IJCMBS

THE INTERNATIONAL JOURNAL OF CURRENT MEDICAL AND BIOLOGICAL SCIENCES e-ISSN: 2791-8815

Orgınal Article

Determination of dry tibia bone morphometry by photo analysis

Kuru Tibia Kemiği Morfometrisinin Foto Analiz ile Belirlenmesi

Seyma TOY[1*], Yusuf SECGIN[1]

[1]Department of Anatomy, Faculty of Medicine, Karabük University, Karabük, TURKİYE

Corresponding author:
Seyma TOY
Adress:
Department of Anatomy, Faculty of Medicine, Karabük University, Karabük, Turkiye
E-mail: seymatoy@karabuk.edu.tr
Received: 21.09.2022
Accepted: 13.10.2022
Cite as: TOY.S , SECGİN. Y Determination of dry tibia bone morphometry by photo analysis IJCMBS 2022;2(3):165-170 doi.org/ 10.5281/zenodo.7195675

Abstract

Background: This study was carried out to determine the morphometry of the dry tibia bones of the Turkish population using the photo analysis method.
Materials and Methods: 33 dry tibia bones were included in the study. The bones obtained were photographed with a professional camera. The photos were transferred to image processing program Image J (Version 1.53e) in jpeg format. From the images transferred, the parameters of articular surface width of medial condyle (MC-ASW), articular surface height of medial condyle (MC-ASH), articular surface width of lateral condyle (LC-ASW), articular surface height of lateral condyle (LC-ASH), distance between medial and lateral intercondylar tubercle (LMIT-D), medium width of body of tibia (BT-MW), length of total tibia (TT-L), height of medial malleolus (MM-H), angle of medial condyle- tibial tuberosity-lateral condyle (MCTTLG-A), angle of fibular notch - tibial tuberosity- medial malleolus (FNTTMM-A), height of inferior articular facet (IAS-H), width of inferior articular facet (IAS-W), distance between nutrient foramen- interosseous border (NFIB-D) were measured. **Results:** Morphometric analysis results were: MC-ASW 6.558±0.896 cm, MC-ASH 9.502±1.364 cm, LC-ASW 6.035±0.988 cm, LC-ASH 8.655±1.673 cm, LMIT-D 3.169±0.632 cm, BT-MW 2.382±0.312 cm, TT-L 36.784±2.734 cm, MM-H 1.296±0.209 cm, MCTTLG-A 97.14±11.63°, FNTTMM-A 7.313±0.514°, IAS-H 6.219±0.776 cm, IAS-W 6.540±1.011 cm, NFIB-D 0.958±0.326 cm. A statistically significant correlation was found between MC-ASW and MC-ASH, LC-ASW, LC-ASH parameters, between MC-ASH and LC-ASH, TT-L parameters, and between BT-MW and TT-L parameters ($p \leq 0.05$). **Conclusion:** As a result of our study, the morphometry of the parameters of the dry tibia bone in the Turkish population and the relationships between these parameters were revealed.
Keywords: Dry tibia bone, Morphometry, Photo analysis

ÖZ

Amaç: Bu çalışma, Türk popülasyonuna ait kuru tibia kemiklerinin foto analiz metodu kullanılarak morfometrilerinin belirlenmesi amacıyla yapıldı.
Materyal ve metod : Çalışmaya 33 adet kuru tibia kemiği dahil edildi. Elde edilen kemikler profesyonel fotoğraf makinesi ile fotoğraflandı. Fotoğraflarda jpeg formatında görüntü işleme programı olan Image J (Version 1.53e)'ye aktarıldı. Aktarılan görüntülerden her bir kuru tibia kemiğinin condylus medialis eklem yüzü genişliği (MC-ASW), condylus medialis eklem yüzü yüksekliği (MC-ASH), condylus lateralis eklem yüzü genişliği (LC-ASW), condylus lateralis eklem yüzü yüksekliği (LC-ASH), tuberculum intercondylare mediale – laterale arası uzaklık (LMIT-D), corpus tibia orta genişliği (BT-MW), tibia'nın total uzunluğu (TT-L), malleolus medialis yüksekliği (MM-H), condylus medialis – tuberositas tibiae – condylus lateralis açısı (MCTTLG-A), incisura fibularis – tuberositas tibiae – malleolus medialis açısı (FNTTMM-A), facies articularis inferior yüksekliği (IAS-H), facies articularis inferior genişliği (IAS-W), foramen nutricium – margo interosseus arası uzaklık (NFIB-D) parametrelerinin ölçümü yapıldı.
Bulgular: Morfometrik analiz ile MC-ASW 6.558±0.896 cm, MC-ASH 9.502±1.364 cm, LC-ASW 6.035±0.988 cm, LC-ASH 8.655±1.673 cm, LMIT-D 3.169±0.632 cm, BT-MW 2.382±0.312 cm, TT-L 36.784±2.734 cm, MM-H 1.296±0.209 cm, MCTTLG-A 97.14±11.63°, FNTTMM-A 7.313±0.514°, IAS-H 6.219±0.776 cm, IAS-W 6.540±1.011 cm, NFIB-D 0.958±0.326 cm olarak bulundu. MC-ASW ile MC-ASH, LC-ASW, LC-ASH parametreleri arasında, MC-ASH ile LC-ASH, TT-L parametreleri arasında, BT-MW ile TT-L parametresi arasında istatistiksel olarak yüksek anlamlı bir ilişki bulundu ($p \leq 0.05$).
Sonuç: Çalışmamız sonucunda kuru tibia kemiğine ait parametrelerinin Türk popülasyonuna ait morfometrisi ve bu parametrelerin aralarındaki ilişkiler ortaya konuldu.
Anahtar Kelimeler: Kuru tibia kemiği, Morfometri, Foto Analiz

