European Journal of Therapeutics https://doi.org/10.58600/eurjther.20232902-336.y

Original Research

Evaluation of Errors Encountered in Photogrammetric Studies on Lower Extremities

Gkionoul Nteli Chatzioglou[1], Kader Yilar[2], Figen Gövsa[3], Yelda Pinar[3], Özcan Gayretli[2]

[1] Department of Anatomy, Istanbul Health and Technology University, Faculty of Medicine, Turkey

[2] Department of Anatomy, Istanbul University, Faculty of Medicine, Turkey

[3] Department of Anatomy, Ege University, Faculty of Medicine, Turkey

ABSTRACT

Objective: The aim of our study is to reveal the errors that can be encountered during the shooting of photogrammetric studies on the lower extremities.

Methods: We revealed the necessary tools that used during photogrammetry measurements of the lower limb. Also, the errors have been encountered of our two previous studies performed on photogrammetry of lower limbs. The technical errors or incorrect positioning of 20 from 220 volunteers were encountered.

Results: The identified errors of 20 volunteers' photographs related to lower limb were about the inadequate quality image, calibration, poor lightining, positioning error of trunk or parts of lower limb and clothes that cover the anatomical points affected the measurements.

Conclusion: Photogrammetry is an important and useful tool for evaluation, diagnosis, treatment, and efficacy monitoring. In anatomy, it is frequently used as a time-saving method in terms of measurement and evaluation in the laboratory, which can be applied and repeated for research. For this reason, errors that occur during the lower extremity have been reported and we think that it will be useful for studies on this part of the body and can be a guide.

Keywords: photogrammetry, lower extremity, lower limb, tools of photogrammetry, errors of photogrammetry

INTRODUCTION

The word "photogrammetry" comes from the Greek words " φως» meaning «light» and «γραμμετρια" meaning "something written or drawn" [1]. It was first used by British scientist Sir John Herschel in 1839 (Figure 1) [2]. The research in this area, which began in the early 19th century, has found that photography can express a great deal more detail than other disciplines like painting and sculpting. The first known photograph that left a permanent mark was produced by Nicéphore Niepce in 1822. "View from the Window at Le Gras," which he photographed in 1826, was the first ever permanent nature image. However, since these shootings can be done in about 8 hours, he tried to find new systems in this field with Louis Daguerre [3]. Daguerre, on the other hand, discovered the method of obtaining images by exposing silver plates known as daguerotype to mercury vapor for a period of 10-20 minutes [4]. Contrarily, a sight captured using this method in 1838, when a man had his shoes painted on the streets of Paris, is considered to be the first human picture in history. During the 19th century, there were many developments such as the transition from silver and copper plates to glass plates. By 1884, George Eastman invented film instead of photographic plates [5]. Photogrammetric measurement, on the other hand, is a method of obtaining reliable information about physical objects and the environment in the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant images and other phenomena [6]. This method is used with high accuracy to detect, measure and interpret the properties of living or non-living things. The primary benefit of photogrammetry is that measurements are obtained from photographic representations rather than directly on objects [7]. Making measurements repeatedly became convenient as a result of this. This approach first appeared about the same time as the photograph. With the advancements, it has also been extensively employed in the field of medical, in addition to areas like maps and architecture [8]. In 1863, American physician Holmes used it for the first time in medicine [9, 10]. This made it possible for him to create prosthetic limbs for Civil War troops who had lost their arms or legs [9,10]. Its use has expanded as development

How to cite: Nteli Chatzioglou G, Yilar K, Gövsa F, Pinar Y, Gayretli Ö (2023) Evaluation of Errors Encountered in Photogrammetric Studies on Lower Extremities. Eur J Ther. 29(2):155-162. https://doi.org/10.58600/eurjther.20232902-336.y

Corresponding Author: Gkionoul Nteli Chatzioglou **E-mail:** gkionoul.chatzooglou@istun.edu.tr; gonul.anatomy@gmail.com

Received: 24.03.2023 • **Accepted:** 05.04.2023 • **Published Online:** 05.04.2023

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

pISSN: 2564-7784
eISSN: 2564-7040

has progressed. Yet, despite declines throughout the world wars, it spread and the region of its utilization continuously grew. As a reproducible replication technique for planning and observing therapeutic treatment for bodily structures, photogrammetry has grown in significance in medicine [11].

