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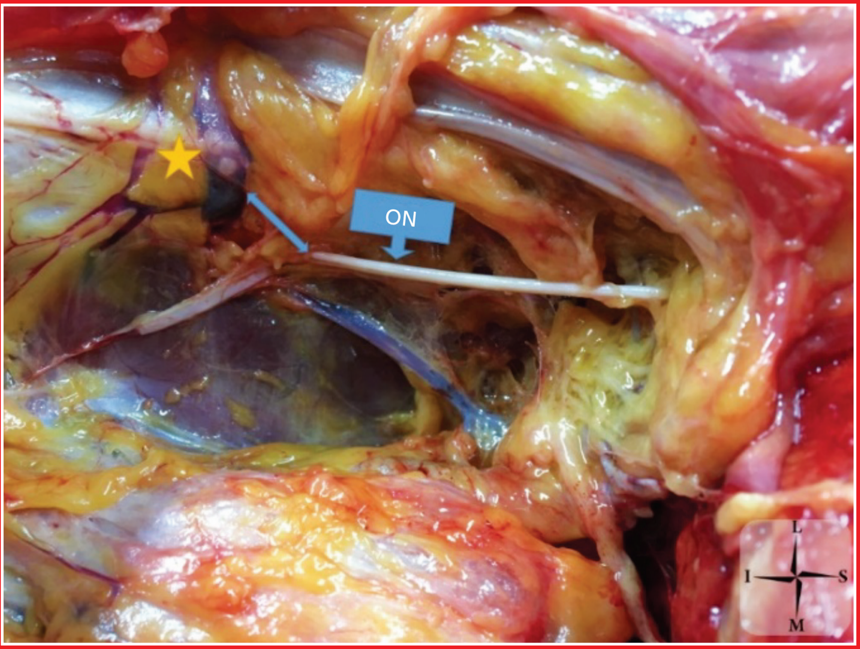

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Anatomical features of venous and arterial corona mortis in fresh cadavers in the Turkish population and anatomical landmarks to be used during surgical procedures

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Abstract

Objectives: The aim of this study is to determine the topographic position of the corona mortis on fresh cadavers and also to determine anatomical landmarks that will facilitate surgeons to consider to this structure during operations by clarifying the relationship of the corona mortis with the surrounding anatomical structures.

Methods: A total of 50 autopsy cases of 31 men and 19 women, all examined within 24 hours post-mortem, were evaluated bilaterally for the presence of corona mortis. When identified, the vascular characteristics (arterial/venous) of the corona mortis were documented. The topographic position of the corona mortis was determined by measuring the distances to the pubic symphysis, promontory, obturator nerve and anterior superior iliac spine. The study also investigated whether some anthropometric measurements affect these distances.

Results: Out of the 100 hemipelves examined, corona mortis were observed in 50 cases. Among these, 34% were arterial (n=17), and 66% were venous (n=33). Anastomoses were identified in the hemipelves of 22 women and 28 men, with no significant gender difference (p>0.05). The average distances to anatomical landmarks were as follows: 5.43 cm to the pubic symphysis, 1.77 cm to the obturator nerve, 9.87 cm to the promontory, and 10.56 cm to the anterior superior iliac spine.

Conclusion: Corona mortis poses a significant risk in surgical procedures. Knowing the vascular anatomy of the pelvis is vital for gynecological, urological and orthopedic interventions, while investigating deaths caused by pelvic trauma is important for forensic practice. This anatomical study contributes to a better understanding of the complex and intricate pelvic structure.

Keywords: autopsy study; corona mortis; pelvis; variant obturator artery

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Introduction

The term "corona mortis" (CM), meaning as the 'crown of death,' denotes a crucial anatomical variant within the pelvic vascular system.[1] The obturator artery can occasionally be replaced by an expanded pubic branch of the inferior epigastric artery that descends into the obturator foramen, according to Gray's Anatomy.[2] An enlarged pubic vein that connects to the external iliac vein can also take the place of the obturator vein. Venous and arterial anastomoses, as well as auxiliary obturator vessels derived from the external iliac systems, may be involved in the formation of CM. Moreover, in cases where arterial CM connection is present, it helps pelvic nutrition by providing anastomosis between the internal iliac artery and external iliac artery.[1–3] Pieroh et al.[4] showed that the corona mortis supplies the upper part of the symphysis pubis.

Previous studies have shown that many patients have variable obturator vessels. It is a structure of great clinical importance due to the possibility of diameters greater than 3 mm.[5] Regardless of whether the anastomosis is arterial or venous, it is known as a formation that should be considered in urological inguinal hernia repairs, gynecological interventions and orthopedic interventions due to pelvic fractures because of its localization.[6–8] Recently, laparoscopic interventions involving this region have been preferred with increasing frequency. In these procedures, damage to the anastomotic structure may occur and complications such as hemorrhage may be observed. This situation causes the patient to turn to open surgery.[9–11] Today, minimally invasive interventions are performed in many fields. CM appears as a structure to be considered for new surgical techniques used in the field of urogynecology.[6,7]

With the classical definition, CM is the anastomosis between the pubic branch of the obturator artery, a branch of the internal iliac artery, and the pubic branch of the inferior epigastric artery, a branch of the external iliac artery.[3] However, there are comments in the literature that this definition is incomplete because of the complex structure of the pelvis and the variety of vascular structures.[12–14] Even studies and meta-analysis have revealed that venous connection is more common than arterial connection.[5,15–16] The venous anastomosis structure is challenging for surgeons in surgical applications to this region as the venous anastomosis is difficult to see and is easily injured. In case of injury, provide hemostasis becomes more complicated for the surgeon.[11,17]

Notably, literature reviews indicate a scarcity of fresh cadaver studies focusing on CM.[5,18–19] The aim of this study is to determine the topographic position of the corona mortis on fresh cadavers and also to determine anatomical landmarks that will facilitate surgeons to consider to this structure during operations by clarifying the relationship of the corona mortis with the surrounding anatomical structures.

Materials and Methods

In 2019–2020, 50 forensic cases autopsied at the Ankara Group Presidency of the Forensic Medicine Institution were included in the study. All cases were examined within 24 hours of death, showed no signs of decomposition, maintained pelvic stability, and were in the age range of 18–70 years. The overall mean age of cases with CM was 46.97 (range: 19–70) years. The mean age of females was 42.92 (range: 23–70) years and 50.06 (range: 19–70) years in males.

Height was measured as head-to-heel distance from the cadaver lying in the supine position. To ensure precision and preserve anterior abdominal wall structures, an inverted V-shaped incision below the umbilicus was made, deviating from the routine vertical incision in standard autopsies.

A digital caliper with a precision of 0.01 mm was used for pelvic measurements. The measurements were performed by ZGK, the single author. The intersection of the corona mortis with the inner surface of the upper pubic ramus was determined. The midpoint of the bone distance of the anastomosis was used as the measurement point. The vertical distances from this midpoint to the promontory (P) and anterior superior iliac spine (ASIS) were recorded. In addition, the bony distance from the midpoint to the pubic symphysis (SP) and the nearest point of intersection with the ON were measured (**Figure 1**).

The data were analyzed using the SPSS (Statistical Package for Social Science for Windows, IBM SPSS 24.0 Corp.; Armonk, NY, USA). Descriptive statistics such as frequency, percentage, mean and standard deviation were used. Mann-Whitney U test was used for pairwise comparisons, and Chi-square test was used for the comparison of descriptive characteristics. Spearman correlation test was used to determine the relationship between variables. $p<0.05$ level was considered statistically significant.

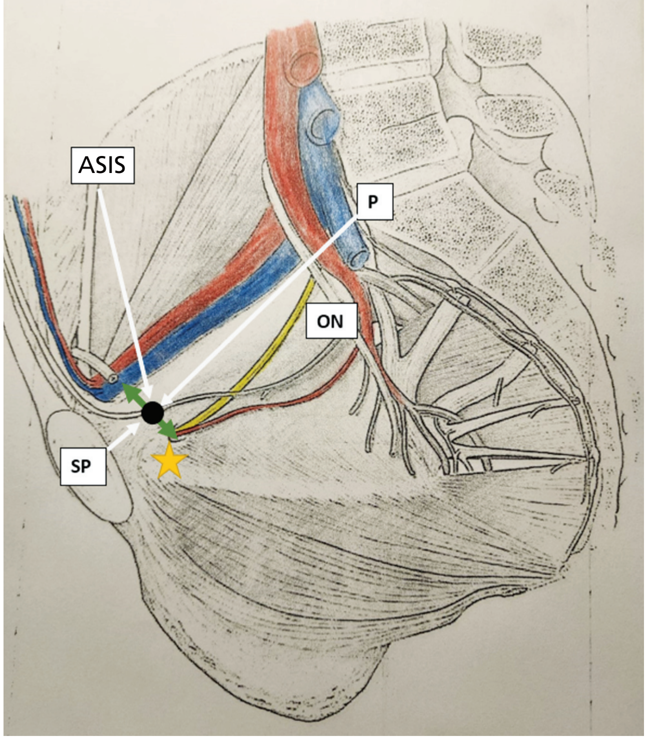

Figure 1. Corona mortis coursing across the medial surface of the superior ramus of the pubic bone (yellow star). The measurement point of corona mortis is shown as a black point. **ASIS:** anterior superior iliac spine; **ON:** obturator nerve; **P:** promontorium; **SP:** pubic symphysis.