Highlights

- Knowing the tibia morphometry of the Turkish population will make important contributions to medical science.
- Knowing the tibia morphometry will guide surgical interventions.

Introduction

Morphometry is a method that enables to show the distances between determined anatomical points and evaluates the relationship between these distances according to age, race and gender (1). Morphometry of the bones of the lower extremity is of greater importance than those of the upper extremity because the bones of the lower extremity take on the task of carrying the weight of the body and moving (2).

The exact determination of bone morphometry is critical in forensic identification, anthropology, anatomy and surgical sciences (1, 3). For example, for orthopaedists, the adaptation of proximal tibia end prosthesis to the bone tissue and thus a successful operation process is possible only when the bone morphometry is fully known (4). Lack of information in tibial morphometry may result in adverse scenarios such as incorrect positioning of the prosthesis, incompatibility and limitation of mobility (5, 6). In forensic medicine and anthropology, knowledge of bone morphometry is critical in cases with disintegrated body from which DNA and fingerprints cannot be obtained. Knowing about bone morphometry provides us important information about biological factors such as gender, age and race (7-9). At this point, tibial morphometry offers an accuracy of higher than 84% in terms of gender (7).

To the best of our knowledge, there is limited information in Middle East countries on tibial morphometry, especially on proximal end morphometry. On the contrary, there is more information in Asian-Pacific countries. Knowing about the tibia morphometry of individuals in Middle Eastern countries will greatly facilitate the selection of suitable prostheses (5). Bone morphometry can be revealed by dry bone or radiological imaging methods such as computed tomography, magnetic resonance imaging, peripheral quantitative computed tomography (1, 7, 8, 10, 11).

This study was conducted to find out dry tibia bone morphometry by using Image J measurement tool and to increase clinicians' level of knowledge on tibia morphometry.

Material and Method

Study Sample

The study was initiated with 2021/729 numbered approval of Karabük University Non-interventional Ethics Committee. 33 tibias of unknown gender taken from bone collections of anatomy laboratories in medical faculties at Karabük University, Bolu Abant İzzet Baysal University and Düzce University were used. Fractured bones, pathological bones and bones which were thought to belong to the pediatric group were excluded from the study. The bone side difference was ignored due to the insufficient number of bones in the bone collections.

Image protocol

Dry tibia bones in the collections were fixed at a height of 40 cm from the ground with a stabilizer. The Professional camera used during the shooting was fixed at a height of 60 cm from the ground with another stabilizer so that it would be stable during each shooting. These images in Jpeg format were transferred to Image J (Version 1.53e) image processing program and length and angle measurements were performed **(Figure1)**.

