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Comparing Endoscopic Measurements of the Anterior and Posterior Ethmoidal Arteries with CT Measurements: A Cadaveric Study

Rukiye Ozcelik Erdem[1, a], Mehmet Akif Dundar[1], Muzaffer Seker[2], Hamdi Arbag[1]

[1]Department of Otorhinolaryngology, Faculty of Medicine, Necmettin Erbakan University, Turkey, [2]Department of Anatomy, Faculty of Medicine, Necmettin Erbakan University, Turkey

Correspondence: *ozcelikrukiye@gmail.com*; Tel.: + 90 553 0800514

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Abstract
Objective. To reveal the reliability of radiological measurements of the ethmoid arteries. **Method.** Five fresh frozen cadaveric heads underwent computed tomography and endoscopic sinus surgery. The lateromedial length of the anterior ethmoidal artery (AEA) and its distance to the axilla of the middle turbinate (MTA), the sphenoethmoidal recess (SR) and the posterior ethmoidal artery were measured. The posterior ethmoidal artery (PEA) was referenced to the SR. These anatomical parameters were measured both radiologically and endoscopically, and the compatibility of the two was examined. **Results.** Ten nasal cavities were dissected. We found that the distance of MTA to the AEA was 16±8 mm in dissection, 21±4 mm radiologically in the sagittal section, the distance of SR to the AEA was 14±3 mm in dissection, 19±4 mm radiologically in the sagittal section, and the distance of the AEA to the PEA was 10±3 mm in dissection, 12±3 mm radiologically in the axial section. The distance of the PEA to SR was 6±3 mm in dissection, 8±2 mm radiologically in the sagittal section. **Conclusions.** The distance of the AEA to the MTA, the distance of the AEA to the PEA and the distance of the PEA to the SR were compatible with each other in the dissection and in the radiologically evaluation, whereas the distance of the AEA to the SR was not compatible.

Key Words: Computed Tomography ▪ Ethmoidal Arteries ▪ Ethmoid Dissection ▪ Radiology Reports ▪ Transnasal Endoscopic Surgery.

Introduction

Anterior and posterior ethmoidal arteries are important landmarks in functional endoscopic sinus surgery (FESS) or other skull base procedures. Iatrogenic injuries to the ethmoidal arteries during endoscopic sinus surgery (ESS) may cause serious complications. Orbital hematoma, severe bleeding, cerebral infection and serious cerebrospinal fluid leak are some of the serious complications that can occur during surgery (1).

The surgeon's recognition of the course of the ethmoidal arteries in preoperative radiological imaging, and knowing its relationship to anatomical landmarks will reduce the risk of complications (2, 3). During endoscopic sinus surgery, to prevent iatrogenic damage the anatomy (length, course, variation, angulation and etc.) of the AEA should be identified preoperatively by a CT scan of the patient (4, 5). Along with this information, to know the landmarks that can be helpful for surgery in the field of the AEA is very valuable intraoperatively (2). These anatomical landmarks have been evaluated in dissections and CT studies in many studies to date. In the CT studies, the axilla of the middle turbinate, nasal spine, nasal beak, nasion, optic foramen and nasal crest were studied (6-8). In the dissection studies, the axilla of the middle turbinate, the nasal sill, the anterior nasal spine, the lateral nasal wall, and the anterior wall of the sphenoid sinus were studied (9-12),

In this study, the distance of the anterior ethmoidal artery to the axilla of the middle turbinate

[a] ORCID: https://orcid.org/0000-0001-5087-4652

(MTA) and the sphenoethmoidal recess, and the distance of the posterior ethmoidal artery to the sphenoethmoidal recess and anterior ethmoidal artery were measured in radiological sections taken before dissection. Then, the same measurements were measured in fresh cadaver dissections and compared with each other. We attempted to obtain anatomical measurements that would help surgeons during surgery, from the preoperative radiological sections.

We aimed to evaluate whether surgeons can reliably use preoperative radiological measurements during surgery.

Materials and Methods

Radiology

All cadavers underwent computed tomography before dissection. A multidetector CT, SOMATOM Sensation 64 model (Siemens) was used to scan the fresh frozen cadaver's paranasal sinuses. After axial sections of 1 mm were acquired, reconversions were made with an overlap of 0.75 mm. Sections were acquired from the beginning of the frontal sinus to the hard palate. Maximum Intensity Projection (MIP) was used to obtain coronal and sagittal images from the axial images.