Results

Corona mortis was observed in fifty (50%) of the hundred hemipelvis analyzed (**Figures 2** and **3**). Of these, 22 (44%) were female and 28 (56%) were male. Gender did not show a statistically significant difference in CM anastomosis formation (p>0.05). The vascular distribution of the 50 CM cases was arterial in 17 (34%) and venous in 33 (66%). Arterial and venous anastomosis were not detected together. Of the 50 CM cases, 22 (44%) were located on the right side and 28 (56%) on the left side and there was no statistically significant difference between the right and left sides (p>0.05).

The average distances of CM to SP was 5.43 (range: 4.14–7.30) cm and to ON 1.77 (range: 0–2.88) cm. On the other hand; the average distances of CM to P was 9.87 (range: 7.70–14.70) cm and to ASIS 10.56 (range: 7.50–14.00) cm (**Table 1**).

The study revealed that there were statistically significant differences between males and females in SP, ON and ASIS distances and these distances were higher in males (p<0.05). On the other hand, there was no statistically significant difference between men and women in terms of P-CM distance (p>0.05).

A strong negative correlation was observed between height and SP (r=-0.568, p<0.01), indicating that as height increases, the SP distance shortens. Height

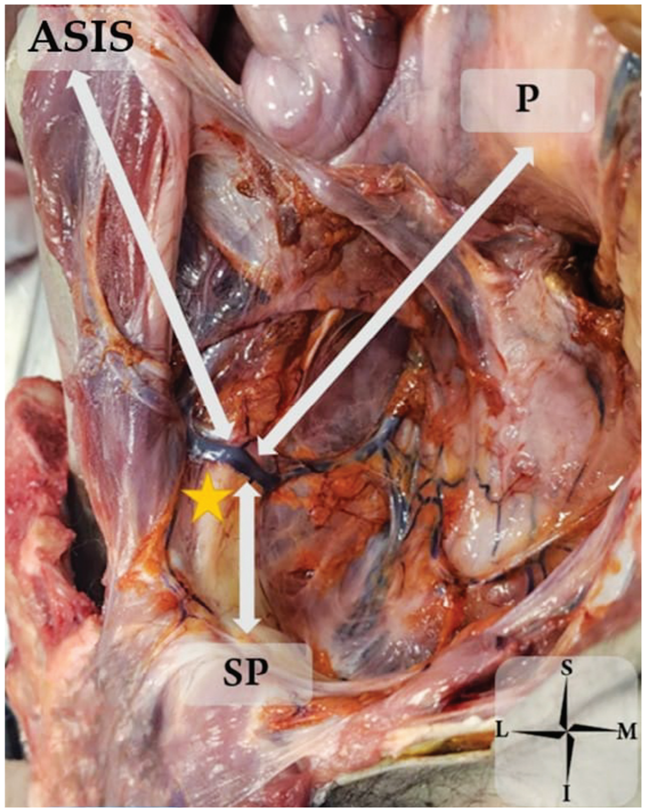

Figure 2. Corona mortis anastomosis crossing the bone on the inner surface of the superior pubic ramus (yellow star). ASIS: anterior superior iliac spine; P: promontorium; SP: pubic symphysis.

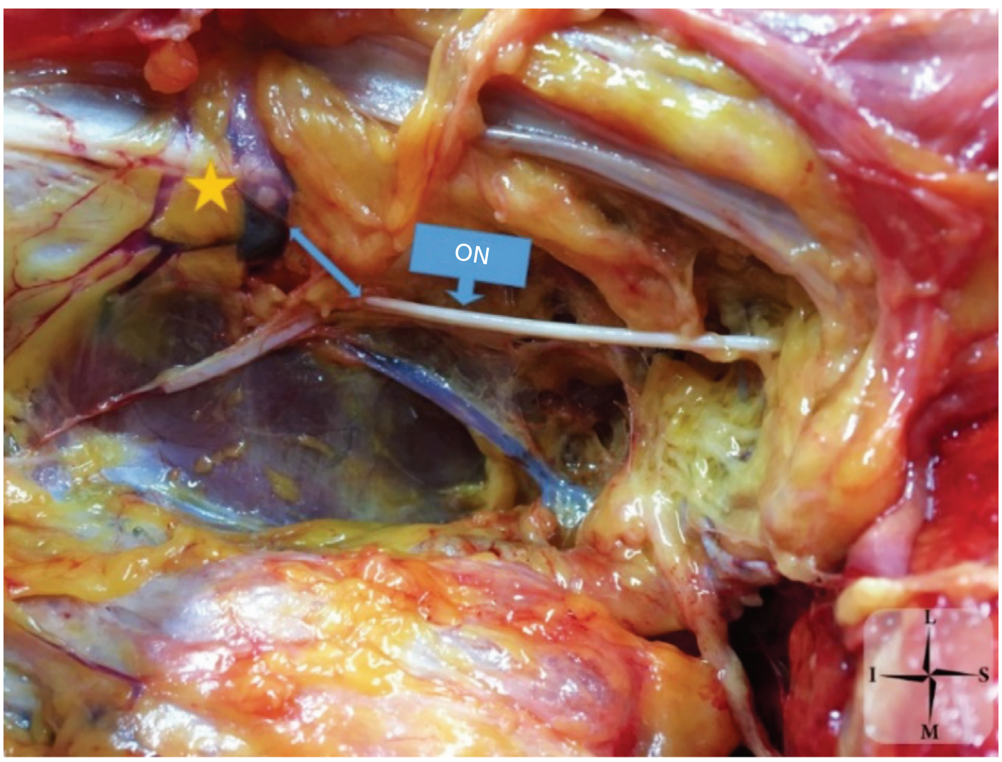

Figure 3. Corona mortis anastomosis crossing the bone on the inner surface of the superior pubic ramus (yellow star). The closest crossing point between obturator nerve (ON) and corona mortis is shown with a blue arrow.

Table 1
Distance of corona mortis to various landmarks by gender.

Gender		SP (cm)	ON (cm)	P (cm)	ASIS (cm)
Women	Mean±SD	5.73±0.86	1.36±0.38	9.48±0.77	9.94±1.2
	Median	5.77	1.42	9.50	9.50
	Minimum	4.20	.00	8.00	8.50
	Maximum	7.30	1.93	10.50	12.50
Men	Mean±SD	5.2±0.78	2.1±0.45	10.18±1.85	11.05±1.54
	Median	5.03	2.17	9.50	11.00
	Minimum	4.14	1.05	7.70	7.50
	Maximum	7.20	2.88	14.70	14.00

ASIS: anterior superior iliac spine; **ON:** obturator nerve; **P:** promontorium; **SD:** standard deviation; **SP:** pubic symphysis.

demonstrated a moderate positive correlation with both ON and ASIS (r=0.391, p<0.01, and r=0.324, p<0.05, respectively), suggesting that as height increases, ON and ASIS distances also increase. However, no correlation was found between height and P value.

Furthermore, the study identified a strong negative correlation between SP distance and ON distance (r=-0.513, p<0.01), signifying that as the SP distance increases, the ON distance decreases. SP and ON distances showed no correlation with P and ASIS values (p>0.05). Notably, a moderate positive correlation was established between P distance and ASIS (r=0.339, p<0.05).

Discussion

Any vascular structure (arterial, venous or both) crossing the super pubic ramus can be considered as "corona mortis".[8,15] Many studies have attempted to classify corona mortis. It is complicated because of the variant the obturator artery origin.[5,18,20]

Surgical interventions within the pelvic region pose significant challenges to surgeons owing to the intricate anatomy of this area. Given the vital importance of understanding the vascular structures in the pelvic region, identifying topographically safe areas becomes imperative for guiding surgeons.[6,7,17]

Most of the studies conducted on the pelvic region are studies performed on embalmed cadavers.[5,20] There are some limitations in the study conducted by Ateş et al.,[21] which examined laparoscopic inguinal hernia surgeries. The pelvis was not examined bilaterally in all cases included in the study. In addition, venous anastomoses could not be seen at the standard 14 mmHg CO_2 pressure given to the patients, but were detected when the pressure was reduced to 10 mmHg. This means that fresh cadaver studies, as we did in our study, have specific advantages such as preservation of tissue integrity, absence of intraoperative variables, and the potential for more accurate anatomical evaluation. In this respect, autopsy studies conducted in our country provide important data.