Determined length and angle measurements were;

- a) Medial condyle articular surface height (MC-ASH),
- b) Medial condyle articular surface width (MC-ASW),
- c) Lateral condyle articular surface height (LC-ASH),
- d) Lateral condyle articular surface width (LC-ASW),
- e) Distance between lateral-medial intercondylar tubercle (LMIT-D),
- f) Total length of the tibia (TT-L),
- g) Medium width of tibia body (BT-MW),
- h) Medial malleolus height (MM-H),
- k) Medial condyle – Tuberosity of tibiae – Lateral condyle angle (MCT-TLG-A),
- l) Fibular notch – Tuberosity of tibiae – Medial malleolus angle (FNT-TMM-A),
- m) Nutrient foramen – Interosseous border distance (NFIB-D).
- n) Inferior articular surface height (IAS-H),
- o) Inferior articular surface width (IAS-W),

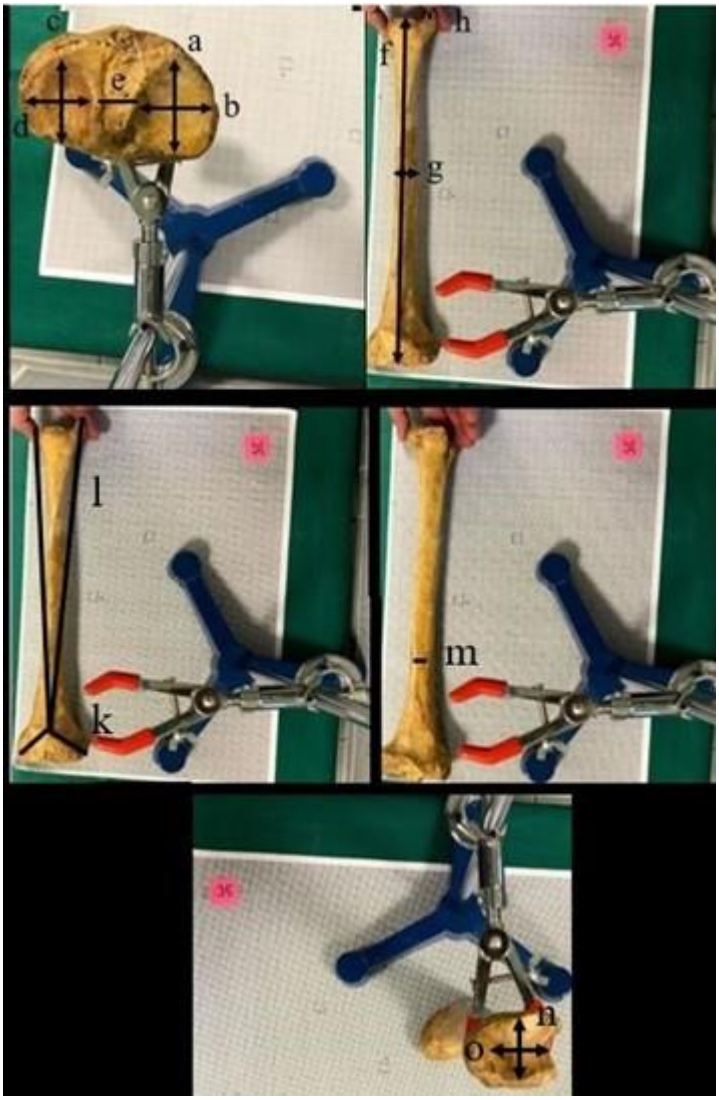

Figure 1. **Demonstration of parameters** (**a:** Medial condyle articular surface height (MC-ASH), **b**: Medial condyle articular surface width (MC-ASW), **c:** Lateral condyle articular surface height (LC-ASH), **d:** Lateral condyle articular surface width (LC-ASW), **e:** Distance between lateral-medial intercondylar tubercle (LMIT-D), **f**: Total length of the tibia (TT-L), **g:** Medium width of tibia body (BT-MW), **h**: Medial malleolus height (MM-H), **k**: Medial condyle – Tuberosity of tibiae – Lateral condyle angle (MCTTLG-A), **l**: Fibular notch – Tuberosity of tibiae – Medial malleolus angle (FNTTMM-A), **m**: Nutrient foramen – Interosseous border distance (NFIB-D), **n**: Inferior articular surface height (IAS-H), **o**: Inferior articular surface width (IAS-W)).

Statistical Analysis

Mean and standard deviation values were included in descriptive statistics. The Normality distribution of the parameters was tested with the Shapiro-Wilk test. Correlation between parameters and the degree of the correlation was tested with the Pearson Correlation test and $p \leq 0.05$ value was considered as statistically significant.

