post-hoc test showing that every trimester period is significantly different from others*

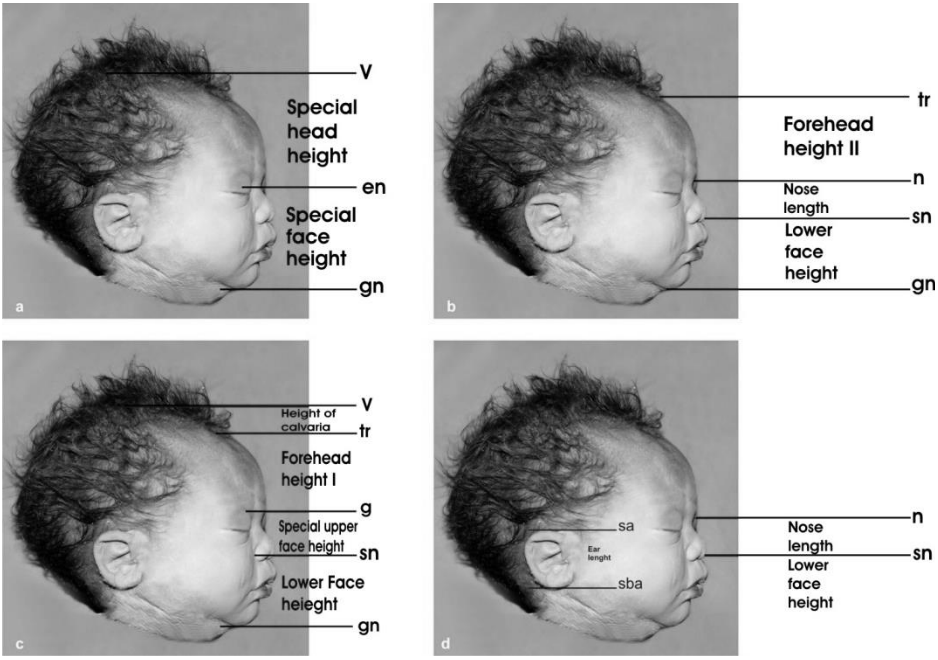

Figure 1: Vertical measurements (11): a; special head height [vertex-endocanthion (v-en)], special face height [endocanthion-gnathion (en-gn)], b; forehead height II [trichion-nasion (tr-n)], nose length [nasion-subnasale (n-sn)], lower face height [subnasale-gnathion (sn-gn)], c; height of calvaria [vertex-trichion (v-tr)], fore head height I [trichion-glabella (tr-g)], special upper face height [glabella-subnasale (g-sn)], lower face height [subnasale-gnathion (sn-gn)], d; nose length [nasion-subnasale (n-sn)], ear length [supraaurale-subaurale (sa-sba)].