Pelvic region trauma is an area that requires attention in forensic medicine practice.[22] If traumas occurring in this area result in death, autopsy is the gold standard to investigate the accuracy of medical practices applied after the injury and to determine the cause of death. Studies have shown that demonstrating pelvic vascular injuries by autopsy gives better results than tomography.[23] Pelvic region vascular structures are a subject that must be mastered not only by surgeons but also by forensic experts in postmortem studies.

In the meta-analysis conducted by Cardoso et al.[18] in 2021; a total of 3107 hemipelves were examined in 18 articles included in the study, and the incidence of CM regardless of the vessel type was found to be 63%±20% (min: 20%, max: 96%). Similar to this high incidence of finding, our study identified CM in 50 out of 100 hemipelves. Studies have revealed that the incidence of corona mortis is more common in Asia (59.3%) compared to Europe (42.8%) and North America (44.3%).[24] Based on the similar detection rates in our study, the high incidence of CM in our country also ensures that the anatomy of this region is known and preoperative preparations become even more important in terms of pelvic surgery.

Although CM was presented as an arterial anastomosis when it was first discovered, studies conducted in later years showed that it was more commonly found as a venous anastomosis.[15,18,25] In the meta-analysis conducted by Marvanova and Kachlik [5] in 2024; data on venous variations of the corona mortis were reported in 27 investigations (n= 2877 hemipelves), with an average incidence of 54.57% (ranging from 17.14% to 100%) (5). In our study, consistent with the literature, 34% of the anastomosis was found to be arterial (n=17) and 66% was venous (n=33). Venous anastomosis is an important situation for surgeons in surgical procedures to this area. In case of venous injury in this region, the surgery becomes more complicated for surgeons.[11,17,21] Thus, pre-operative knowledge of the locations of venous anastomoses, as highlighted in this study, can contribute to safer surgical approaches.

One of the bone measurement points used for laparoscopic studies is the pubic symphysis.[10] The distance of the CM to the SP, which becomes a clear measurement point after entering the retroperitoneal space, was measured as 33.4 (range: 21.4–41) mm in 98 right hemipelves conducted by Karakurt et al.[26] In another study examining 50 hemipelves, it was found to be 6.2 (range: 3–9) cm.[22] Our study is also compatible with the literature information[5] and the average SP distance of the CM anastomosis was determined as 5.43±0.85 cm. It has been observed that this distance is longer in men than in women. It is thought that this difference may be due to the difference in pelvic structure between men and women in the Turkish population.[27] Furthermore, a substantial negative association was noted between height and SP and a somewhat positive correlation with ON and ASIS were noted, despite the fact that no link was identified between height and P value. This underscores the potential significance of anthropometric measurements, often overlooked in practice, as a valuable noninvasive method in corona mortis examinations.

ON which is a branch of the lumbar plexus and is formed by the union of the branches coming from the L2–4 lumbar nerves, emerges from underneath the medial margin of the psoas major muscle, progresses to the pelvis and enters the obturator canal together with the homonymous vessels. ON is the most commonly encountered nerve in radical hysterectomy. The course of ON is important because it establishes the boundaries of pelvic lymph node dissection. It is necessary to dissect the lymph nodes until the ON is visible.[28] Protecting the ON itself and the surrounding anatomical structures used for oncogynecological surgery is also a priority for the surgeon. CM localization is closely related to ON, and in the literature review, no study showing the relationship between these two structures could be found. The midpoint of the superior ramus of the pubic bone distance, or the midpoint of the CM's bone transition, served as the measurement site for this investigation (**Figure 1**). The average distance from the CM to the ON was 1.77 (range: 0–2.88) cm. In one instance, the obturator nerve's pelvic route intersected the CM. Therefore, the findings obtained can make an important contribution to developing safer and more effective methods in medical practices by filling the gap in knowledge about the distance between these two structures.

There are many orthopedic interventions for the pelvic region, especially pelvic fractures. The biggest cause of death in the first 24 hours of pelvic fractures is bleeding.[29] The plates used during the treatment of these fractures with the intrapelvic approach also extend to the superior ramus of the pubic bone. For this reason, the vascular structures in this region are at risk both from the trauma itself and from the surgical intervention performed.[30] In this study, we measured the distances of P and ASIS, two points commonly utilized as guides in open pelvic surgeries, from the CM. The utilization of these landmarks and neurovascular data may mitigate the risks associated with intraoperative approaches.

In summary, what we found in our study, the significance of SP and ON distances is noteworthy for laparoscopic surgeries, while P and ASIS distances serve as crucial landmarks in open surgery. Given the challenges in identifying veins during surgery, and the potential for serious bleeding from vein injuries, specifying the locations of CM before the operation, elucidating their relationships with surrounding structures, and detailing the landmarks of these variations on the bone are expected to facilitate the surgeon's tasks.

In future studies, it is important to adopt multidisciplinary approaches to more clearly understand the effects of anatomical details in the pelvic region on various surgical practices and to integrate this knowledge into clinical practice. In this way, it is thought that it will contribute to making surgical interventions safer, more effective and patient-oriented.

The limitations of the study are that all cadavers included in our study were forensic autopsy cases. Due to forensic processes and security reasons, measurements could only be performed by the author within a limited time. Due to the limited autopsy time, the structures in the dissected area could not be revealed and photographed as in fixed anatomy cadaver studies. Another limitation was the difference in the number of cases between males and females since the majority of deaths in forensic cases were male.

Conclusion

The pelvic region is of vital importance for many medical specialties. This study stands out as a step that encourages cooperation between different surgical disciplines and increases the knowledge in this field. In gynecological, urological and orthopedic surgical applications, anatomical knowledge of the corona mortis plays a critical role in surgical planning and safe performance of procedures. This study provides guidance not only for surgeons but also for forensic medicine specialists.

Conflict of Interest

There is no conflict of interest.

Author Contributions

ZGK: concept, design, literature search, data collection, processing, analysis and interpretation of the results, writing the manuscript; AU: design, literature search, writing the manuscript.

Ethics Approval

Approval for the study was received from the Scientific Research Board of the Istanbul Forensic Medicine Institute (Number: 21589509/2019/373, date: 20.05.2019).

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Sonographic findings of COVID-19-related acute dacryoadenitis

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Abstract

Objectives: To evaluate the ability of grayscale sonography and color Doppler sonography in determining the involvement of the lacrimal glands in coronavirus disease (COVID-19).

Methods: A retrospective analysis was performed on a total of 25 COVID-19 patients with symptoms of acute dacryoadenitis and 25 healthy participants. The study's inclusion criteria encompassed pain, swelling, and discomfort in the superior temporal aspect of the upper eyelid and orbit, consistent with acute dacryoadenitis occurring within 30 days of a positive test for SARS-CoV-2. PCR testing yielded positive results for all patients. Inclusion criteria for healthy participants included asymptomatic orbit and upper lid, no prior trauma or surgery involving the orbit, no evidence of upper respiratory tract infection consistent with SARS-CoV-2 in the past 6 months, and no history of systemic inflammatory disorders. The evaluation of the lacrimal gland and periorbital adipose tissue involved gray-scale and color Doppler ultrasonography to assess echogenicity, homogeneity, vascularity and enlargement of the lacrimal gland. The patients involved in the study underwent orbital examination and US evaluations repeated at 3 weeks and 3 months.

Results: The mean age of the patients were 41.5±12.2 years (range, 18 to 63 years), while for the healthy participants, it was 34.4±5.2 years (range, 18 to 47 years). Significant differences were observed in the echogenicity ($p=0.025$), homogeneity ($p=0.018$), and vascularity ($p<0.001$), size ($p<0.001$) of the lacrimal gland between healthy participants and COVID-19 patients exhibiting symptoms of acute dacryoadenitis. However, no difference was noted in the perilacrimal fat tissue changes between COVID-19 patients with symptoms of acute dacryoadenitis and the control group ($p=0.054$).

Conclusion: Gray-scale and color Doppler ultrasonography demonstrates as a valuable radiologic technique for assessing the acute onset involvement of the lacrimal glands in COVID-19.