Results

Mean and standard deviation values of the parameters of 33 tibia were evaluated by using Image j are shown in **Table 1.**

Table 1. **Mean and standard deviations of parameters taken from Tibia**

Parameters	Mean	Standard Deviations
MC-ASW (cm)	3.018	0.494
MC-ASH (cm)	4.751	0.682
LC-ASW (cm)	3.279	0.448
LC-ASH (cm)	4.328	0.837

LMIT-D (cm)	1.584	0.316
BT-MW (cm)	2.383	0.312
TT-L (cm)	36.784	2.734
MM-H (cm)	1.296	0.209
MCTTLG-A (°)	97.14	11.63
FNTTMM-A (°)	7.313	0.514
IAS-H (cm)	6.219	0.776
IAS-W (cm)	6.540	1.011
NFIB-D (cm)	0.958	0.326

The correlation between parameters and the degree of correlation was tested with Pearson Correlation test and high significant correlation was found between the 6 parameters. High significant correlation was found between LC-ASW parameter and MC-ASW and MC-ASH parameters, between LC-ASH parameter and MC-ASH and LC-ASW parameters, between TT-L parameter and MC-ASH and BT-MW parameters ($p \leq 0.05$), (**Table 2).** These findings show that there is a high degree of relationship between condyle articular surfaces.

Table 2. **Pearson correlation table**

Parameters	**r/p**	**MC-ASW**	**MC-ASH**	**LC-ASW**	**LC-ASH**	**LMIT-D**	**BT-MW**	**TT-L**	**MM-H**	**MCTTLG-A**	**FNTTMM-A**	**IAS-H**	**IAS-W**
MCASH	r	0.548[c]	1.00										
	p	**0.001**	-										
LCASW	r	0.673[d]	0.642[d]	1.00									
	p	**0.000**	**0.000**	-									
LC-ASH	r	0.464[c]	0.639[d]	0.665[d]	1.00								
	p	**0.007**	**0.000**	**0.000**	-								
LMIT-D	r	0.218	0.354[b]	0.360[b]	0.243	1.00							
	p	0.223	**0.043**	**0.040**	0.173	-							
BT-MW	r	0.524[c]	0.436[c]	0.505[c]	0.382[b]	0.245	1.00						
	p	**0.002**	**0.011**	**0.003**	**0.028**	0.169	-						
TT-L	r	0.538[c]	0.618[d]	0.577[c]	0.453[c]	0.497[c]	0.669[d]	1.00					
	p	**0.001**	**0.000**	**0.000**	**0.008**	**0.003**	**0.000**	-					
MM-H	r	-0.153	0.093	0.110	0.251	-0.284	0.193	0.127	1.00				
	p	0.393	0.606	0.540	0.159	0.109	0.282	0.480	-				
MCTTLG-A	r	0.276	0.105	0.167	-0.251	-0.065	-0.039	-0.126	-0.147	1.00			
	p	0.120	0.560	0.354	0.158	0.719	0.831	0.484	0.414	-			

FNTTMM-AA	r	0.466[c]	0.402[c]	0.243	0.286	-0.079	0.257	0.194	-0.036	0.375[b]	1.00		
	p	**0.006**	**0.020**	0.173	0.107	0.663	0.149	0.279	0.843	**0.031**	-		
IAS-H	r	0.354[b]	0.514[c]	0.551[c]	0.585[c]	0.102	0.300	0.426[c]	0.380[b]	0.113	0.216	1.00	
	p	**0.043**	**0.002**	**0.001**	**0.000**	0.574	0.090	**0.013**	**0.029**	0.531	0.227	-	
IAS-W G	r	0.446 [c]	0.574[c]	0.414[c]	0.495[c]	0.165	0.281	0.399[b]	0.364[b]	-0.133	-0.028	0.594[c]	1.00
	p	**0.009**	**0.000**	**0.017**	**0.003**	0.358	0.113	**0.021**	**0.038**	0.462	0.876	**0.000**	-
NFIB-D	r	-0.077	-0.098	-0.237	-0.070	0.039	0.013	-0.022	-0.263	-0.159	-0.084	-0.450[c]	-0.182
	p	0.671	0.586	0.185	0.697	0.831	0.945	0.904	0.140	0.376	0.641	**0.009**	0.311

Aberrations: [a] very weak correlation, [b] weak correlation, [c] moderate correlation, [d] high correlation, (MC-ASH: Medial condyle articular surface height, MC-ASW: Medial condyle width, LC-ASH: Lateral condyle height, LC-ASW: Lateral condyle width, LMIT-D: Distance between lateral-medial intercondylar tubercle, TT-L: Total length of the tibia, BT-MW: Medium width of tibia body, MM-H: Medial malleolus height, MCTTLG-A: Medial condyle – Tuberosity of tibiae – Lateral condyle angle, FNTTMM-A: Fibular notch – Tuberosity of tibiae – Medial malleolus angle, NFIB-D: Nutrient foramen – Interosseous border distance, IAS-H: Inferior articular surface height, IAS-W: Inferior articular surface width)