A radiologist examined the CT images. First, on the coronal sections the medial notch, recognized as a bone protrusion in the medial orbital wall, was determined to be the anterior ethmoidal foramen (Figure 1). On sagittal sections, the anterior aspect of the middle turbinate axilla was recognized. In the sagittal section, measurements were made between the stated landmarks (Figure 1). Secondly, on a sagittal section, the sphenoethmoidal recess (SR) was identified and the distance to the AEA was measured.

After measuring the distance between the AEA and the designated landmarks, measurements related to the PEA were started. By following the ethmoidal canal, the posterior ethmoidal artery was identified according to its relationship with the ethmoid compartment on the coronal section. The distance between the PEA and the sphenoethmoidal recess, which was previously distinguished by CT, was measured in the sagittal section. Finally, the distance between both ethmoidal arteries was measured in the axial section (Figure 1).

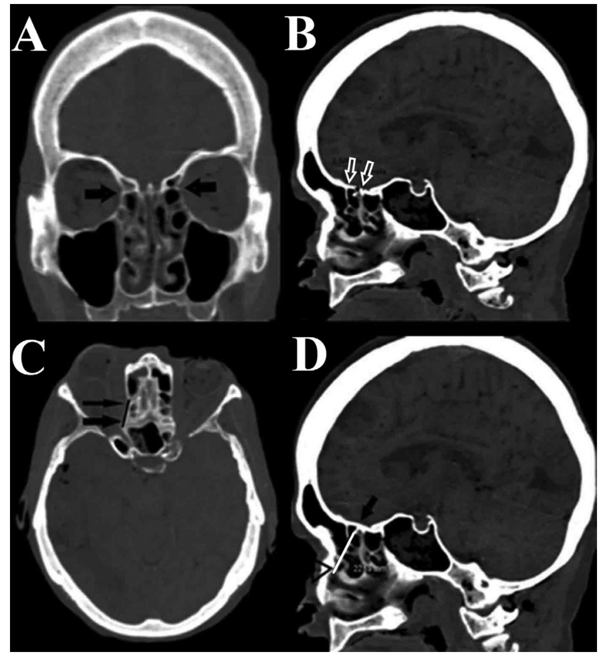

Figure 1: (A) The anterior ethmoidal foramen on the coronal section. (B) The anterior ethmoidal artery between the second and third lamellae on the sagittal section. (C) The distance between the AEA (thin arrow) and PEA (thick arrow) on the axial section. (D) The distance of the AEA to the middle turbinate axilla on the sagittal section.

Cadaveric Dissection

Five fresh frozen cadaveric heads underwent endoscopic sinus surgery in the anatomy laboratory. The surgical procedure began after endoscopic evaluation of the nasal cavities. An endoscope (0^0, 45^0 Storz Hopkins, Germany) and a video-endoscope system were used, alongside sinus surgery instruments (Karl Storz, Tuttlingen, Germany). The procedures were performed by an otolaryngologist who was experienced in endoscopic sinus surgery. First, an uncinectomy was performed. Then, the ethmoidal bulla was opened inferomedially, and its anterior wall was removed. The posterior ethmoidal cells were opened by exposing and

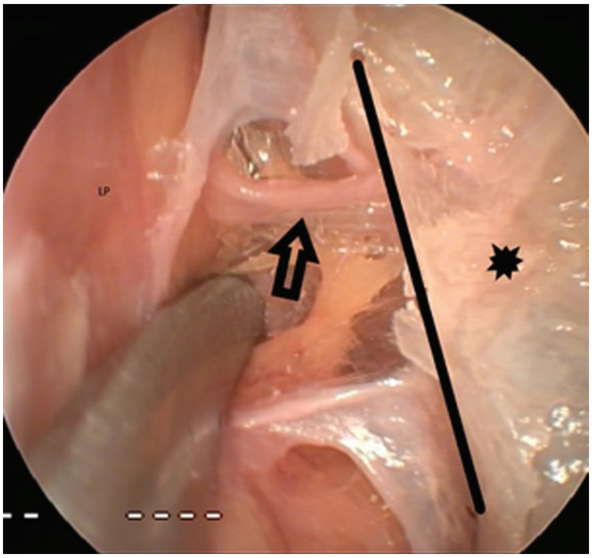

Figure 2. The entrance of the AEA from the orbit to the nasal cavity. LP=Lamina papyracea; Asterisk= Nasal cavity; Arrow=AEA; Line=Border between the lamina papyracea and nasal cavity.

