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Morphometric Evaluation of Occipital Artery

Emrah ÖZCAN[1], Esma DERİNÖZ[2], Bahar YANIK KEYİK[3], Ömür KARACA[1], Tuğba GİRGİN[4], İlter KUŞ[1], Alper VATANSEVER[5]

[1] Balikesir University, Faculty of Medicine, Department of Anatomy
[2] Balikesir University, İvrindi Vocational School of Health Services
[3] Balikesir University, Faculty of Medicine, Department of Radiology
[4] Balikesir University, Health Sciences Institute
[5] Bursa Uludag University, Faculty of Medicine, Department of Anatomy

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ABSTRACT

Objective: Occipital artery anatomy should be well known in order to minimize complications that may occur in the occipital artery, which is closely adjacent to this nerve, during greater occipital nerve blockade. In this study, it is aimed to evaluate the morphometric relationship of the occipital artery with neighboring anatomical structures in order to prevent damage during clinical applications. **Materials and Methods:** This study was carried out using CTA images of the head and neck region of patients who applied to Balikesir University Medical Faculty Training and Research Hospital for various reasons between 2015 and 2021. In the study, CTA images of 85 individuals aged 35-63 years were evaluated morphometrically using Radiant DICOM viewer 64-bit computer software. The obtained data were transferred to SPSS Version 25 software and analyzed quantitatively. **Results:** According to the results obtained from the study, no significant difference was found between the variables and genders. As the age of the individual increased, it was observed that the left occipital artery was located more inferolateral to the external occipital protuberance. As a result of the data obtained, a negative correlation was observed between the closest distance between the right OA-ML and the right EOP-ML and the spinous process of the seventh cervical vertebra. **Conclusion:** In line with the average values obtained as a result, it is thought that an injection to the central point of the triangular area, which is formed as a result of combining the reference points in the posterior occiput, may be safer in order to protect the occipital artery.

Keywords: Occipital Artery, Safe Zone, CTA, Morphometry.

Arteria Occipitalis'in Morfometrik Değerlendirilmesi

ÖZ

Amaç: Nervus occipitalis major blokajı sırasında, bu sinir ile yakın komşuluk yapan arteria occipitalis'te oluşabilecek komplikasyonları en aza indirgemek için arteria occipitalis anatomisinin iyi bilinmesi gerekir. Bu çalışmada; arteria occipitalis'in klinik uygulamalar sırasında zarar görmesini önleyebilmek adına, komşu anatomik yapılarla olan morfometrik ilişkisinin değerlendirilmesi amaçlanmaktadır. **Gereç ve Yöntem:** Bu çalışma, Balıkesir Üniversitesi Tıp Fakültesi Eğitim ve Araştırma Hastanesi'ne 2015-2021 yılları arasında çeşitli sebeplerle başvuran hastaların baş-boyun bölgesine ait BTA görüntüleri kullanılarak gerçekleştirildi. Araştırmada; 35-63 yaşları arasındaki toplam 85 bireyin BTA görüntüleri Radiant DICOM viewer 64-bit bilgisayar yazılımı kullanılarak morfometrik olarak değerlendirildi. Elde edilen veriler SPSS Versiyon 25 yazılımına aktarılarak kantitatif olarak analiz edildi. **Bulgular:** Çalışmadan elde edilen sonuçlara göre; değişkenler ile cinsiyetler arasında anlamlı bir fark tespit edilmedi. Bireyin yaşının artmasıyla sol arteria occipitalis'in, protuberantia occipitalis externa'nın daha inferolateralinde yer aldığı görüldü. Elde edilen veriler sonucunda, sağ AO-MH ve sağ POE-MH arasındaki en yakın mesafe ile yedinci servikal vertebra'nın processus spinosus'u arasında negatif bir korelasyon gözlendi. **Sonuç:** Sonuç olarak; elde edilen ortalama değerler doğrultusunda, posterior oksiputta referans alınan işaret noktalarının birleştirilmesi sonucu oluşan üçgen sahanın merkez noktasına yapılacak bir enjeksiyonun, arteria occipitalis'i korumak adına daha güvenli olabileceği düşünülmektedir.