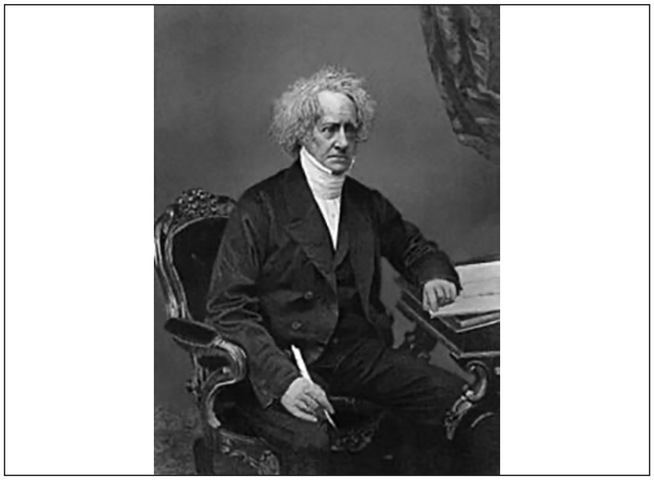

Figure 1. British scientist Sir John Herschel (1839) who was first used the photogrammetry.

Photography in medicine was first used by the French physician Alfred François Donnê. Donnê, who was also the inventor of photomicrography, used the materials he revealed using the "daguerrotype" method in his lectures, and collected what he took under the microscope in his book titled "Cours de Microscopie, Complementaire des Études Médicales: Anatomie Microscopique et Physiologie des Fluides de L'Economie" [12,13]. The first daguerrotype taken in the field of dermatology was a photograph of skin disease in 1848, and the photographs taken before and after surgery in the field of orthopedics in 1852 [12]. Taking photos from inside the body was not realized until 1883 due to the light problem [12].

For the design and evaluation of therapeutic treatment and its outcomes, photogrammetry has grown in popularity in medicine [14]. It is a technique for reproducing bodily structures in a reproducible manner. As photogrammetry is non-invasive and precise technique that uses photographs to measure and analyze the shape, size, and position of objects. In medicine, photogrammetry has a wide range of applications, where the most common used now is in orthopedics. They provide rapid measurements of the whole body or specific body parts, such as in screening exams for spinal curvatures, determining the craniofacial anthropometric features or lower limb [15-19].

Main Points:

- The importance of correct use of the necessary tools that used during photogrammetry measurements (camera, tripod, light source, White background, calibration object, markers, foot support, software and computer)
- Correct positioning of the volunteer before shooting and planning the preparations correctly.
- Removing clothes or accessories from the area(s) where the photo will be taken and ensuring the hygiene of the area.

METHODS

During our studies of the "Variable Lower Limb Alignment of Clinical Measures With Digital Photographs" [18] and "Physical attractiveness: analysis of buttocks patterns for planning body contouring treatment" [19], the detection of difficulties and errors we encountered in photogrammetry was examined. Although a total of 220 adult volunteers (115 male, 105 female) between the ages of 19-21 participated in the study, 200 of them have been included in the study. Twenty volunteers' photos were excluded from the study due to low resolution, incorrect extremity position, etc. The reasons for 20 individuals who were not included in the study were explained in the result section. None of the participants had a history of surgery or reported trauma, lower extremity fractures, or pain in the lumbar spine and lower extremity until at least 3 months prior to measurement. The studies were ethically approved by Ege University Faculty of Medicine and complies with the Declaration of Helsinki.