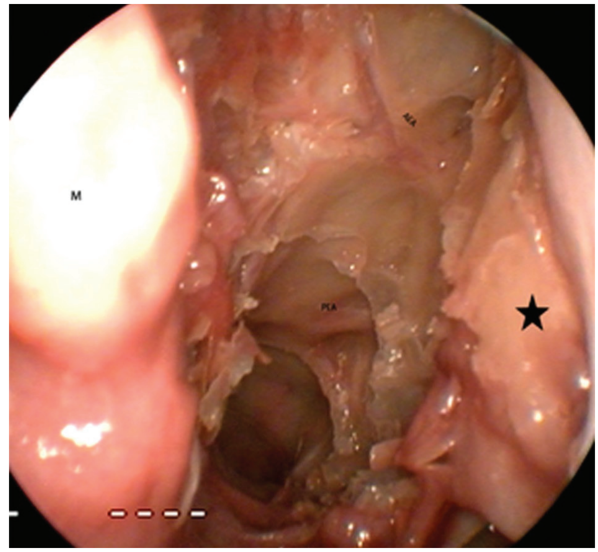

Figure 3. The AEA and PEA in dissection. M=Middle turbinate; Asterisk=Lamina papyracea.

dissecting the basal lamella. The anterior wall of the frontal recess was dissected, and the AEA was identified in the posteroanterior and lateromedial directions through the posterior wall of the frontal recess (Figure 2). After tracing from the nasal cavity to the lamina papyracea, its entry into the nasal cavity was confirmed. Then, the lateromedial length of the AEA and its distances to the MTA and the sphenoethmoidal recess were measured with a curved, calibrated seeker. The PEA was identified superior to the junction of the posterior ethmoidal cells and the sphenoid roof (Figure 3). The interarterial distance and the distance between the PEA and the SR were measured.

Ethics Statement

This study was approved by the Ethics Committee of Necmettin Erbakan University (Decision No: 2023/4238).

Statistical Analyses

Dissection and radiological measurements were compared using the dependent sample t-test. All analyses were performed with the R 3.5.3 program. P values below or equal to 0.05 were considered as statistically significant.

Results

CTs were performed on 10 nasal cavities. The ethmoidal arteries were identifiable on all cadaver heads. The mean AEA intranasal length was 6±2 mm. The distance from the MTA to the AEA was 21±4 mm in the sagittal section, and 16±8 mm in dissection (P=0.067). The differences found were not statistically significant. As a significant finding (P< 0.05), the mean distance between the sphenoethmoidal recess to the AEA was 19±4 mm in the sagittal section and 14±3 mm in dissection. This was a significant finding (P=0.0034). The distance from the sphenoethmoidal recess to the PEA was 8±2 mm in the sagittal section and 6±3 mm in dissection (P=0.073). The interarterial distance was 12±3 mm in the axial section and 10±3 mm in dissection (P=0.16). There was no significant difference between these radiological measurements and the dissection measurements.

There was no significant difference between radiological and dissection measurements, except for the distance between the AEA and the SR, and

Table 1. Statistical Evaluation of Dissection and Radiological Measurements

Distances	Radiology ($\bar{x}$ ± SD) mm	Dissection ($\bar{x}$ ± SD) mm	P*
AEA-SR	19±4	14±3	0.0034
AEA-MTA	21±4	16±8	0.067
AEA-PEA	12±3	10±3	0.16
PEA-SR	8±2	6±3	0.073

AEA=anterior ethmoidal artery; MTA=Axilla of the middle turbinate; PEA=Posterior ethmoidal artery; SR=Sphenoethmoidal recess; *Dependent sample t-test.

it was observed that the measured values were compatible with each other. The results of the measurement are reported in Table 1. The distribution of the mean values of dissection and radiological measurements is shown in Figure 4. In Figure 5 there are box plots that illustrate the comparisons of the distances between the dissection and radiological measurements.