Anahtar Kelimeler: Arteria Occipitalis, Güvenli Bölge, BTA, Morfometri.

Sorumlu Yazar / Corresponding Author: Emrah ÖZCAN, Balikesir University, Faculty of Medicine, Department of Anatomy, Balikesir, Turkey
E-mail: emrahozcan@balikesir.edu.tr

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INTRODUCTION

Occipital neuralgia is characterized by paroxysmal or constant stabbing pain in the areas of the occipital region innervated by the greater occipital nerve. It has been clinically proven that the greater occipital nerve is compressed in certain neck positions. As a result of this compression, paresthesia and pain are observed in the sensory areas of the greater occipital nerve (Dash et al., 2005; Gille et al., 2004; Loukas et al., 2006). Specific conditions such as whiplash injury, rheumatoid arthritis, and degenerative C1-C2 arthrosis are known to cause occipital neuralgia (Shimizu et al., 2007). Occipital neuralgia may also be seen due to nerve damage after surgical interventions on the posterior region of the head (Dash et al., 2005; Gille et al., 2004; Loukas et al., 2006). However, during posterior cervical and cranial surgery, tumor surgery in the suboccipital fossa, pontocerebellar angle tumor surgery, aneurysm surgery and other surgical procedures in this region, the occipital nerve may be damaged and cause postoperative occipital neuralgia (Loukas et al., 2006; Natsis et al., 2006; Shimizu et al., 2007).

In cases of occipital neuralgia, many conservative or surgical treatments are applied, including greater occipital nerve blockade, chemical or radiofrequency greater occipital nerve ablation and surgery, with or without various medications. Greater occipital nerve blockade is an effective treatment for many headaches, such as migraine, cervicogenic and cluster headaches, apart from occipital neuralgia (Becser et al., 1998; Gille et al., 2004; Hecht et al., 2004; Leinisch-Dahlke et al., 2005; Loukas et al., 2006; Scattoni et al., 2006; Shimizu et al., 2007). However, the anatomy of the occipital artery should be well known in order to minimize the complications that may occur in the occipital artery, which is closely adjacent to the greater occipital nerve during nerve block applications.

The occipital artery arises posterior to the external carotid artery, inferior to the mastoid process. The occipital artery, which has a superoposterior course, enters the groove for occipital artery, which is located medial to the mastoid process. After passing here, it pierces the aponeurotic parts of the trapezius muscle and sternocleidomastoid muscle that attach to the cranium and progresses in a curved way in the superficial fascia. The last part of the occipital artery courses in the suboccipital triangle together with the greater occipital nerve (Arıncı & Elhan, 2014; Standring et al., 2005).

External carotid artery and internal carotid artery are two important vessels responsible for the nutrition of the head and neck region. In case of damage to any of the external carotid artery and internal carotid artery, bypass operation is performed. In cases where bypass operation is required, superficial temporal artery is generally used. However, in cases where this artery cannot be used, it has been determined as a result of literature research that occipital artery is used (Kimura et al., 2017). However, there is a risk of injury to the vertebral artery during skull base and upper cervical region surgeries. In these cases, injury to the vertebral artery has fatal consequences. In case of injury to the vertebral artery, occipital artery is used as a bypass. When all clinical outcomes are examined, it is seen that it is very important to know the occipital artery morphometry (Elhammady et al., 2012; Inoue et al., 2019; Keser et al., 2018; La Rocca et al., 2017; Maughan et al., 2013).

In this study, it is aimed to evaluate the morphometric relationship of the occipital artery with neighboring anatomical structures in order to prevent damage during clinical applications. By marking the clinically palpable points and determining the localization of the occipital artery, it is aimed to define a safe zone in order to protect this artery in the interventions to be applied for the suboccipital triangle.