Research Plan and Procedure of Photogrammetry

Five characteristics the thigh, knee, leg, ankle and foot of lower limb were assessed in this study. Utilizing a variety of measurement techniques, including the Image J tool to measure digital photos. A standard posture was used to acquire weight-bearing, full-length, antero-posterior, and lateral digital photos of the lower limb. Participants were asked to stand in a neutral position, which is described as having the feet shoulder-width apart, the toes looking forward, and the upper extremities crossed over the chest, in order to assess the static lower limb alignment factors. The anatomical body landmarks indicating the center (kneecap, tibial tuberosity, the knee joint center, lateral femoral condyle, ankle joint, and lateral malleolus) were marked on the skin with nontoxic color pencils. Each participant was assigned a number before the picture shoot, and the photographs that matched that number were subsequently uploaded to a digital folder. Care was also taken to ensure that the picture session was done in metric (Figure 2).

Figure 2. The standart positions of the lower limb during photo shoot from anterior, posterior and lateral views.

As the feet were more swollen towards the end of the day, we performed the photo taking both feet accurately in the morning/afternoon. The procedure of picture shoot of the foot was done with a glass-supported setup. Obtained digital pictures were imported into Image J software (http://rsbweb.nih.gov/ij) in order to calculate the determined parameters (Figure 3).

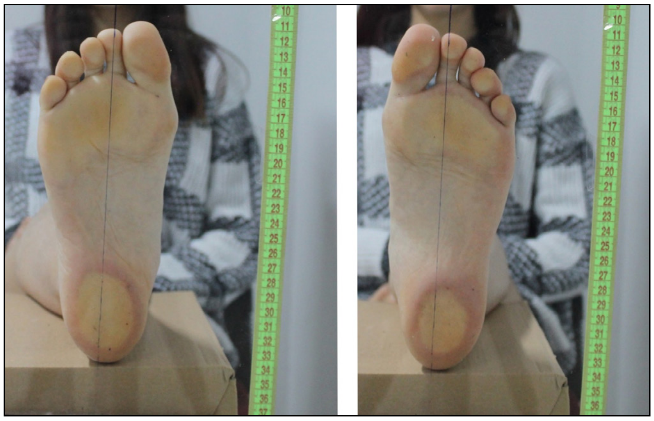

Figure 3. The standart position of the plantar surface of foot

The necessary tools that used during photogrammetry measurements of the lower limb were as follows:

a) Camera: A digital camera with high resolution and good image quality was essential for capturing detailed images of the foot.
b) Tripod: A tripod was necessary to keep the camera steady and ensure that the images were in focus.
c) Light source: A consistent and even light source was important for capturing clear and accurate images. A softbox or diffused light source was used to reduce shadows and glare.
d) White background: A plain white background was used to provide contrast and enhance the visibility of the markers on the images.
e) Calibration object: A calibration object (the green metric) was used to establish the scale of the images and ensure accurate measurements. It was a green plastic meter stick or a custom-made object of known size.
f) Markers: Markers were used to identify specific anatomical landmarks on the foot, which were necessary for accurate measurements. The skin was marked with nontoxic color pencils.
g) Foot support: A foot support was used to position the foot in a standardized position for imaging. It was a custom-made support or a commercially available one.
h) Software: Photogrammetry software was necessary to process the images and obtain accurate measurements. Some popular photogrammetry software options included Agisoft Metashape, Pix4D, and RealityCapture.
i) Computer: A powerful computer with sufficient storage and processing power was necessary to handle the large image datasets and process the images using photogrammetry software. Overall, photogrammetry of the lower limb, especially the foot, requires specialized equipment and software to ensure accurate measurements and reliable results.

RESULTS

It was observed that 20 of the 220 volunteers who were photographed had errors in their images. The technical errors or incorrect positioning were encountered in our study (Figure 1 and Figure 2).