Keywords: acute dacryoadenitis; COVID-19; ultrasonography

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Introduction

The lacrimal gland, an exocrine gland responsible for the aqueous component of lacrimal fluid production, is located in the orbit on the lateral side of the orbital rim of the frontal bone. It is divided into two parts, palpebral and orbital, by the levator palpebrae superioris muscle. The lacrimal fluid produced by this gland drains into the nasal cavity through the lacrimal puncta, lacrimal canaliculi, lacrimal sac and nasolacrimal ducts.[1]

Dacryoadenitis is an inflammatory condition affecting the lacrimal gland. Acute dacryoadenitis (AD) is characterised by a rapid inflammatory process affecting the lacrimal gland, often seen in children and women.[2] The main causes of acute dacryoadenitis include viral, bacterial, traumatic and autoimmune factors. Among these, Epstein-Barr virus stands out as the most common pathogen, while others include adenovirus, mumps virus, herpes simplex virus and herpes zoster virus.[3,4] Typical symptoms of AD include orbital pain, painful eye movements, swelling and discomfort in the upper eyelid, and red eye appearance. Common signs of AD include tenderness, swelling, redness and droopy eyelid (ptosis) in the temporal region of the orbit (**Figure 1**).

The coronavirus disease (COVID-19) is an infectious illness caused by SARS-CoV-2. Since its emergence in 2019, COVID-19 has become a significant global health

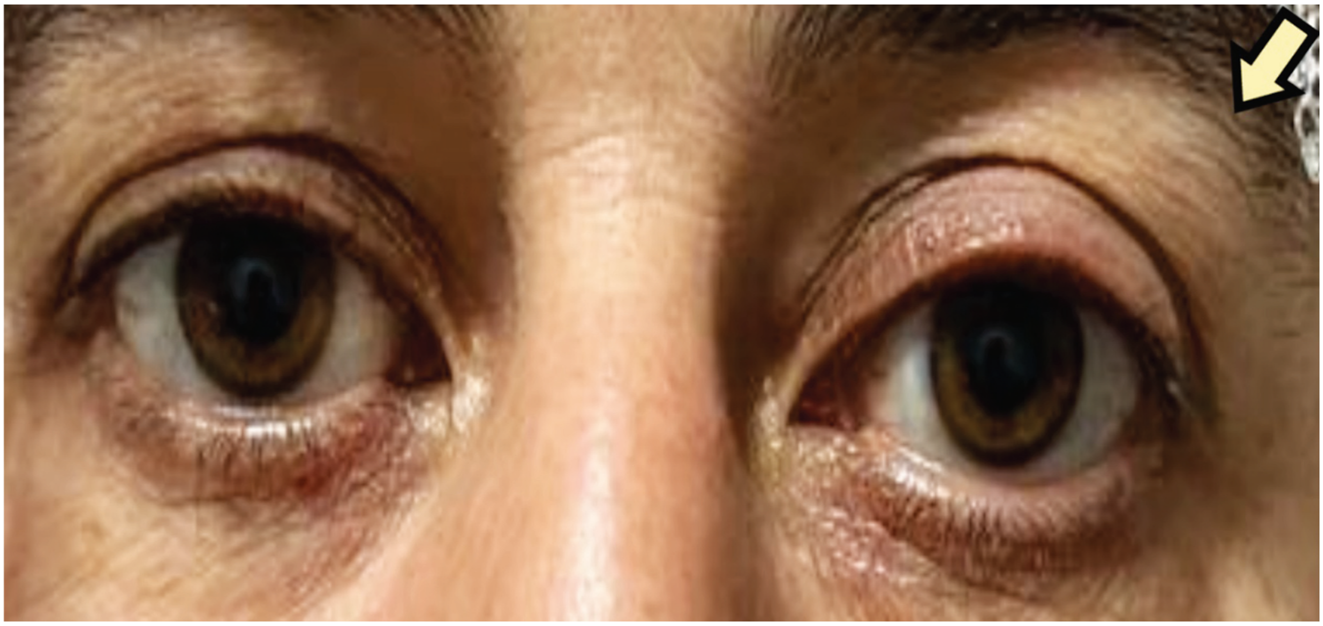

Figure 1. 42 years of female COVID-19 patient with left upper temporal eye lid swelling localized to lacrimal gland (**yellow arrow**).

concern, leading to widespread impacts on human health and society.[5] Recently, ocular complications associated with the coronavirus (SARS-CoV-2) have been reported. These complications include follicular conjunctivitis, inflammatory changes in both the anterior and posterior segments of the eye, orbital cellulitis, and retinal disorders such as retinal vasculitis and retinal degeneration.[6] Involvement of the lacrimal gland by SARS-CoV-2 is exceptionally rare, and only a limited number of studies and case reports have documented such occurrences, primarily presenting as acute dacryoadenitis.[2,7–10]

The diagnosis of AD is primarily established through the identification of typical clinical manifestations and physical examination findings. Additionally, a range of radiologic modalities are utilized for diagnosing AD, including conventional sonography and color Doppler ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI).[11]

Inflammatory changes, autoimmune disorders, and masses affecting the lacrimal gland can be effectively visualized using sonography and elastography techniques.[12,13] The lacrimal gland is situated in the superior lateral aspect of the globe.

The ocular globe and lacrimal artery serve as key landmarks for locating the lacrimal gland during examination. Once the lacrimal gland is identified, sonographic evaluation can be easily performed. Although the lacrimal gland presents as a homogeneous hypoechoic exocrine gland similar to other salivary glands, sonography is infrequently employed in clinical practice for diagnosing AD, despite the superficial location of the glands.

This study aimed to investigate the potential utility of sonographic imaging in diagnosing lacrimal gland involvement in COVID-19 by assessing imaging features such as echogenicity, homogeneity, vascularity and dimensions of the lacrimal gland.

Materials and Methods

Approval was obtained from the institutional review board and informed consent was obtained from all participants before starting the study. The study included 25 patients with a clinically confirmed diagnosis of COVID-19 who presented to the hospital with acute dacryoadenitis symptoms between January 2020 and January 2022 and 25 healthy participants. The inclusion criteria for this study involved the presence of pain, swelling, and discomfort in the superolateral aspect of the upper eyelid and orbit, consistent with AD within 30 days of a positive test for SARS-CoV-2. PCR testing yielded positive results for all patients. Healthy participants were included based on criteria including asymptomatic orbit and upper lid, absence of prior trauma or orbital surgery, no symptoms of upper respiratory tract infection compatible with SARS-CoV-2 within the preceding 6 months, and no history of systemic inflammatory disorders. PCR testing was negative for the control group over the preceding 6 months. Exclusion criteria involved a clinical history of surgery, fracture, or other diseases affecting the lacrimal gland, such as sarcoidosis, Sjögren's syndrome, Graves' disease and wegener granulomatosis, as well as chronic progression of acute dacryoadenitis due to conditions such as syphilis, leprosy, tuberculosis, and trachoma.

Both the control group and patients underwent examination using gray-scale and color Doppler sonography (LOGIQ S7 Expert, GE Medical Systems, Chicago, IL, USA utilizing a 5–11 MHz linear-array transducer, performed by a radiologist with 5 years of experience. In our study, all participants were positioned supine on a stretcher with their heads turned to the opposite side and their eyelids closed. Following the application of a conductive gel, the 5–11 MHz linear array transducer was placed directly over the skin corresponding to the lacrimal fossa region. The examination of the lacrimal gland began obliquely, with the scanning plane parallel to the superotemporal aspect of the supraorbital margin. Landmarks such as the ocular globe and lacrimal artery were used to locate the lacrimal gland. Once identified, the longitudinal and transverse diameters of the lacrimal gland were measured by orienting the probe in transverse and craniocaudal directions. Gray scale and color Doppler sonography were performed using the 5–11 MHz linear array transducer. Doppler parameters were adjusted to detect low velocity or low volume flow, or both.

Anterior segment examination and dilated fundoscopy revealed normal findings, with no signs of intraocular inflammation. The patients involved in the study underwent orbital examination and ultrasonography (US) evaluations repeated at 3 weeks and 3 months.

All statistical analyses were conducted using SPSS software (version 26.0, IBM Corp., Armonk, NY, USA). Continuous variables were described using the median and range, while categorical variables were described using counts and percentages. The normality of distribution for variables was assessed using the Kolmogorov-Smirnov test. To compare continuous variables between healthy participants and patients, the Mann-Whitney U test and Kruskal-Wallis test were employed. Categorical variables were analyzed using the chi-square test and Fisher exact test. A p-value <0.05 was considered statistically significant.