MATERIALS AND METHODS

Study group

This study was carried out using Angiography (CTA) images obtained by Computed Tomography of the head and neck region of patients who applied to Balikesir University Faculty of Medicine Training and Research Hospital for various reasons between 2015 and 2021. Male and female individuals who did not have a history of surgery for the head and neck region, were not diagnosed with migraine, and had not received any treatment for cardiovascular diseases were included in the study. Three-dimensional reconstructions of individuals who met these criteria were examined and individuals were excluded if the occipital artery was unilateral. CTA images of 85 individuals between the ages of 35-63 were evaluated in the study. The distribution of the study group by gender is given in Table 1.

Table 1. Distribution of the study group by gender.

Study group	Female	Male	Total
CTA	32	53	85

Imaging Technique and Analysis

CTA images examined in the study were obtained from the archive of Balikesir University Faculty of Medicine, Department of Radiology, and the research was carried out retrospectively.

All patients underwent routine diagnostic CTA imaging of the carotid arterial system performed at 64 slice CT scanner (Aquillon 64, Toshiba Medical Systems, Ottawa, Japan). The patient was supine position on the scanner table, headfirst and swallowing was prevented during the examination. The scanning area was from the ascending aorta to the Willis polygon. Antero-posterior and lateral plain films were obtained. The tube voltage and current were 120 kV and 300 mA, respectively. The field of view used was 260-300 mm with a slice thickness of 1 mm, reconstruction interval of 0.8 mm and a pitch of 0.65.

Scanning was performed in the cranio-caudal direction. When the contrast agent was seen in ICA at the level of skull base, the examination was started manually for the optimal scan timing. Scanning was done by administering 70-80 ml of non-ionic contrast agent (300 mg/ml iodine concentration) at an injection rate of 4.8 ml/s. Immediately after the injection of contrast agent, 20 mL of saline was injected. For venous access, the cephalic vein of right elbow and a 20-gauge IV cannula were used. After image acquisition, the raw data were transferred in the Digital Imaging and Communications in Medicine standard (DICOM) format to the post-processing workstation.

The obtained images were quantitatively evaluated by transferring them to the Radiant DICOM Viewer 64-bit computer program. High resolution 3D reconstructions of CTA series, which were taken with 1 mm to 0.5 mm section thickness for the head and neck region, were analyzed morphometrically in accordance with the parameters given below. All variables were measured bilaterally, right and left.

1. The closest distance between external occipital protuberance (EOP) and the spinous process of the C7 vertebra / Median Line (ML) (cm) (Fig. 1).
2. The closest distance (cm) between external occipital protuberance (EOP) and occipital artery (OA) (Fig. 2).
3. The closest distance (cm) between the occipital artery (OA) and the median line (ML) (Figure 3).
4. The closest distance (cm) between external occipital protuberance (EOP) and the axis that cuts the median line (ML) transversely (Fig. 4).

Among the parameters analyzed in the study, EOP and the spinous process of the C7 vertebra were accepted as reference points due to its easy palpability. The closest distance (cm) between these two reference points was determined as the median line (ML).

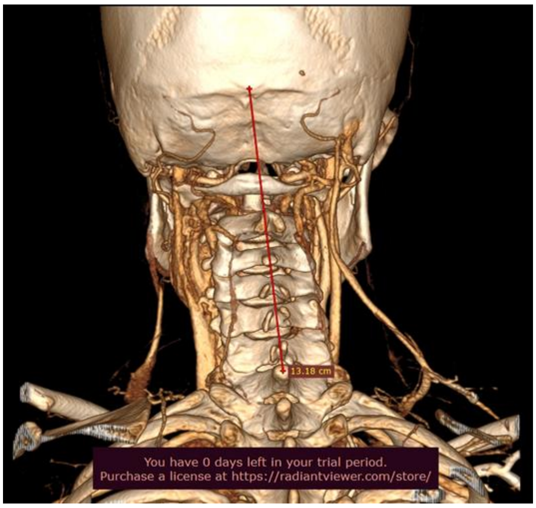

Fig. 1. The closest distance between external occipital protuberance and thespinous process of the C7 vertebra / Median Line (ML) (cm).