Errors identified in a photogrammetric study of lower limb:

a) clothing and underwear covering the anatomical points made it impossible to make the planned measurements (Figure 4).
b) incorrect rotational trunk (Figure 5) or lower extremity (Figure 6) position: It was important that the planned parameters were realized in a static upright posture. Therefore, rotations of different parts of the body were not preferred during shooting.
c) inadequate technical error-picture quality (Figure 7): Poor image quality not only made the analysis with the photogrammetric method difficult, but also led to inaccuracies in measurement.

Errors identified in a photogrammetric study of the foot and the plantar surface:

a) it was observed that the possible reflection of the sole of the foot, which occurred due to the glass apparatus used during the photo shoot, affected the measurements (Figure 8). In addition, it was another mistake that the clarity of the metric (green meter) placed on the glass was insufficient for measurement. It was also necessary to prevent reflections that might be caused by the glass material used during photo shoots. For this, it was necessary to control the light and camera before shooting.
b) removal of digitus secundus from the midline (Figure 9): The parameters planned to be measured should be done with the foot in a standard position.
c) insufficient hygiene of the plantar surface (Figure 10): The parameters that were planned to be measured must be clear and understandable. In this case, care should be taken to ensure that the plantar surface of the foot was hygienic.
d) clothes (thin socks) that cover the anatomical points affected the measurements (Figure 11): Clothing that covers the landmarks determined during the measurement should be avoided.

Figure 4. Clothes and underwear that cover the anatomical points of the lower limb.

Figure 5. Incorrect position of trunk.

Figure 7. Inadequate picture quality durig the photo shoot of lower limb resulting in poor image.

Figure 6. Incorrect position of the lower limb.

Figure 8. Inadequate picture quality durig the photo shoot of the foot resulting in poor image.

Figure 9. Incorrect position of the plantar surface of the foot where the digitus secundus has been removal from the midline.

Figure 10. Insufficient hygiene of the plantar surface.

Figure 11. Undesired clothes such as socks that cover the anatomical points of the lower limb.

DISCUSSION

Photogrammetry is a technique that involves taking measurements and making three-dimensional models of objects or scenes from photographs [20]. It has a wide range of applications, including in the field of medicine, where it is used for measurements of lower limb and foot. One of the most common uses of photogrammetry in lower limb and foot measurements is for orthopedic purposes [21]. By taking precise measurements of the foot and lower limb, orthopedic specialists can identify any anomalies or abnormalities, such as flat feet or misaligned joints [18, 22]. These measurements can then be used to create customized orthotics or other devices to help correct these issues. Another use of photogrammetry in lower limb and foot measurements is in the field of biomechanics [23]. Biomechanists use photogrammetry to study the movement and mechanics of the lower limbs and feet during various activities, such as walking, running, and jumping [24]. By analyzing these movements, areas of potential injury or strain can be identified and develop strategies to prevent or reduce these issues. Therefore, photogrammetry is a valuable tool in the field of lower limb and foot measurements, allowing for precise and accurate measurements that can aid in diagnosis, treatment, and prevention of various foot and lower limb issues [25].

Photogrammetry can also be used to design custom orthotics, which are shoe inserts that are used to correct foot posture and improve foot function. By taking photographs of the foot in different positions, photogrammetry can be used to create a 3D model of the foot that can be used to design custom orthotics. So, the photogrammetry is a useful tool in the assessment and treatment of foot-related conditions, as well as in the design of custom orthotics and footwear [26].

In studies to be carried out with the photogrammetric method, the marked anatomical points and the photographs taken should be clear. Especially during the measuring of determined parameters with the Image J software is crucial. The software which has been used in this study is a free, open-source image analysis software developed by the National Institutes of Health (NIH). It is widely used in scientific research, particularly in the fields of biology and biomedical research [27]. It allows users to analyze digital images and videos by performing measurements, processing, and enhancing of images. The software provides a wide range of functions, such as filtering, thresholding, segmentation, and morphological operations. It also offers tools for image registration, colocalization analysis, and 3D rendering. In research, Image J is commonly used to analyze images obtained from various techniques such as anatomy [28], histology [29], and radiology [30-33].