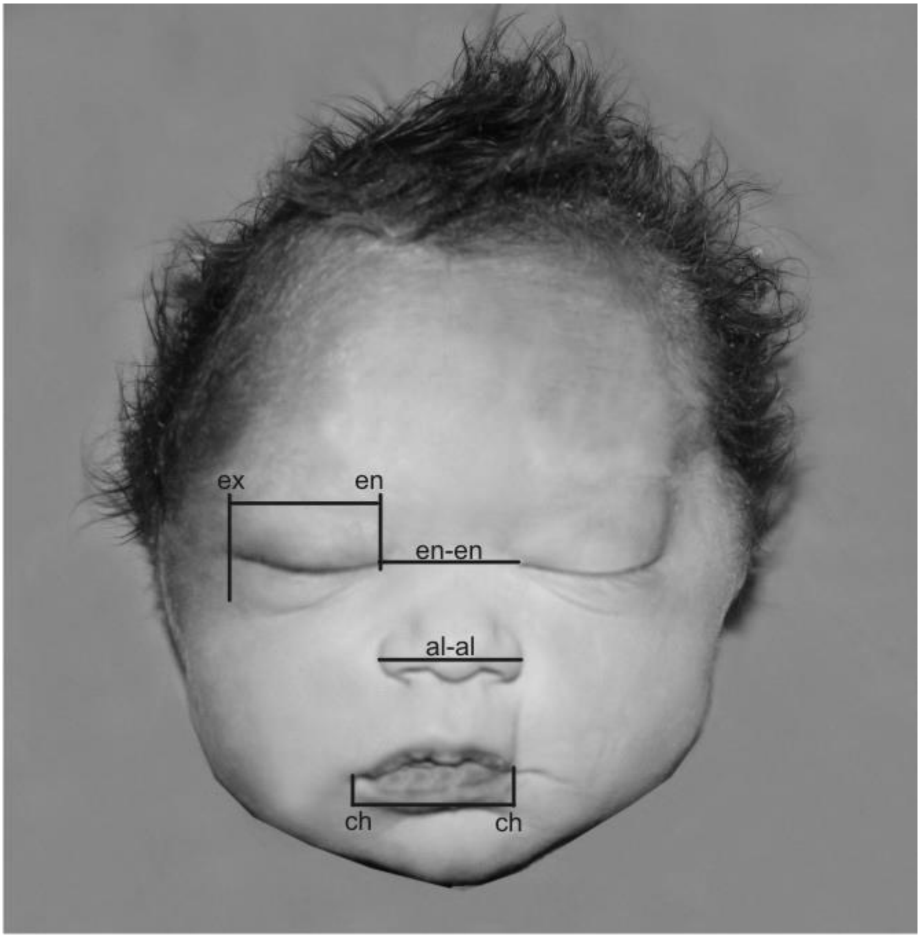

Figure 2: Horizontal measurement (11): right eye fissure length [exocanthion-endocanthion (ex-en)], intercanthal distance (endocanthion-endocanthion (en-en)], nose width [alare-alare (al-al)], mouth width [cheillion-cheillion (ch-ch].

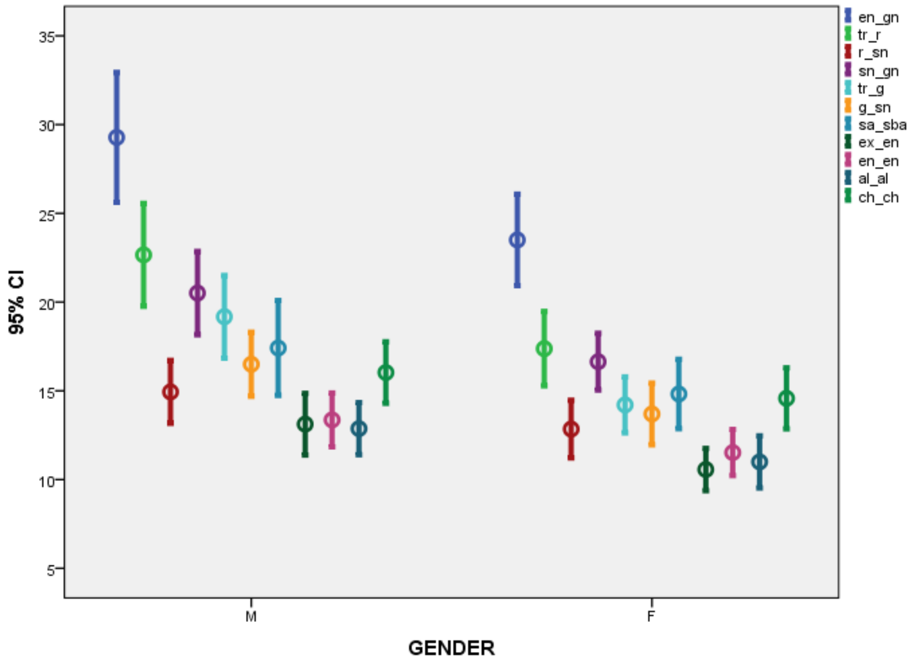

Figure 3: Fetus face measurements according to gender

CHAPTER 6

EXAMINATION, EVALUATION AND STATISTICAL ANALYSIS OF HUMAN FEMORAL ANTHROPOMETRY IN TURKISH POPULATION

Assoc. Prof. Dr. Işık TUNCER

INTRODUCTION

The longest and strongest bone in human body is the femur. It carries the weight of the body and transfers it to lower parts via hip joints. Its intracapsuler heads are in the shape of a half sphere and make joint with hips on the left and right. Femur neck is about 5 cm and it was 125˚ with its shaft.

The quadrangular greater trochanter and conical lesser trochanter are located at the neck-shaft joint. When the human body is in anatomical position femoral shafts are obliquely positioned. Shafts both seem cylindrical, triangular. Distal end of femur has two big articular condyles (Lingamdenne et al.).