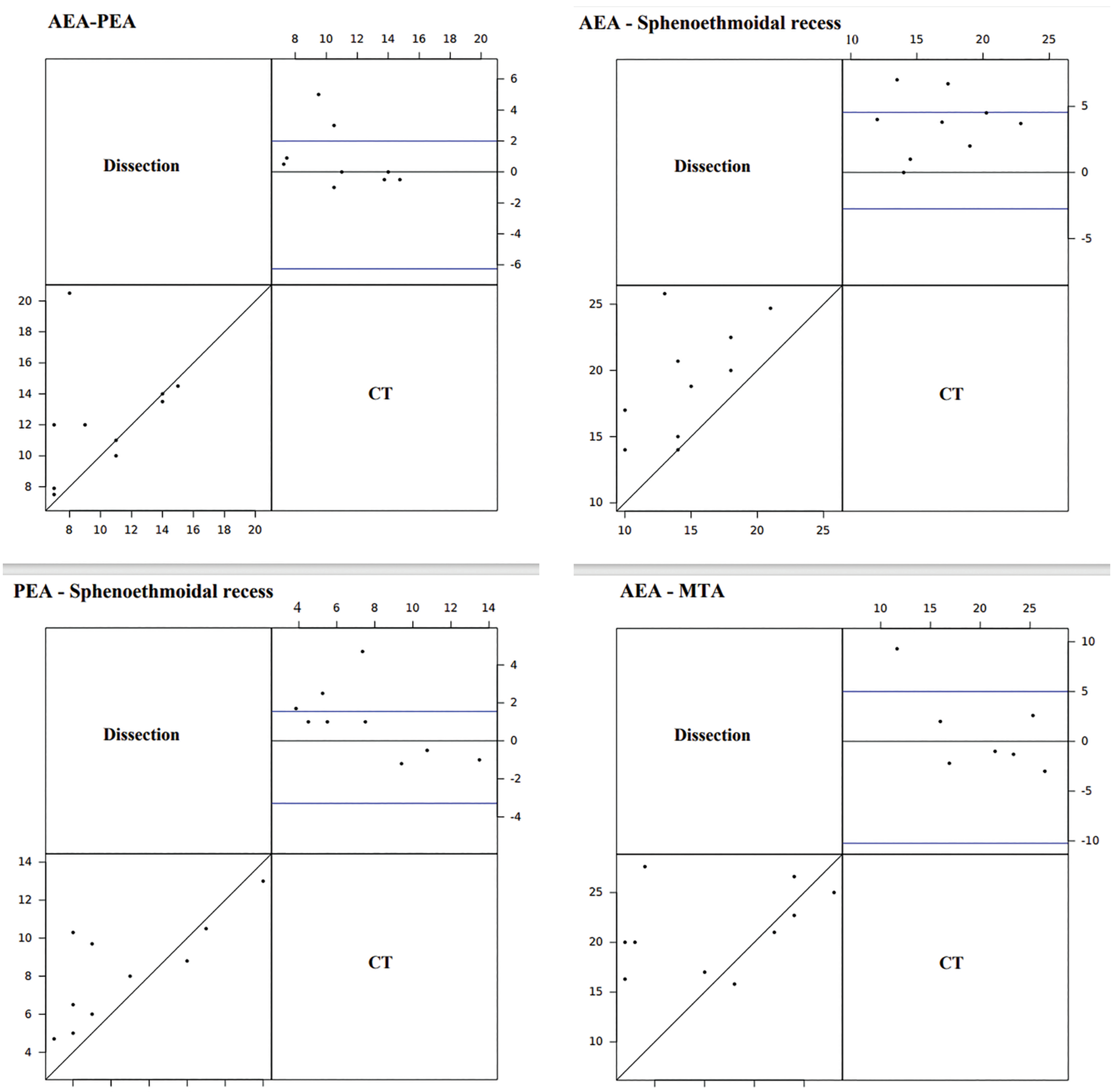

Figure 4. Distribution of dissection (X axis) and radiological (Y axis) data around the mean value. AEA=Anterior ethmoidal artery; PEA=Posterior ethmoidal artery; MTA=Axilla of the middle turbinate.