Results

The study included a total of 50 participants, divided into two groups: 25 patients and 25 healthy participants. Among the 50 participants in the study, 21 were males and 29 were females. Of the 25 patients, 9 were male and 16 were female. Of the 25 participants in the control group, 12 were male and 13 were female. The mean age of the patients was 41.5±12.2 years and ranged between 18 and 63 years. The mean age of healthy participants was 34.4±5.2 years and ranged between 18 and 47 years. There was no significant difference between patients and healthy participants for age and gender (p=0.345 and 0.312 respectively). In 25 patients with clinically confirmed COVID-19 and symptoms of acute dacryocystitis, 11 patients had unilateral right lacrimal gland involvement, 12 patients had unilateral left lacrimal gland involvement, and 2 patients had bilateral lacrimal gland involvement. The participants included in this study had a total of 27 lacrimal glands with symptoms compatible with AD and 50 normal lacrimal glands. The mean time to the onset of symptoms of AD after COVID-19 infection was 17.7 days±6.8, with a range of 7 to 30 days. These baseline characteristics of the participants were summarized in **Table 1**.

The echogenicity of the lacrimal gland was increased in 23 out of 25 patients (92%). The homogeneity of the lacrimal gland was inhomogeneous in 18 out of 25 patients (72%). The vascularity of the lacrimal gland was increased in 20 out of 25 patients (80%). The resistive index in patients was low resistance flow (0.65±0.05).

Table 1
Demographic data of COVID-19 patients with symptoms of acute dacryoadenitis and control group.

	COVID-19 patients with acute vertebral level dacryoadenitis findings (n=25)	Control group (n:25)	p-value
Age	33.5±12.2 (min: 18; max: 43)	29.95±5.8 (min: 18; max: 34)	0.345
Male/female	9/16	12/13	0.312
Mean time to AD symptoms after COVID-19	17.7±6.8 (min: 7; max: 30) days	-	
Lacrimal gland involvement	right: 11 left: 12 bilateral: 2	-	

Perilacrimal fat tissue was normal in 18 out of 25 patients (72%). The mean transverse diameter of the lacrimal gland in patients group was 14.19±2.38 mm, ranged between 9 mm to 18.2 mm. The mean anteroposterior (AP) diameter of the lacrimal gland in patients with AD was 8.08±1.9 mm, ranging from 5.5 mm to 12 mm.

Among the 50 lacrimal glands examined in the 25 control healthy group, the echogenicity of the lacrimal gland was normal in 44 out of 50 glands (88%). The homogeneity of the lacrimal gland was normal in 49 out of 50 glands (98%). Vascularity of the lacrimal gland and echogenity of perilacrimal fat tissue showed normal sonography parameters in healthy participants. The resistive index in healthy participants was low resistance flow (0.62±0.04). The mean transverse diameter of the lacrimal gland in healthy participants was 7.89±1.5 mm, ranged between 9 mm to 18.2 mm. The mean AP diameter of the lacrimal gland in healthy participants was 5.14±1.05 mm, ranged between 3.2 mm to 7.7 mm.

The echogenicity of the lacrimal gland exhibited significant differences between healthy participants and COVID-19 patients (p=0.025). The homogeneity of the lacrimal gland exhibited significant differences between healthy participants and COVID-19 patients (p=0.018). Vascularity of the lacrimal gland exhibited significant differences between healthy participants and COVID-19 patients (p<0.001). The transverse diameter of the lacrimal gland in patients (14.19±2.38 mm, range: 9–18.2 mm) was significantly increased compared to healthy participants (7.89±1.5 mm, range: 9–18.2 mm) (p<0.001). Additionally, the AP diameter of the lacrimal gland in patients (8.08±1.9 mm, range: 5.5–12 mm) was significantly increased compared to healthy participants (5.14±1.05 mm, range: 3.2–7.7 mm) (p<0.001). However, there was no significant difference observed in the perilacrimal fat tissue changes between COVID-19 patients and the control group (p=0.054). And, no significant differences in the RI were measurable between AD (RI: 0.65±0.5) and control group (RI: 050.62±0.04) (p=0.078).

The sonographic characteristics of participants were summarized in **Table 2**.

Discussion

The ocular complications associated with SARS-CoV-2 infection include follicular conjunctivitis, inflammatory changes in the anterior and posterior segments, orbital cellulitis, and retinal disorders such as retinal vasculitis and retinal degeneration. However, lacrimal gland involvement due to SARS-CoV-2 infection is remarkably rare. Only a few studies and case reports have documented lacrimal gland involvement in the form of acute dacryoadenitis.[2,6–9]

There are limited previous studies regarding the evaluation of the effectiveness and reliability of lacrimal gland US in gland pathology. Giovagnorio et al.[14] evaluated that sonography was able to visualize 12 out of 30 lacrimal glands in 6 out of 15 patients affected by Sjögren's syndrome as significantly larger than normal (major axis: 7.6±0.9 mm; minor axis: 3.5±0.4 mm). Our study also revealed that the gland diameter was significantly enlarged in COVID-19-related AD patients compared to the control group. Ali et al.[15] demonstrated that the vascular flow around the lacrimal sac was increased with higher flow velocities in primary acquired nasolacrimal ducts obstruction compared to normal conditions. Moreover, Martinoli et al.[16] reported that color and power Doppler sonography could be utilized in the diagnosis and differentiation of chronic inflammatory processes and malignant tumors of

Table 2
Sonographic evaluation of COVID-19 patients with acute dacryoadenitis findings and control group.

Sonographic findings		Acute dacryoadenitis (n=25)	Control group (n:25)	p-value
The echogenicity of lacrimal gland	Normal	4	44	0.025
	Increased	23	6	
Homogeneity of lacrimal gland	Homogeneous	9	49	0.018
	Inhomogeneous	18	1	
Vascularity of lacrimal gland	Normal	7	50	<0.001
	Increased	20	-	
Perilacrimal fat tissue changes	Normal	18	50	**0.054**
	Increased	9	-	
Lacrimal gland transverse diameter		14.19±2.38 (min: 9; max: 18.2) mm	7.89±1.5 (min: 9; max: 18.2) mm	**<0.001**
Lacrimal gland AP diameter		8.08±1.9 (min: 5.5; max: 12) mm	5.14±1.05 (min: 3.2; max: 7.7) mm	**<0.001**

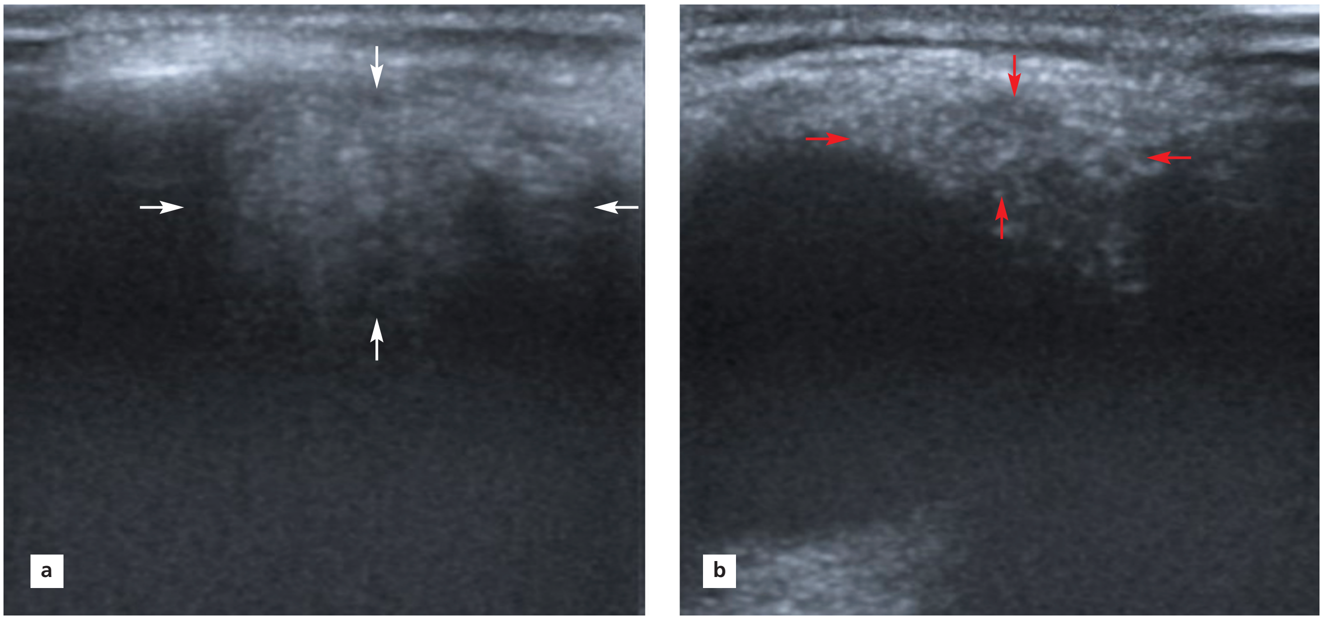

Figure 2. (**a**) B mode sonography findings of increased echogenicity, inhomogeneity, and enlargement of lacrimal gland (right side) (**white arrows**), compared to (**b**) healthy participant (**red arrows**).

the salivary glands. Additionally, Lecler et al.[17] demonstrated that non-epithelial lesions and acute dacryoadenitis were significantly more likely to present with high vascular intensity, both central and peripheral vascularization, tree-shaped vascularization, and a low resistance index (RI). Our study is consistent with previous studies that increased vascular flow in lacrimal dacryoadenitis. De Lucia et al.[18] revealed that lacrimal gland ultrasonography (US) is reliable imaging for the evaluation of US features in healthy subjects with a good-excellent intra and inter-rater reliability and the inter-rater agreement for the glandular parenchyma visibility, homogeneity, and size was good, and moderate for fibrous gland appearance.