Discussion

This study was conducted to determine the morphometry of dry tibia bone determined with photo analysis and to find out the correlation between parameters. The results found were MC-ASW 3.018±0.494 cm, MC-ASH 4.751±0.682 cm, LC-ASW 3.279±0.448 cm, LC-ASH 4.328±0.837 cm, LMIT-D 1.584±0.316 cm, BT-MW 2.382±0.312 cm, TT-L 36.784±2.374 cm, MM-H 1.296±0.209 cm, MCTTLG-A 97.14±11.63°, FNTTMM-A 7.313±0.514°, IAS-H 6.219±0.776 cm, IAS-W 6.540±1.011 cm, NFIB-D 0.958±0.326 cm. The correlation between parameters and the degree of correlation was tested with the Pearson Correlation test and high significant correlation was found between LC-ASW parameter and MC-ASW and MC-ASH parameters, between LC-ASH parameter and MC-ASH and LC-ASW parameters, between TT-L parameter and MC-ASH and BT-MW parameters ($p \leq 0.05$).

Knowing the exact tibial morphometry is critical for surgical interventions to this area and to find out pathologies. Knowing the morphometric information of this area will increase success in total knee prosthesis surgery, osteoarthritis treatment and anterior cruciate ligament ruptures. These morphometric data should be determined exactly since they will differ between races (4, 12-14). In total knee arthroplasty, morphometry of the proximal end of the tibia and morphometric relationships are of great importance (4, 15). In our study, it was determined that there was a high and positive correlation between the parameters of the proximal end of the tibia and the correlation result.

In their study they conducted on 60 dry tibia bones of Indian individuals, Ahmad et al. found the following results: LC-ASH 36.41±4.29 mm, MC-ASH 40.19±5.11 mm, LC-ASW 27.90±3.72 mm, MC-ASW 28.38±3.33 mm (16). In a study they conducted on 100 dry tibia bones of Korean individuals, Surendran et al. found LC-ASH as 42.2±3.7 and MC-ASH as 45.9±4.2 (4). In a study they conducted on 100 dry tibia bones of Indian individuals, Gandhi et al. found MC-ASH on the right side as 42.39±4.19 in women and as 48.45±4.14 in men, on the left side as 42.36±4.65 in women and as 47.73±4.37 in men; they found MC-ASW on the right side as 27.25±3.05 in women and as 30.18±2.83 in men, on the left side as 26.96±2.18 in women and as 29.38±3.14 in men; they found LC-ASH on the right side as 36.78±3.03 in women and as 40.86±3.79 in men, on the left side as 37.30±3.81 in women and as 40.69±4.13 in men; they found LC-ASW as 26.14±2.51 in women on the right side and as 28.82±3.12 on the left side in women and as 28.82±3.12 mm in men (2). In their study they conducted on 172 dry tibia bones of Chinese individuals, Cheng et al. found LC-ASH as 45.3±2.5 and MC-ASH as 50.7±2.4 mm (17). In their study they conducted on 120 dry tibia bones of Brazilian individuals, Santos et al. found LMIT-D as 1.054±0.262 in women and as 1.167±0.279 in men; they found MC-ASH as 4.334±0.317 in women and as 4.707±0.406 in men; they found LC-ASH as 3.549±0.382 in women and as 4.023±0.414 in men; they found MC-ASW as 2.702±0.298 in women and as 3.024±0.307 in men; they found LC-ASW as 2.991±0.281 in women

and as 3.405±0.323 cm in men (18). In a study conducted by Gardasevic on 664 individuals in the western part of Kosovo, TT-L was found as 37.60±2.52 (19). In the present study we conducted on dry tibia bones of 33 Turkish individuals, the results we found were: MC-ASW 3.018±0.494 cm, MC-ASH 4.751±0.682 cm, LC-ASW 3.279±0.448 cm, LC-ASH 4.328±0.837, TT-L 36.784±2.374 cm. Literature results support our results and shows that there is slight difference between populations. We believe that this difference is critical for surgical sciences.

Conclusion

As a result of our study, the range of values of tibial morphometry was determined in Turkish population. We believe that this range of values will guide both anthropological studies and specialist physicians who perform surgery in this region.