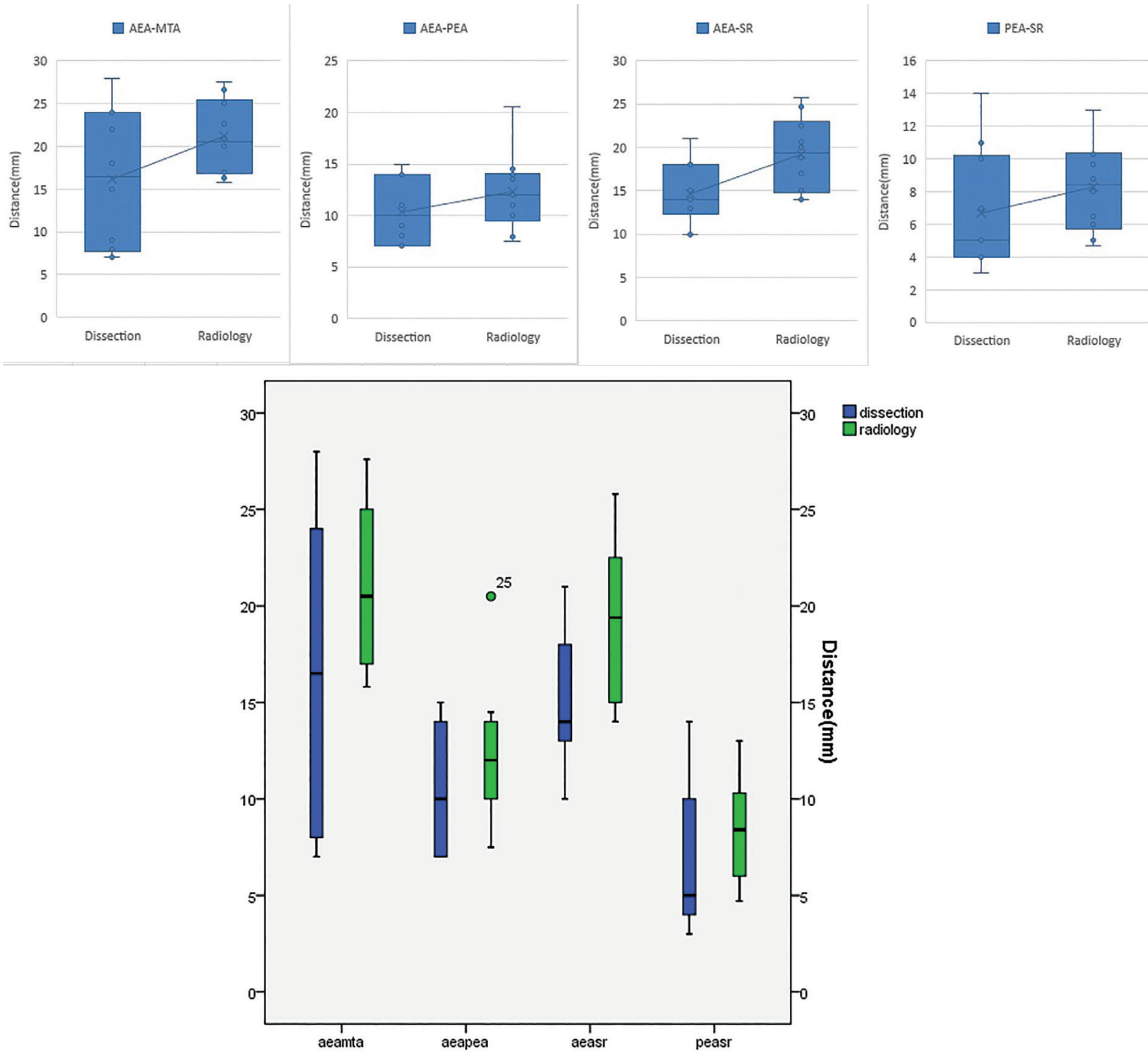

Figure 5. Box plots illustrating the comparisons of the distances. AEA=Anterior ethmoidal artery; MTA=Axilla of the middle turbinate; PEA=Posterior ethmoidal artery; SR=Sphenoethmoidal recess.