Although the photogrammetry is a non-invasive technique that involves using photographs to measure the shape and size of objects easily, there are some disadvantages to using photogrammetry in the lower limb analysis, which are discussed below:

a) inaccuracy: one of the main disadvantages of photogrammetry is the potential for measurement errors. The accuracy of photogrammetry depends on several factors, including the quality of the camera, the angle and distance of the camera from the subject, and the presence of any obstructions in the image. These factors can affect the accuracy of the measurements, resulting in errors in the data.
b) limited range: another disadvantage of photogrammetry is the limited range of motion that can be captured. To obtain accurate measurements, the subject must remain still during the imaging process, which can be difficult for some individuals, particularly those with mobility issues or pain. Additionally, the range of motion that can be captured is limited by the angle of the camera and the distance from the subject, which can be problematic in assessing dynamic movements such as walking or running.
c) equipment requirements: photogrammetry requires specific equipment, including a high-quality camera and software, which can be expensive. Additionally, the process requires a trained professional to capture the images, which can further increase the cost of the analysis.
d) image quality: the quality of the images captured can also affect the accuracy of the measurements. If the images are blurry, overexposed, or underexposed, the measurements may be inaccurate, making it difficult to obtain reliable data.
e) complex data analysis: photogrammetry data analysis can be complex and time-consuming. The images must be processed using specialized software, and the data must be carefully analyzed to obtain meaningful results. This requires a skilled and experienced professional, which can further increase the cost of the analysis.
f) ethical considerations: Finally, there are ethical considerations to consider when using photogrammetry in lower limb analysis.

This technique involves taking photographs of the subject's body, which can be intrusive and uncomfortable for some individuals. Additionally, there is the potential for the images to be used inappropriately, which can lead to privacy concerns.

The encountered errors of photogrammetry related to lower limb have been explained in this study. However, other than the lower limb errors, may be encountered in studies performed on other parts of the body (upper limb, face, etc.). Although this study has been described the encountered errors during the photogrammetry of young Anatolian adults, a number of other errors related to photogrammetry may also be encountered depending on race or age. Therefore, it is thought that this study may be a guide for photogrammetric measurements to be made about the lower limb, as well as encouraging new studies to reveal the errors that may be encountered in different ethnic groups, ages or demographic features.

In conclusion, photogrammetry is a useful tool for lower limb analysis, but it is not without its limitations. The potential for measurement errors, limited range of motion, equipment requirements, image quality issues, complex data analysis, and ethical considerations must be carefully considered before using this technique. Despite the disadvantages of photogrammetry, it is thought that this method will contribute to patient control, treatment planning / treatment follow-up, and revealing the morphometric and morphological characteristics of the lower limb as a method to reduce radiation preference.

Peer-review: Externally peer-reviewed.

Funding: The authors declared that this study has received no financial support.

Competing interest for all authors: No financial or non financial benefits have been received or will be received from any party related directly or indirectly to the subject of this article. The authors declare that they have no relevant conflict of interest.

Ethics Committee Approval: Ethics committee approval was obtained from Ege University Clinical Research Ethics Committee (Approval date: 22.11.2016, approval number: 16-10.1/14).

Author's contributions: Conception: GNC, FG; Design: KY, OG; Supervision: FG; Fundings: YP; Materials: GNC, KY; Data Collection and Processing: GNC, YP; Analysis and Interpretation: GNC, OG, KY ; Literature Review: GNC, KY; Writing: GNC, KY, FG; Critical Review: GNC, FG.
All authors read and approved the final version.

REFERENCES

1. Μαστραπάς Α (2009) Βελτίωση ψηφιακής φωτογραφίας. University of Patras, Doctoral dissertation.