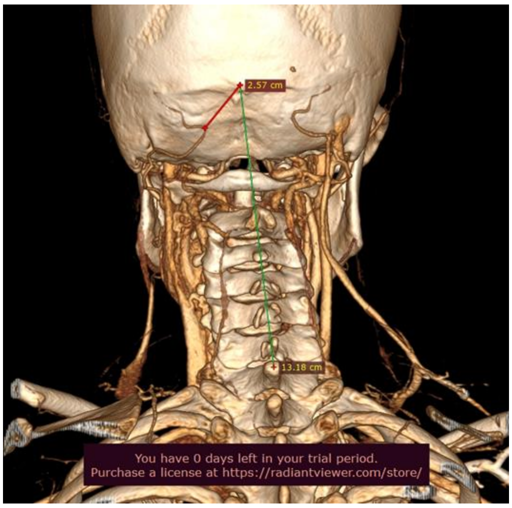

Fig. 2. The closest distance (cm) between external occipital protuberance (EOP) and occipital artery (OA).

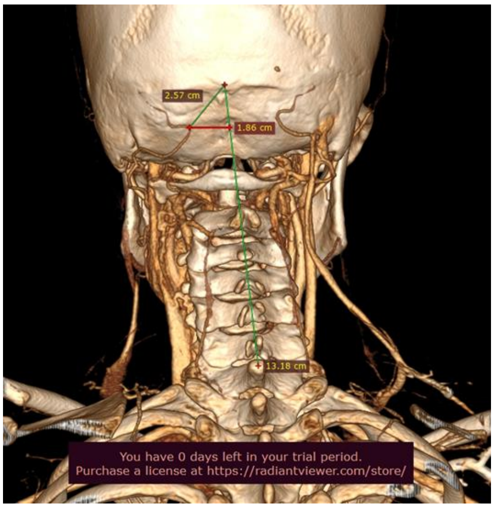

Fig. 3. The closest distance (cm) between the occipital artery (OA) and the median line (ML).

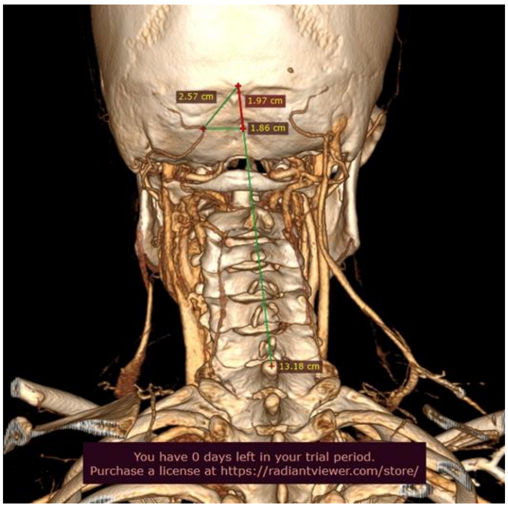

Fig. 4. The closest distance (cm) between external occipital protuberance (EOP) and the axis that cuts the median line (ML) transversely.

Statistical analysis
The data obtained as a result of the morphometric analysis of the images were transferred to SPSS Version 25 software and evaluated quantitatively. According to George and Mallery (2010), variables with Skewness-Kurtosis values between +2.0 and 2.0 were considered to have a normal distribution. Normally distributed variables were compared between genders with the Independent Group T Test, one of the parametric tests. The relationship of the variables with each other without gender discrimination was analyzed by Pearson correlation analysis. In the obtained data, cases where the p value was less than 0.05 were considered statistically "significant".