All patients exhibited symptoms of pain, swelling, and discomfort in the superolateral aspect of the upper eyelid and orbit, consistent with AD, within 30 days of testing positive for SARS-CoV-2 (**Figures 2** and **3**). Anterior segment examination and dilated fundoscopy revealed normal

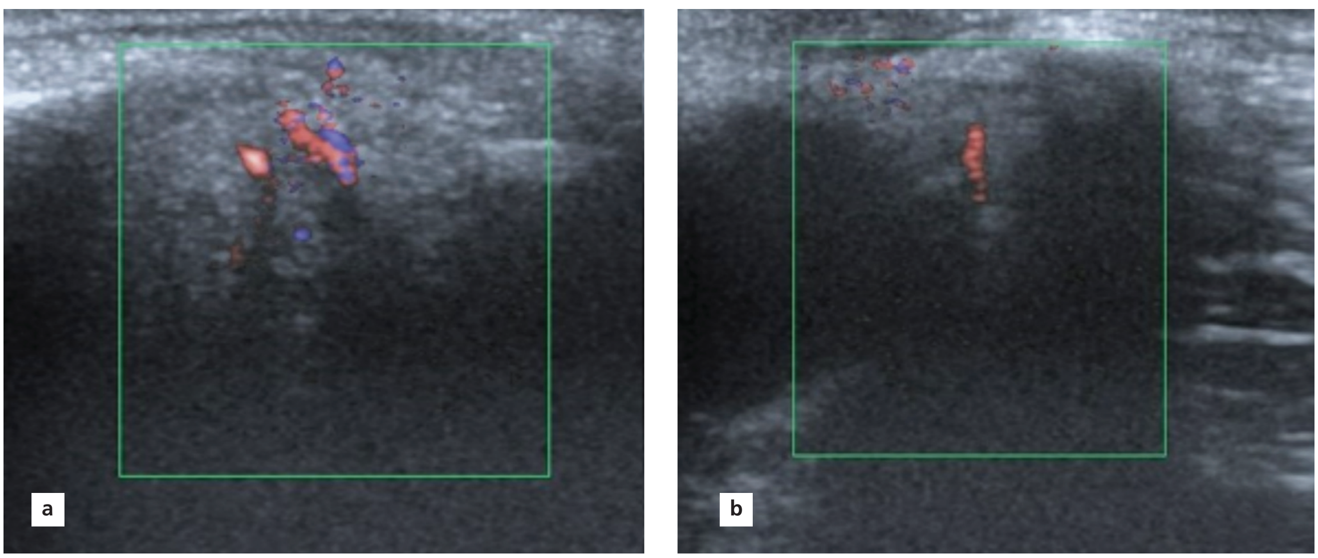

Figure 3. (**a**) Color Doppler sonography findings increased increased vascularity of the right lacrimal gland (right side), compared to (**b**) healthy participant.

findings, with no signs of intraocular inflammation. All patients' symptoms improved with one week of topical antibiotic-steroid and oral non-steroidal anti-inflammatory treatment. Normal visual and orbital functions were observed during the 3rd week and 3rd month follow-up examinations. During the 3-week follow-up examinations, increased echogenicity in the lacrimal gland persisted. And all sonographic parameters were observed to be normal during the 3-month follow-up examinations.

To our knowledge, this is the first study to evaluate acute dacryoadenitis after coronavirus (SARS-CoV-2) disease using sonographic and Doppler ultrasound. There are few case reports regarding coronavirus-related acute dacryoadenitis. Only three case reports have shown acute onset of lacrimal gland involvement in COVID-19 disease.[5–10] This study demonstrates that sonography and color doppler ultrasound is a reliable diagnostic tool for clinically confirmed COVID-19 patients with symptoms of Acute dacryoadenitis and US features such as increased echogenicity, inhomogeneity, increased vascularity, and enlargement of lacrimal gland are important US findings for AD. While the diagnosis of lacrimal gland involvement in AD in COVID-19 disease relies on clinical and laboratory criteria, evaluating structural changes in the glands and periorbital inflammation involvement necessitates diagnostic imaging modalities such as CT and MRI. Sonography is able to provide noninvasively volumetric and structural information needed by the clinician. Based on our experience, gland enlargement, increased echogenicity, and vascularity were found to correlate with lacrimal gland involvement in the disease process. Sonography accurately allowed for the assessment of gland dimensions, as it can identify the optimal plane in real time for measuring both transverse and anteroposterior diameters. Changes in echotexture of gland, periorbital echogenicity and vascularity, were reliably identified, making ultrasonography a viable tool for monitoring and follow up structural changes during disease progression.

Several limitations need to be acknowledged in this study. Firstly, ultrasonography imaging is a highly operator-dependent modality. We did not assess interobserver and intraobserver variability. To avoid sampling error, we measured the diameter of the lacrimal gland twice and calculated an average measurement. Secondly, histopathological correlation of AD was not conducted as the gold standard test, due to the invasive nature of the procedure. Thirdly, there was no radiologic correlation between ultrasound and other imaging modalities such as CT and MRI. Lastly, the study's sample size for both healthy participants and the disease group was small.

Conclusion

Lacrimal gland grey scale and colour Doppler ultrasonography are emerging as promising and valuable sonographic techniques to assess acute-onset involvement of the lacrimal glands in COVID-19, and reliable sonographic parameters such as echogenicity, homogeneity, vascularity and enlargement of the lacrimal gland contribute to the diagnostic accuracy of the disease.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

SE: designed the research study, performed the research, analyzed the data and wrote the manuscript; MCÖ: performed the research, analyzed the data and wrote the manuscript; MB: designed the research study; all authors have read and approve the final manuscript.

Ethics Approval

Approval for this retrospective study was obtained from the institutional ethics committee (Ethics Committee of Ankara Bilkent City Hospital, Ankara, Turkey, decision number: ABCH-EK-2023/09-E2-23-4907).

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Morphometric description of the subfascial intermuscular adipose tissue of anterior compartment of the leg

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Abstract

Objectives: To describe the morphological characteristics of subfascial intermuscular adipose tissue (IMATS) in the anterior compartment of the leg, considering its developmental and functional relationship with the crural fascia.

Methods: In twenty formalin-fixed cadaveric legs (13 males, 7 females), after removal of the skin and crural fascia, the IMATS was exposed and classified into four types according to its shape. Leg length was divided into eight regions. The length, width at the widest point, closest distances of the upper and lower ends to the intermalleolar line and the anterior margin of the tibia, as well as the thickness of the skin-subcutaneous tissue complex, limb and leg lengths were measured for IMATS.

Results: The most common type of IMATS was the short-large type. The largest point of IMATS was located in zone 3 or 4, and this point was located in the two zones closest to the lower end of IMATS in 75% of cases. In all cases, one to three connecting vessels piercing the crural fascia (80% were in zones 2, 3 or 4) connected to the IMATS in a slightly lateral to medial oblique course of the IMATS from top to bottom. The IMATS was superficially located in the tendinous and muscular parts of the extensor digitorum longus and/or tibialis anterior muscles, loosely attached to the muscles and crural fascia, but not between the muscle fibers. Although the largest point ($p=0.041$) and the distance from the distal end to the anterior margin of the tibia were found to be greater in males ($p=0.049$), the gender difference disappeared when normalized for limb length.

Conclusion: No data on IMATS morphometry could be found in the literature. A remarkable finding of the study, which is open to interpretation in terms of the function of the IMATS, is that the location of the IMATS overlaps with the crural fascia region, which is reported to be biomechanically stiffer in the transverse direction. Our data that a connecting vessel is always connected to the IMATS by a fixed spatial relationship strengthens the argument that the developmental history of both structures may intersect.