Three dimensional descriptions of condyles of femur are still needed and not very well defined. A representative knee joint geometry is usually expected which requires an approximation of the irregular joint geometry while taking into account interspecimen variations in joint modeling. Femoral condyles in the saggittal aspect were examined by many researchers. A comprehensive data may be seen in the study of Nuno and Ahmed (Nuño & Ahmed, 2001, 2003). The widest one is the study of Zoghi et al. (Zoghi et al., 1992). They used model profiles consisted two and three circular arcs to mathematically reconstruct the saggital profiles of the medial and lateral condyles, respectively, from the measurements of four specimens. Iwaki et al. (Iwaki et al., 2000) also studied saggittal profiles of condyles via circles gauges og magnetic resonanges images from 24 cadaveric knees. Nuno and Ahmed (Nuño & Ahmed, 2001) reported the profiles of the femoral condyles with the measurements of 12 distal femurs in their latest study. In their study they reported that medial and lateral condyles may be adequately described by two-circular arcs in the femorotibial contact region (includes posterior and distal parts of the condyles). Preciseness of such a description was determined to be lower than 0.2 mm in terms of the difference between the experimental data and the fitted two-circular –arc representation. But, this study was limited to two the description of one representative sagittal plane for each condyle. The frontal profile of condyles of femur was not covered very well like its saggittal profile. Kurosawa et al. (Kurosawa et al., 1985) explained frontal profiles of by using a circular arc on 10 samples.

The race, sex and environmental factors affect shapes and structures of bones. Nurzenki et al. showed that life conditions also affect the geometric indices of bone strength in the proximal femur (Nurzenski et al., 2007).

Femur head offset and vertical offset are important parts for the range of motion and abductor muscle strength after total hip arthroplasty (McGrory et al., 1995). Hip prostheses are produced according to data obtained from Europe populations (Husmann et al., 1997; Rubin et al., 1992). So wrong size hip prostheses may have effects. Surgical operations are applied mostly for to fix anatomical reduction a stable fracture fixation that supports bone reunion and allows early mobilization. Good contour fit bone and plate is needed to develop strong bone construction (Ahmad et al., 2007). Morphometric study of proximal part of the femur was conducted in different populations and communities (Mahaisavariya et al., 2002). And the study showed that femoral morphometry had regional features and social differences.

We aimed to study the morphometric characteristics of the proximal and distal parts of femur in the Central Anatolian population in Turkey and to establish a regional database for prosthesis design and medical applications.

1.MATERIAL AND METHOD

This study was conducted in Meram Faculty of Medicine, The Department of Anatomy in Necmettin Erbakan University in 2017. It has been approved by ethical committee of Necmettin Erbakan University according to Copenhagen criteria (2016/214). First bones were examined by inspection. Measurements were performed on 78 bones (right:37, left:41) without gross anomaly. For the purpose of accuracy all measurements were performed by the same person. 10 parameters for proximal and distal parts were recorded (Fig 1,2,3,4,5,6). Measuring tape and millimetric callipers were used. Parameters and measurements were:

Proximal femur,

- Distance from the head of the femur to the lesser trochanter of the femur (FHLT).
- Distance from the tip of the greater trochanter of the femur to the lesser trochanter of the femur (GTLT).
- Distance from the lesser trochanter of the femur to the medial condyle (LTCM).
- Distance from the lesser trochanter of the femur to the lateral condyle (LTCL).
- Distance from the head of the femur to the lateral condyle (FHCL).
- Distance from the head of the femur to the medial condyle (FHCM).

Distal femur,

- Medial condyle height: Maximal height of medial condyle (CMH).
- Lateral condyle height: Maximal height of lateral condyle (CLH).
- Inter-condyles height: Maximal height of between condyles (ICH).
- Distal circumference: Maximal circumference of distal part of the femur (DC).

Measurements were recorded on computer. Mean and standard deviation values were calculated. SPSS for Windows 10.00 were used for statistical analysis. For comparison according to lateralization student-t test and also Pearson correlation test were performed.

Figure 1: Anterior view of the left femur

Figure 2: Anterior view of the left femur (continued)

Figure 3: Anterior view of the left femur (continued)

Figure 4: Anterior view of the left femur (continued)

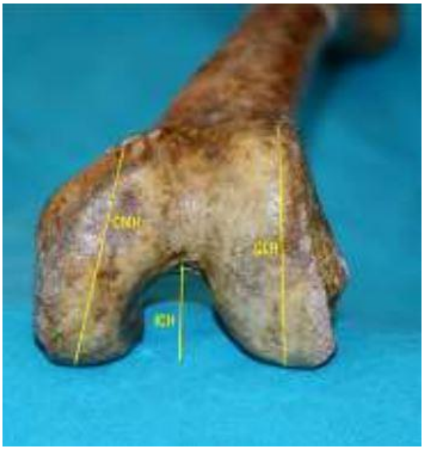

Figure 5: inferior view of the left femur (continued)

Figure 6: Anterior view of the left femur (continued)

2.RESULTS

In this study 37 right and 41 left, totally 78 femur bones have been evaluated morphometrically. The statistical comparison of the results obtained by measuring femur samples was shown in Table 1. Significant statistical differences were found between these measurements ($p<0.05$). Right and left side comparison values of femoral morphometrical measurements were shown in Table 2. All values except LTCL and FHCL were found to be higher in right femur.