Discussion

In this study, the mean distance of the PEA to the sphenoethmoidal recess was 6 mm in dissection, 8 mm in the sagittal section. The distance from the AEA to the PEA was 10±3 mm in dissection and 12±3 mm in axial section. There were no statistically significant differences between the radiological and dissection measurements. As a result, both the AEA and the sphenoethmoidal recess can be used for identifying the PEA. Similar to our study, in their cadaveric study Han et al. indicated that the PEA was usually 10 to 13 mm behind the AEA, while they also indicated that using the AEA as an endoscopic landmark to find the PEA might not be the most consistent landmark. Rather, the anterior wall of the sphenoid sinus can be a better endoscopic landmark for finding the PEA (10). In another radiological investigation, the average distance from the AEA to the PEA was 11.24 mm (7).

The relationship of the anterior ethmoidal artery to the sphenoid sinus has not been studied as much as its relationship to the posterior ethmoidal artery. The distance from the sphenoethmoidal recess to the AEA was 19±4 mm in the sagittal section, 14±3 mm in dissection. The difference was statistically significant ($P<0.05$). The sphenoid sinus is not as reliable as the PEA for the AEA.

The mean distance of the AEA to the MTA was 16±8 mm in dissection and 21±4 mm in the sagittal section. There was no statistically significant difference between the dissection and the radiological evaluation. One of the most studied landmarks for recognition of the AEA is the MTA. Lee et al. stated that the distance from the MTA to the artery was 20 mm on average in their cadaver anatomical study, and it was accepted that it had the least variation both within and between individuals (12). Similar to this study, in another study the MTA was the most dependable anatomic landmark to localize the artery (11, 13). In addition to these studies, in a radiological study the average distance from the MTA to the AEA was 1.88 cm (6).

There is no study in which both radiological and dissection evaluations of the ethmoid arteries were performed between two points in the same subject, but the current literature includes only either radiological or dissection studies. In our study, the distances between two landmarks were measured in radiological sections taken before dissection. Then, the same measurements were measured in fresh cadaver dissection and compared with each other. The difference between published articles and our parameters can be attributed to different ethnicities and genders (11, 12). However, the MTA is an important anatomical landmark in defining the anterior ethmoidal artery.

In recent years, many scientists around the world have made a great effort to find the ethmoidal arteries, and have tried different approaches. However, the diversity of anatomical relationships between ethmoidal arteries and ethmoid cells, and their variations make it difficult to recognize the artery during surgery on the basis of these data alone (14). Therefore, we believe that the measurement of landmarks determined in the ethmoidal arteries on each patient's CT section before surgery will benefit the surgeon during the operation.

Ethmoid arteries are landmarks used in nasal surgery, endoscopic neurosurgery and control of epistaxis. In addition, in order to be protected from complications in nasal surgery, the ethmoid arteries should be recognized and protected from damage. Therefore, it is important to localize the ethmoid arteries and identify them using landmarks. In our study, we evaluated the important landmarks for the ethmoidal arteries from CT images, and showed that they can be used during surgery. We believe that this information will be a guide for sinus surgery, endoscopic neurosurgery and epistaxis interventions.

Conclusion

In conclusion, to obtain information about the anatomic localization of the ethmoidal arteries and to measure the distances of these arteries to the stated landmarks, CT should be performed preoperatively and evaluated. Endoscopic and radiological measurements of the ethmoidal arteries are consistent and reliable with each other. It would be beneficial for surgeons to have measurements of the ethmoidal arteries in the radiology report.

What Is Already Known on This Topic:
There are many studies that focus on the course of the ethmoidal arteries. In the CT studies, the axilla of the middle turbinate, nasal spine, nasal beak, nasion, optic foramen and nasal crest were studied. In the dissection studies, the axilla of the middle turbinate, nasal sill, the anterior nasal spine, the lateral nasal wall, and the anterior wall of the sphenoid sinus were studied.

What This Study Adds:
There is no study in which both radiological and dissection evaluations of the ethmoid arteries were performed between two points in the same subject, and the current literature usually includes only either radiological or dissection studies. In our study, the distances between two landmarks were measured in radiological sections taken before dissection. Then, the same measurements were measured in fresh cadaver dissection and compared with each other.

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Conflict of interest: The authors declare that they have no conflict of interest.

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