Keywords: anterior compartment of leg; crural fascia; extensor digitorum longus; fat pad; intermuscular adipose tissue; tibialis anterior muscle

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Introduction

Adipose tissue serves as an energy storage, a metabolic lipid source, thermal insulation and mechanical shock absorber, and adapts to the changing shape and volume of the components during movement.[1] These tissues, which can produce inflammatory mediators and growth factors, are considered an endocrine organ with sensory and immune functions.[2] Intermuscular fat masses are typically deposits of lipids in adipocytes beneath the deep fascia of the muscle, and can be found intramuscular or intermuscular.[3] Intramuscular ones are the result of ectopic lipid accumulation in myocytes, while intermuscular adipose tissues (IMAT) are described as visible muscle fat deposits resulting from the infiltration of fatty tissue between muscle fibers.[4] The prevailing view regarding the formation of IMAT suggests that depending on the conditions, satellite cells around the myofibrils, differentiate into adipocytes and become fat depots instead of muscle precursor cells.[5,6]

Under normal conditions, adipogenic formation or differentiation of muscle satellite cells is negligible in healthy muscles; however, the adipogenic potential changes with age, and factors such as increased insulin resistance, decreased oxygen supply, and alterations in metabolic conditions may induce muscle satellite cells to undergo the alternative mesenchymal lineage differentiation pathway, ultimately increasing IMAT accumulation by increasing their transformation of satellite into mature adipocytes.[5]

The function of IMAT, found in certain amounts in normal individuals, is not yet clearly understood. It has been suggested that decreased physical activity in healthy individuals causes significant (15–20%) increases in IMAT levels without changes in subcutaneous adipose tissue.[7] Excess IMAT is associated with lower levels of muscle strength, impaired mobility, older age and higher risk of disability.[3,7–12] It is acknowledged that adipose tissues not only serve as energy storage but also have a direct mechanical function, providing protection for sensitive organs and buffering body parts exposed to high levels of mechanical stress.[13,14]

Kager's fat pad is an example of a deep-seated fat pad, i.e. IMAT, that can assume biomechanical roles. It is suggested that during ankle plantar flexion, this fat pad helps lubricate the subtendinous region of the Achilles tendon as it moves towards the bursal space, increasing the efficiency of the system.[15–17] Similarly, it is accepted that the infrapatellar fat pad acts as a biomechanical support and stabilizing role, absorbs a portion of the load reaching the joint. It provides the distribution and dampening of mechanical stresses during joint activity, and distributes the tensile stress around it homogeneously to neighboring biological structures through its cushioning role in the knee joint.[13,18–20]

Anatomical studies evaluating IMAT in crural compartments are quite limited in the literature. Takumi et al.[21] suggested that adipose tissue located deep within the crural fascia (CF) in the posterior compartment of the leg may reduce frictional and compressive stress, and present data suggesting that pain complaints associated with medial tibial stress syndrome may be a result of inflammation of this fat pad. Ortiz-Miguel et al.[22] mentioned a fat pad located between the extensor digitorum longus muscle (EDL) and tibialis anterior muscle (TA) in the anterior compartment in their study on CF and related anatomical structures but did not mention the morphological features of the fat pad. In Stecco's book "Functional Atlas of the Human Fascial System", in which he discusses fascia in a comprehensive and detailed manner, the fat pad can be clearly distinguished in cadaveric images of the anterior compartment of the leg, but no specific definition or name is given to this structure.[23]

This study aims to identify the subfascial intermuscular adipose tissue (IMATS), which is located as a fat pad deep to the CF superficial to the EDL and/or TA in the anterior compartment of the leg, and to evaluate its anatomical features in relation with its possible developmental history and biomechanical role.

Materials and Methods

Twenty formalin-fixed cadaver legs (13 males, 7 females, 9 bilateral sides) from the inventory of the Anatomy Laboratory of Mersin University were included in the study. There was no significant difference in mean age between male (66.35±9.72) and female (67.74±1.55) cadavers.

After the skin-subcutaneous tissue complex (SSTt) of the anterior leg was dissected, two transverse incisions were made in the CF, passing through the head of the fibula above and the intermalleolar line below. With a longitudinal incision following the medial side of the anterior intermuscular septum, the CF of the anterior compartment was incised from the lateral edge, and then it was released from the deep muscles and IMATS with a gentle blunt dissection technique and deviated medially (**Figure 1**). Along the medial edge of the CF, the anterior compartment was divided into four equal parts throughout its length as: first quarter (Q1), second quarter (Q2), third quarter (Q3) and fourth quarter (Q4). Then the Q2, Q3 and Q4 parts where IMATS could be located were divided into two on the photographs and six regions were determined that would allow the relative settlement relationships of the structures to be analyzed (**Figure 2a**). IMATS was revealed and classified into four types according to its shape (**Figure 2**).

IMATS was distinguished with a near-longitudinal oblique course deep to the CF of all legs, mostly in the lower half of the anterior compartment. To describe the location and dimensions of the IMATS, its length, width at the largest point, the distance of its distal end to the anterior margin of the tibia and to the intermalleolar line were measured. The zones of the upper end, lower end, largest point of the IMATS and, if present, the connecting vein connecting to the IMATS by piercing the CF were noted (**Figure 2a**). The thickness of the SSTt of the same region was measured at the level of the IMATS. A digital caliper with 0.01 mm precision (MARCAL 16 ER, Mahr, Gottingen, Germany) was used for these measurements. In addition, the length of lower extremity (distance from the anterior superior iliac spine to the lowest point of the heel) and leg length (distance between the two transvers lines mentioned above) were measured with a tape measure.

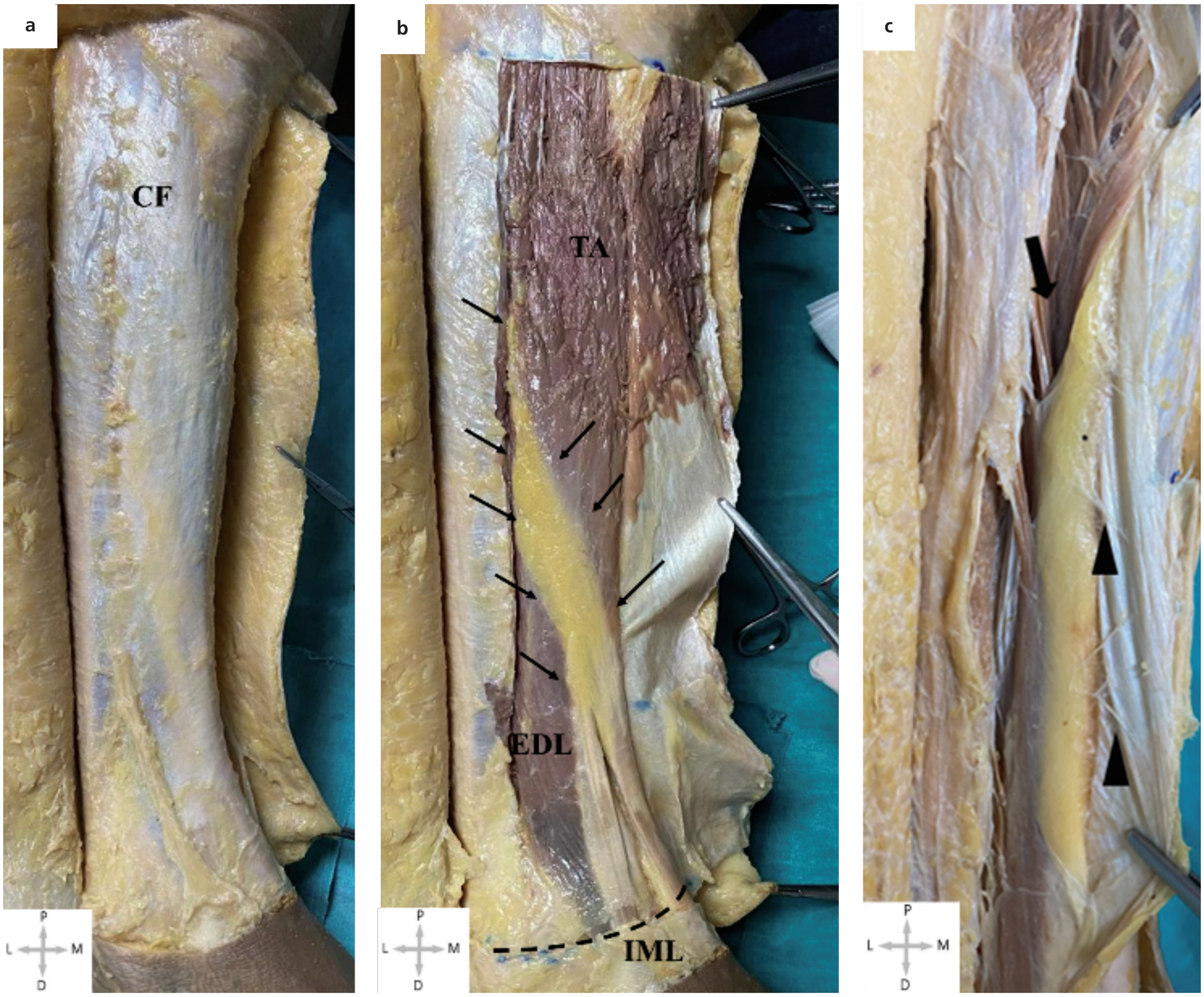

Figure 1. (**a**) Crural fascia after dissection of the skin. (**b**) A complete view of IMATS (**arrows**). (**c**) Fibrous fibers between the CF and IMATS (**arrow heads**), there is no fat tissue between the muscle fibers (**bold arrow**). **CF:** crural fascia; **EDL:** extensor digitorum longus muscle; **IML:** intermalleolar line; **SFN:** superficial fibular nerve; **TA:** tibialis anterior muscle.