Ethical considerations
This study was begun after getting approval from Balikesir University Faculty of Medicine Non-Invasive Clinical Research Ethics Committee (Decree No: EK-2020-60).

RESULTS
In the study, CTA images of a total of 85 individuals, 32 female and 53 male, with a mean age of 53.29 ± 6.85 were examined. The descriptive statistical numerical values of the variables are given in Table 2.
According to George and Mallery (2010), the normality assumptions of the variables in the study were evaluated. Accordingly, all variables were found to have a normal distribution.

Table 2. Descriptive statistics numerical values of the variables.

Descriptive Statistics									
	n	**Min**	**Max**	**Mean**	**SD**	**Skewness**		**Kurtosis**	
	Statistic	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Std. Error**	**Statistic**	**Std. Error**
Age	85	35	63	53.29	6.852	-1.014	0.261	0.365	0.517
Median Line / cm	85	9.74	16.59	13.2346	1.44382	-0.032	0.261	-0.181	0.517
(left) EOP-OA / cm	85	2.16	5.06	3.2445	0.49954	0.684	0.261	1.384	0.517
(left) OA-ML / cm	85	1.68	4.24	2.9627	0.52588	-0.033	0.261	0.374	0.517
(left) EOP-ML / cm	85	0.11	2.93	1.2522	0.58467	0.450	0.261	-0.226	0.517
(right) EOP-OA / cm	85	2.33	5.09	3.4378	0.58459	0.596	0.261	0.366	0.517
(right) OA-ML / cm	85	1.58	5.02	3.1198	0.63396	0.522	0.261	1.019	0.517
(right) EOP-ML/ cm	85	0.00	2.83	1.2853	0.62301	0.426	0.261	-0.178	0.517

Min=Minimum, **Max**=Maxiumu, **SD**=Standard deviation.

Table 3. Numerical values and statistical data of the means in which the variables were compared between genders.

Group Statistics						
	Gender	**n**	**Mean**	**SD**	**Std. Error Mean**	**p**
Age	Female	32	52.13	7.762	1.372	0.251
	Male	53	54.00	6.211	0.853	
Median Line / cm	Female	32	12.8659	1.52632	0.26982	0.077
	Male	53	13.4572	1.35813	0.18655	
(left) EOP-OA / cm	Female	32	3.2300	0.58010	0.10255	0.847
	Male	53	3.2532	0.44975	0.06178	
(left) OA-ML / cm	Female	32	2.9287	0.62209	0.10997	0.670
	Male	53	2.9832	0.46356	0.06367	
(left) EOP-ML / cm	Female	32	1.3328	0.61589	0.10887	0.338
	Male	53	1.2036	0.56538	0.07766	
(right) EOP-OA / cm	Female	32	3.4741	0.63208	0.11174	0.669
	Male	53	3.4158	0.55908	0.07680	
(right) OA-ML / cm	Female	32	3.0575	0.75081	0.13273	0.517
	Male	53	3.1574	0.55619	0.07640	
(right) EOP-ML / cm	Female	32	1.4069	0.62106	0.10979	0.165
	Male	53	1.2119	0.61844	0.08495	

Min=Minimum, **Max**=Maxiumu, **SD**=Standard deviation.

The safe zone defined by the mean values obtained in line with the descriptive statistical numerical data of the variables is given in Figure 5.

Normally distributed variables were compared between genders with the Independent Group T Test, one of the parametric tests. The numerical values and statistical data of the means in which the variables were compared between the genders are given in Table 3. It was determined that the data with a p value of <0.05 in the variables were statistically significant. According to the Independent Group T Test results; There was no significant difference between the variables and genders (p>0.05).

The results of the correlation analysis of the variables without gender discrimination are given in Table 4. The relations of the variables examined in the study with each other are expressed in Figure 6 with the scatter matrix graph.