Pearson correlation test was performed to test the significance of correlations and their relation with parameters. Correlation coefficients numbers between femoral measurements were shown in Table 3.

Table 1: Measurements of femur-parameters 78 bones (37 right, 41 left) (cm)

Parameter	N	Mean	SD	Minimum	Maximum
FHLT	78	12.80	3.68	12.00	13.68
GTLT	78	9.95	5.56	8.92	10.81
LTCM	78	32.54	3.95	30.86	33.70
LTCL	78	42.78	10.41	41.70	44.56
FHCL	78	48.39	8.86	46.10	55.28
FHCM	78	45.28	9.50	43.80	49.78
CMH	78	25.97	5.28	15.00	37.20
CLH	78	38.94	18.78	18.80	75.70
ICH	78	23.39	3.73	13.70	32.90
DC	78	184.10	6.24	80.00	300.00

Table 2: Comparison of measured parameters on femur according to lateralization (right-left) (mean, SD, n: 37 right, n: 41 left) (cm)

Parameter	N	Right Mean ± SD	Left Mean ± SD	*p*
FHLT	78	13.25 ± 2.28	12.61 ± 4.61	< *0.001*
GTLT	78	10.22 ± 5.38	9.52 ± 6.21	< *0.001*
LTCM	78	33.11 ± 4.15	32.92 ± 8.14	< *0.001*
LTCL	78	42.25 ± 9.01	43.52 ± 6.34	< *0.001*
FHCL	78	49.20 ± 12.05	53.41 ± 10.24	< *0.001*
FHCM	78	47.67 ± 5.52	45.41 ± 4.25	< *0.001*
CMH	78	26.42 ± 5.38	25.58 ± 5.23	< *0.001*
CLH	78	41.58 ± 20.17	36.63 ± 17.39	< *0.001*
ICH	78	23.78 ± 4.12	23.04 ± 3.38	< *0.001*
DC	78	197.10 ± 5.28	172.90 ± 6.82	< *0.001*

Table 3: Correlation efficients (r) between the femoral anthropometric measurements

Parameter	FHLT	GTLT	LTCM	LTCL	FHCL	FHCM	CMH	CLH	ICH	DC
FHLT										
GTLT	0.038									
LTCM	0.045	0.230*								
LTCL	0.609*	0.220	0.186							
FHCL	322	-0.880*	0.204	0.938						
FHCM	0.323*	-0.751*	0.312*	0.312	-855					
CMH	0.220	0.631*	0.428*	-0.444*	-0.191	0.390*				
CLH	0.072	0.349*	0.030	-0.356*	-0.524*	0.524*	0.516			
ICH	0.072	0.602*	0.202	-0.521*	-0.571	0.120	-0.315*	0.474		
DC	-0.050	0.868*	0.062	-0.870*	0.508	0.590*	0.512	0.312	0.424	

*P<0.05

3. DISCUSSION

Different disorders may have effects on femur and hip joint. Anthropometric measurements are valuable assets diagnosis purposes, and also for approaches to some disorders. Values that obtained by measuring bone parts and racial variations and are of immerse value to anatomists, anthropologists and forensic experts.

The study of Lingamdenne et al. (Lingamdenne & Marapaka, 2016) reports that the maximum length and trochanter length has significant correlation with the proximal breadth, and the mid shaft parameters. According to study of Vaghefi et al. (Hassan Eftekhar Vaghefi et al., 2015) the values were 44.99 cm and 40.81 cm in Iranian males and females respectively. And Ziylan et al. (Ziylan et al., 2002) showed the maximum length of femur as 42.8 cm on the left side and 41.6 cm on the right side in Turkish people. In Lingamdenne’s study, it has been found that the maximum length of the femur to be 43.02 cm similar to the values reported in other south Indian studies: 44.62 cm as showed by Khan et al, (Khan et al., 2014) and 43.74 cm as reported by Pillai et al (Pillai et al., 2014).