2. Sutton MA (1974) Sir John Herschel and the development of spectroscopy in Britain. Br J Hist Sci. 7(1):42-60. https://doi.org/10.1017/S0007087400012851

3. Braive MF (1973) Birth of Photography. Chest. 63(6):951. https://doi.org/10.1378/chest.63.6.951

4. Benjamin W (1972) A short history of photography. Screen. 13(1):5-26. https://doi.org/10.1093/screen/13.1.5

5. Jenkins RV (1975) Technology and the market: George Eastman and the origins of mass amateur photography. Technol Cult. 16(1):1-19. https://doi.org/10.2307/3102363

6. Mitchell HL, Newton I (2002) Medical photogrammetric measurement: overview and prospects. J Photogramm Remote Sens. 56(5-6):286-94. https://doi.org/10.1016/S0924-2716(02)00065-5

7. Petriceks AH, Peterson AS, Angeles M, Brown WP, Srivastava S (2018) Photogrammetry of human specimens: an innovation in anatomy education. J med educ curric dev. 5:2382120518799356. https://doi.org/10.1177/2382120518799356

8. Magnani M, Douglass M, Schroder W, Reeves J, Braun DR (2020) The digital revolution to come: Photogrammetry in archaeological practice. Am Antiq. 85(4):737-60. https://doi.org/10.1017/aaq.2020.59

9. Struck R, Cordoni S, Aliotta S, Pérez-Pachón L, Gröning F (2019) Application of photogrammetry in biomedical science. Biomed Vis. 1:121-30. https://doi.org/10.1007/978-3-030-06070-1_10

10. Lane HB (1983) Photogrammetry in medicine. Photogramm Eng Remote Sensing. 49(10):1453-6.

11. Ey-Chmielewska H, Chrusciel-Nogalska M, Fraczak B (2015) Photogrammetry and its potential application in medical science on the basis of selected literature. Adv Clin Exp Med. 24(4):737-41. https://doi.org/10.17219/acem/58951

12. Harting MT, DeWees JM, Vela KM, Khirallah RT (2015) Medical photography: current technology, evolving issues and legal perspectives. Int J Clin Pract. 69(4):401-9. https://doi.org/10.1111/ijcp.12627

13. Donné A (1844) Cours de microscopie complémentaire des études médicales: anatomie microscopique et physiologie des fluides de l'économie. Baillière.

14. Barut C, Ertilav H (2011) Guidelines for standard photography in gross and clinical anatomy. Anat Sci Educ. 4(6):348-56. https://doi.org/10.1002/ase.247

15. Furlanetto TS, Sedrez JA, Candotti CT, Loss JF. (2016) Photogrammetry as a tool for the postural evaluation of the spine: a systematic review. World J Orthop. 7(2):136. https://doi.org/10.5312/wjo.v7.i2.136

16. Bahşi I, Orhan M, Kervancioğlu P, Karatepe Ş, Sayin S (2021) Craniofacial anthropometry of healthy Turkish young adults: analysis of head and face. J Craniofac Surg. 32(4):1535-1539. https://doi.org/10.1097/SCS.0000000000007219

17. Bahşi I, Orhanc M, Kervancioğlu P (2021) Confusion of the Standardization in Craniofacial Soft Tissue Measurements: Frankfort Horizontal Plane or Natural Head Position?. J Craniofac Surg. 32(8):2578-9. https://doi.org/10.1097/SCS.0000000000007883

18. Govsa F, Nteli Chatzioglou G, Hepguler S, Pinar Y, Bedre O (2020) Variable lower limb alignment of clinical measures with digital photographs and the footscan pressure system. J Sport Rehabil. 30(3):437-44. https://doi.org/10.1123/jsr.2018-0283

19. Nteli Chatzioglou, G, Govsa F, Bicer A, Ozer MA, Pinar Y (2019) Physical attractiveness: analysis of buttocks patterns for planning body contouring treatment. Surg Radiol Anat. 41:133-40. https://doi.org/10.1007/s00276-018-2083-4

20. Lowe DG (1987) Three-dimensional object recognition from single two-dimensional images. Artif Intell. 31(3):355-95. https://doi.org/10.1016/0004-3702(87)90070-1