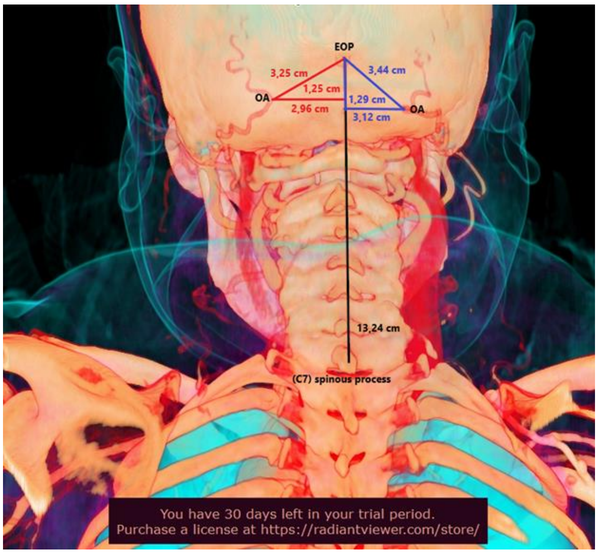

Fig. 5. Safe zone defined as a result of average values.

Table 4. Correlation analysis results.

Variables		Gender	Age	(left) EOP-OA / cm	(left) OA-ML / cm	(left) EOP-ML / cm	(right) EOP-OA / cm	(right) OA-ML / cm	(right) EOP-ML / cm	Median Line / cm
Gender	**r**	1	0.133	0.023	0.050	-0.108	-0.049	0.077	-0.153	0.200
	p		0.224	0.837	0.646	0.326	0.659	0.485	0.163	0.067
Age	**r**	0.133	1	0.220*	0.287**	-0.071	0.027	0.095	-0.146	-0.104
	p	0.224		0.043	0.008	0.521	0.804	0.388	0.182	0.342
(left) EOP-OA / cm	**r**	0.023	0.220*	1	0.878**	0.382**	0.308**	0.312**	-0.065	0.084
	p	0.837	0043		0.000	0.000	0.004	0.004	0.552	0.444
(left) OA-ML / cm	**r**	0.050	0.287**	0.878**	1	-0.069	0.382**	0.459**	-0.214*	-0.101
	p	0.646	0.008	0.000		0.527	0.000	0.000	0.049	0.360
(left) EOP-ML / cm	**r**	-0.108	-0.071	0.382**	-0.069	1	-0.111	-0.207	0.133	0.270*
	p	0.326	0.521	0.000	0.527		0.312	0.057	0.225	0.013
(right) EOP-OA / cm	**r**	-0.049	0.027	0.308**	0.382**	-0.111	1	0.905**	0.164	-0.077
	p	0.659	0.804	0.004	0.000	0.312		0.000	0.133	0.486
(right) OA-ML / cm	**r**	0.077	0.095	0.312**	0.459**	-0.207	0.905**	1	-0.231*	-0.216*
	p	0.485	0.388	0.004	0.000	0.057	0.000		0.033	0.047
(right) EOP-ML / cm	**r**	-0.153	-0.146	-0.065	-0.214*	0.133	0.164	-0.231*	1	0.315**
	p	0.163	0.182	0.552	0.049	0.225	0.133	0.033		0.003
Median Line / cm	**r**	0.200	-0.104	0.084	-0.101	0.270*	-0.077	-0.216*	0.315**	1
	p	0.067	0.342	0.444	0.360	0.013	0.486	0.047	0.003	

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed).

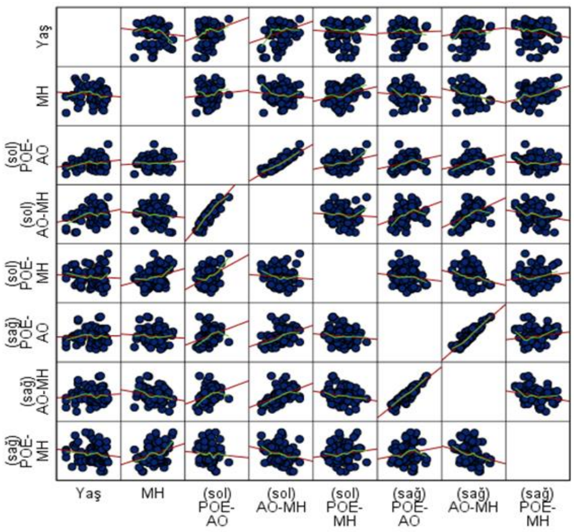

Fig. 6. Scatter matrix graph.