Acknowledgements: None

Ethical Approval: *The study was initiated with 2021/729 numbered approval of Karabük University Non-interventional Ethics Committee*

Author Contributions: *Concept: S.T., Y.S. Literature Review: Y.S. Design: S.T. Writing manuscript: S.T., Y.S. Critical revision of manuscript: S.T., Y.S.*

Conflict of Interest: *The authors have no conflicts of interest to declare.*

Financial Disclosure: *Authors declared no financial support.*

References

1. Lucena dos Santos ERS, Albuquerque PPFd, Albuquerque PVd, et al. Determination of sex based on the morphometric evaluation of the proximal tibia. International Journal of Morphology. 2018;36(1):104-8.
2. Gandhi S, Singla RK, Kullar JS, et al. Morphometric analysis of upper end of tibia. Journal of clinical and diagnostic research: Journal of Clinical and Diagnostic Research. 2014;8(8):AC10.
3. Taşer F, Toker S, Kılınçoğlu V. Evaluation of morphometric characteristics of the fibular incisura on dry bones. Joint Diseases and Related Surgery. 2009;20(1):52-58
4. Surendran S, Pengatteeri YH, Park SE, et al. Morphometry of the proximal tibia to design the tibial component of total knee arthroplasty for the Korean population. The Knee. 2007;14(4):295-300.
5. .Moghtadaei M, Moghimi J, Farahini H, et al. Morphology of proximal tibia in Iranian population and its correlation with available prostheses. Medical journal of the Islamic Republic of Iran. 2015;29:225.
6. Kucukdurmaz F, Tuncay I, Elmadag M, et al. Morphometry of the medial tibial plateau in Turkish knees: correlation to the current tibial components of unicompartmental knee arthroplasty. Acta Orthopaedica et Traumatologica Turcica. 2014;48(2):147-51.
7. Ekizoglu O, Er A, Bozdag M, et al. Sex estimation of the tibia in modern Turkish: A computed tomography study. Legal Medicine (Tokyo). 2016;23:89-94.
8. Secgin Y, Oner Z, Turan MK, et al. Gender prediction with parameters obtained from pelvis computed tomography images and decision tree algorithm. Medicine. 2021;10(2):356-61.
9. Secgin Y, Oner Z, Turan MK, Oner S. Gender prediction with the parameters obtained from pelvis computed tomography images and machine learning algorithms. Journal of the Anatomical Society of India. 2022;71(3):204.
10. Okazaki N, Chiba K, Burghardt AJ, et al. Differences in bone mineral density and morphometry measurements by fixed versus relative offset methods in high-resolution peripheral quantitative computed tomography. Bone. 2021;149:115973.
11. Toy S, Secgin Y, Oner Z, et al. A study on sex estimation by using machine learning algorithms with parameters obtained from computerized tomography images of the cranium. Scientific Reports. 2022;12(1):1-11.
12. .Shimizu M, Tsuji H, Matsui H, et al. Morphometric analysis of subchondral bone of the tibial condyle in osteoarthrosis. Clinical orthopaedics and related research. 1993(293):229-39.
13. Vasta S, Andrade R, Pereira R, et al. Bone morphology and morphometry of the lateral femoral condyle is a risk factor for ACL injury. Knee Surgery, Sports Traumatology, Arthroscopy. 2018;26(9):2817-25.
14. Babacan S, Kafa İM. Morphometric Analysis of Tibial Plateau for Knee Arthroplasty and Prosthesis Design: Morphometric Analysis of Tibial Plateau. International Journal of Current Medical and Biological Sciences. 2022;2(1):57-63.
15. Küçükdurmaz F, Tuncay I, Elmadag M, et al. Morphometry of the medial tibial plateau in Turkish knees: correlation to the current tibial components of unicompartmental knee arthroplasty. Acta orthopaedica et traumatologica turcica. 2014;48(2):147-51.
16. Ahmad N, Singh D, Dubey A, et al. Morphometric analysis of proximal end of the tibia. National Journal of Clinical Anatomy. 2019;8(2):82.
17. Cheng FB, Ji XF, Lai Y, et al. Three dimensional morphometry of the knee to design the total knee arthroplasty for Chinese population. The Knee. 2009;16(5):341-7.
18. Lucena-dos-Santos ERS, Albuquerque PPFd, Albuquerque PVd, et al. Determination of sex based on the morphometric evaluation of the proximal tibia. International Journal of Morphology. 2018;36(1):104-8.
19. Gardasevic J. Standing Height and its Estimation Utilizing Tibia Length Measurements in Adolescents from Western Region in Kosovo. International Journal of Morphology. 2019;37(1).