21. Pérez Pico AM, Marcos Tejedor F, de Cáceres Orellana LC, de Cáceres Orellana P, Mayordomo R (2022) Using Photogrammetry to Obtain 3D-Printed Positive Foot Casts Suitable for Fitting Thermoconformed Plantar Orthoses. Processes. 11(1):24. https://doi.org/10.3390/pr11010024

22. Sacco ICN, Picon AP, Ribeiro AP, Sartor CD, Camargo-Junior F, Macedo DO, et al. (2012) Effect of image resolution manipulation in rearfoot angle measurements obtained with photogrammetry. Braz J Med Biol. 45:806-10. https://doi.org/10.1590/S0100-879X2012000900003

23. Larsen PK, Simonsen EB, Lynnerup N (2010) Use of photogrammetry and biomechanical gait analysis to identify individuals. Proceedings of the 18th European signal processing conference; 1660-4.

24. Morales-Acosta L, Ortiz-Prado A, Jacobo-Armendáriz VH, González-Carbonell RA (2019) Biomechanical analysis of weeding labor in mexican farmers through the simultaneous use of photogrammetry and accelerometry. Proceedings of the 8th Latin American Conference on Biomedical Engineering and XLII National Conference on Biomedical Engineering; 2019 Oct 2-5; Cancún, México. 850-7. https://doi.org/10.1007/978-3-030-30648-9_111

25. Zahra SU, Kervancioğlu P, Bahşi İ (2018) Morphological and topographical anatomy of nutrient foramen in the lower limb long bones. Eur J Ther. 24(1):36-43. https://doi.org/10.5152/EurJTher.2017.147

26. Shilov L, Shanshin S, Romanov A, Fedotova A, Kurtukova A, Kostyuchenko E, et al. (2021) Reconstruction of a 3D

Human Foot Shape Model Based on a Video Stream Using Photogrammetry and Deep Neural Networks. Future Internet. 13(12):315. https://doi.org/10.3390/fi13120315

27. Schneider CA, Rasband WS, Eliceiri KW (2012) NIH Image to ImageJ: 25 years of image analysis. Nat Methods. 9(7):671-5. https://doi.org/10.1038/nmeth.2089

28. Akcay E, Chatzioglou GN, Gayretli O, Gurses IA, Ozturk A (2021) Morphometric measurements and morphology of foramen ovale in dry human skulls and its relations with neighboring osseous structures. Medicine. 10(3):1039-46. https://doi.org/10.5455/medscience.2021.04.149

29. Shintaku H, Yamaguchi M, Toru S, Kitagawa M, Hirokawa K, Yokota T, et al. (2019) Three-dimensional surface models of autopsied human brains constructed from multiple photographs by photogrammetry. PloS one. 14(7):e0219619. https://doi.org/10.1371/journal.pone.0219619

30. Arslan D, Ozer MA, Govsa F, Kitis O (2019) Surgicoanatomical aspect in vascular variations of the V3 segment of vertebral artery as a risk factor for C1 instrumentation. J Clin Neurosci. 68:243-9. https://doi.org/10.1016/j.jocn.2019.07.032

31. Adanir SS, Bakşi YE, Bahşi I, Kervancioğlu P, Yalçin ED, Orhan M (2022) Evaluation of the Cranial Aperture of the Optic Canal on Cone-Beam Computed Tomography Images and its Clinical Implications for the Transcranial Approaches. J Craniofac Surg. 33(6):1909-13. https://doi.org/10.1097/SCS.0000000000008577

32. Ayvaz DK, Kervancıoğlu P, Bahşi A, Bahşi İ (2021) A radiological evaluation of lumbar spinous processes and interspinous spaces, including clinical implications. Cureus. 13(11):e19454. https://doi.org/10.7759/cureus.19454

33. Bahşi İ, Orhan M, Kervancıoğlu P, Yalçın ED (2019) The anatomical and radiological evaluation of the Vidian canal on cone-beam computed tomography images. Eur Arch Otorhinolaryngol. 276:1373-83. https://doi.org/10.1007/s00405-019-05335-6