DISCUSSION

In this study, which aims to evaluate the morphometric relationship of the occipital artery with neighboring anatomical structures in order to prevent damage during clinical applications, two safe areas, right and left, are defined in the surgical interventions for the suboccipital triangle. The safest point to inject is thought to be the center point of these triangles.

Clinicians who need to localize the occipital nerves in the treatment of occipital neuralgia can perform the injection more safely by referring to palpable landmarks. One of these landmarks is external occipital protuberance. Tubbs et al. (2007) morphometrically examined the distance between the nerve and the external occipital protuberance to avoid damage to the greater occipital nerve. In this study we present, external occipital protuberance was taken as a reference point for the defined safe zone in order not to damage the occipital artery during greater occipital nerve blockade. As a result of the data obtained, it was determined that there was a negative correlation between the closest distance between the right OA-ML and the right EOP-ML and the spinous process of the seventh cervical vertebra. This shows that the bend point of the right occipital artery closest to the median line is located more laterally in individuals with cervical vertebral length less than the mean values. However, the closest distance between the EOP and the spinous process of the seventh cervical vertebra was found to be greater in males than females. However, it has been shown that this difference is not statistically significant. Clinicians who will administer right greater occipital nerve injection in women should consider this situation in order not to damage the artery.

The greater occipital nerve is relatively easy to access in the posterior occiput. However, during injections, injecting local anesthetics into the central nervous system and the occipital artery, which is in close proximity to this nerve, should be avoided (Hecht et al., 2004). In this study, in which we defined the safe zone for injection, it was determined that the left occipital artery moves away from the external occipital protuberance with the increasing age of the individual, and the fold point closest to the median line is located more inferolaterally. Accordingly, we believe that it would be safe to inject at a point close to the medial side of external occipital protuberance during the application. Complications of greater occipital nerve blockade, in which local anesthetic agents are used, include infection, hematoma, and damage to structures at the injection site. Inan et al. (2019) reported that negative aspiration should be applied to avoid injection into an artery during nerve blockage, and thus the risk of developing side effects can be minimized. Palamar et al. (2015), on the other hand, performed nerve blockade of the greater occipital nerve with the help of a portable USG in order to visualize the occipital artery at the injection site. However, they suggested that in cases where USG cannot be used, localization of the occipital artery by palpation can be followed by a blockade application to the medial side of the artery. However, according to the data presented in our study, it is thought that in cases where the occipital artery cannot be localized by palpation, injecting into the defined safe area would be more practical and applicable to reduce morbidity.

CONCLUSION

According to the results obtained from the study, by palpating the external occipital protuberance and the spinous process of the seventh cervical vertebra, the distance of the closest bend point of the occipital artery to the median line, to the external occipital protuberance and to the median line was determined in line with the data obtained. It has been determined that an injection to the central point of the triangular area obtained by combining these landmark points in the posterior occiput may be safer to protect the occipital artery. The results obtained by the morphometric analysis of the posterior occiput of 85 individuals evaluated in the study are insufficient in number in terms of generalizability of the data. However, the values to be obtained by reaching the images of more individuals will be beneficial in terms of increasing the reliability and generalizability of the study.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

Plan, design: EÖ, ED; **Material, methods and data collection:** EÖ, ED, AV; **Data analysis and comments:** EÖ, ED, BYK, ÖK, TG, İK, AV; **Writing and corrections:** EÖ, ED.

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