Some studies of proximal femur parameters which were conducted in Asian countries also as in Malay population (Baharuddin et al., 2013), Chinese population (Lin et al., 2014) and in Pakistani (Umer et al., 2010) population. Different studies like these also support the fact of regional difference in the parameters of proximal femur but the data obtained from Asian population is very close with the parameters obtained from Verma’s study. Some studies often reported measurements that are related to increased risk of fracture include a longer hip axis, length of femur, a larger neck shaft angle and a larger femoral neck width (Bhattacharya et al., 2015).

Head measurements of the bone are important in pathologies of hip joint. These treats help to make proper implants for hip replacement surgeries. Best implant is the one that serves the patient best which will prevent postoperative complications and last longer (Ravichandran et al., 2011).

Every year more than 80.000 hip joint replacement are being done in the world (Li et al., 2003). But there are differences in human anatomy in difference places, and these differences should be considered while designing prosthesis. Reddy et al. (Reddy et al., 1999) told that a wrong application between femoral bone and stem probably will result in micromotion which may lead to thigh pain, osteolysis and aseptic loosening. In any case that the implant is big for the femur it may cause fractures, also highly undersized implant may fail to bond with bone (Vaidya et al., 2000).

Mahaisavaria et al. (Mahaisavariya et al., 2002) used CT imaging technique and combined it with reverse engineering to collect data to analyze three dimensional inner and outer geometry of the proximal cadaveric femur (Mahaisavariya et al., 2002). On their study Deshmukh et al. covered the geometry of femur in the Vidarbha (central) region of India by using the mathematical approach (Deshmukh et al., 2010).

There was a good correlation between anthropometric measurements and mathematical models. Siwach RC and Dahia S. used the parameters of femur in Indian cadavers, and compared them with Chinese and Hong Kong population (Siwach, 2018). Ho Jung Cho et al. studied on anatomic differences of femur in Korean subjects from Americans and Japanese (Cho et al., 2015). He concluded that designing hip prosthesis for Asian population was necessary. In their study De Sousa E. et al. used Auto Cad 200 Software to evaluate variables of proximal femur in Brazilian Population then he compared the results with other study result from other regions (Branco de Sousa et al., 2010).

Rawal et al. suggested that dimensions of cementless femoral stem for Indian population (Rawal et al., 2012). There was a difference with the rate of 16.8 % in Femur Head Offset (FHO) between Indian and Swiss population. This may have affect on soft tissue and rage of motion.

Braun et al. (Braun et al., 2007) said that accurate total hip arthroplasty with the Metha shortstem prosthesis (Braun Aesculap; Tuttlingen, Germany) depends on the correct indication and an accurate preoperative measurement of the femoral bone shape, and intraoperatively, that the bone quality, osteotomy and implant position of are of the particular importance.

Navigation helps with the selection of modular neck adapters for optimal free range of motion. The selection of adapters changes depending on the usage of navigation in the surgery. Applying the correct position of the osteotomy is related to the surgeon's experience and judgment and also the local anatomical conditions. The osteotomy may be determined intra-operatively by the positioning of the rasp. Right positioning of the osteotomy and right dorsolateral contact of the short stem shows the optimal implant position. Implant depth must be adjusted by considering the lateral circumference of the femoral neck rather than in relation to the calcar osteotomy. The loss of lateral support on valgus positioning is not wanted. Navigation usage affects the neck position.

A reduction in the dimensions of the proximal and distal femur studied that could be considered a symptom of calcium metabolic disturbances, calcium deficiency and osteoporotic causes in older subjects is also caused by increasing age (Murshed et al., 2005). Existing wrong notch measurements in the literature can maybe be explained by a few factors, also with an analysis of different populations. Also differences in measurement techniques should have an effect in these wrong results. Another difficulty in the measurements is that parts of measurement on the distal femur were not flat, so this also affects measurement results (Murshed et al., 2005).

4. CONCLUSION

We covered the fracture and normal cases in individuals for morphometric evaluation of the proximal and distal femur. The comparison is difficult due to not many studies exist in the field which standardize parameters for these treats.

Parameters show significant differences between populations. There are also big differences between male and female individuals, which we also showed in this study. Another factor to affect the results is the state of the bone, whether it is from a dry sample or from a cadaver. MRI is the key on our future studies, which will make your data stronger than before. We believe the results we had in this study shall assist for surgical interventions on proximal and distal parts of femur and for arthroplasty applications, with its contribution to analysis of bone.

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