The conformity of the variables to normal distribution was examined by Shapiro-Wilk and Skewness-Kurtosis. Descriptive statistics were presented using mean and standard deviation (**Table 1**). Since the metric data were found to be normally distributed, comparisons according to sex were evaluated with independent samples t-test, comparisons according to side were evaluated with paired samples t-test (only for bilateral cases), and correlation analysis was evaluated with Pearson's correlation coefficient. Significance level was taken as $p<0.05$.

Relations of the upper end, lower end with the largest point and the level of connecting vein attachment to the IMATS were evaluated with the Spearman's correlation test. Descriptive statistics for these parameters were given as ratio and percentage.

Results

IMATS was distinguished in all legs, extending obliquely from top to bottom and from lateral to medial, with the majority of its in the lower half of the anterior compartment. It was connected to the fascia by loose connective tissue that could be easily dissected even with a gentle blunt dissection. A few slightly resistant tight connective tissue strands extending from the IMATS to the fascia were rarely present (**Figure 1c**). In all cases, one to three connecting veins attached to the IMATS were detected by

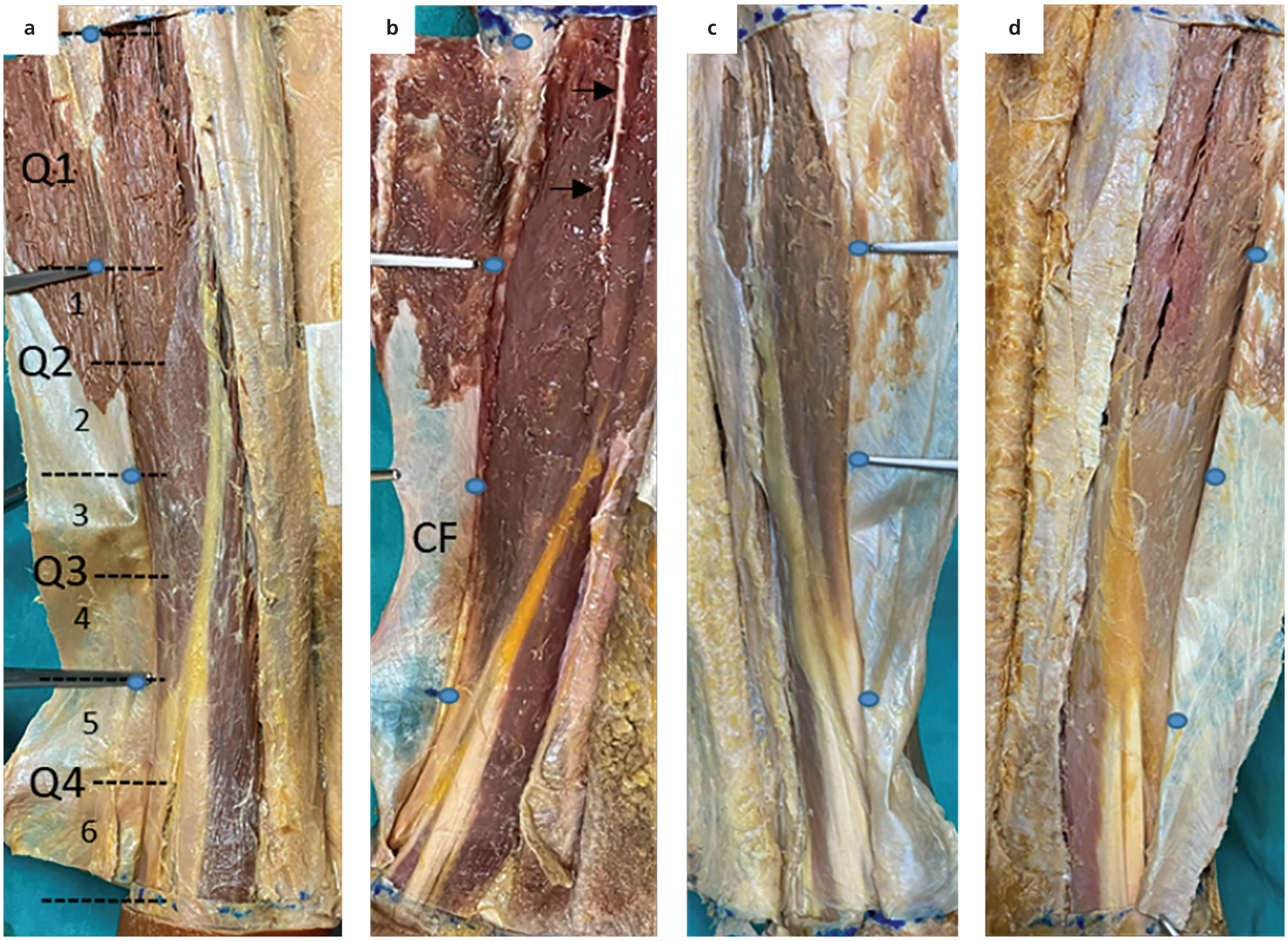

Figure 2. Description of six regions and appearances of the four types of IMATS. (**a**) Slim-long type (left side of a female cadaver). (**b**) Slim-short type (left side of a male cadaver) (**black arrows:** septum between TA and EDL). (**c**) Large-long type (right side of a female cadaver). (**d**) Large-short type (right side of a male cadaver). **1-6:** zones; **blue dots:** ¼ cut points for segmentation of the anterior compartment; **CF:** crural fascia deviated medially; **Q1:** first quarter; **Q2:** second quarter; **Q3:** third quarter; **Q4:** fourth quarter of the anterior compartment.

piercing the CF in a location appropriate to the oblique course of the IMATS (**Figure 3**).

The course of IMATS showed a near-longitudinal oblique continuity over the tendon, myotendinous junction, and the muscular portion of the EDL and/or TA, without any segmentation or interruption (**Figure 1**). IMATS, which was always flat, was located superficial to both of the tendons of the EDL and TA in 13 legs, and only superficial to the EDL tendon in 6 legs. The largest part of the IMATS, usually located in the lower half of the leg. In only one case, the lower end of the IMATS divided at the distal ¼ part; its medial end extended superficial to the TA tendon, and its lateral end superficial to the EDL tendon.

As such, the IMATS resembled a mass independent of epimysial continuity, forming a well-defined space, along a certain oblique line between the muscle and the CF, albeit of variable size, rather than a fatty mass dispersed throughout the compartment. It did not show any division conforming to the intermuscular border, i.e., the integrity of the IMATS body was not interrupted between the muscles or at the ventral-tendon transition points (**Figure 1c**).

According to appearance, large-short type (n=9/20, 45%) and slim-long type (n=5/20, 25%) were common, while slim-short type and large-long type were less common (for both n=3/20, 15%).

The widest part of the IMATS was wider in males than females (p=0.041 and the distance from the distal end to the anterior edge of the tibia was longer in males (p=0.049). Considering that limb length is also different according to gender, when the difference between genders

Table 1
Descriptive statistics and independent samples t-test results according to sex.

		Sex	n	Mean	SD	p-value
Extremity length (cm)		Male	13	94.46	3.13	**0.0001***
		Female	7	81.86	2.48	
Leg length (cm)		Male	13	31.35	1.41	**0.0001***
		Female	7	27.00	1.29	
SSTt (mm)		Male	13	2.30	0.81	0.450
		Female	7	1.98	1.06	
IMATS parameters	*Distal end – IML (mm)*	Male	13	75.08	18.36	0.845
		Female	7	73.42	16.89	
	IMATS length (mm)	Male	13	116.00	29.51	0.101
		Female	7	90.67	34.43	
	Width at the largest part (mm)	Male	13	12.91	5.14	**0.041***
		Female	7	8.44	1.87	
	Distal end – AMT (mm)	Male	13	14.23	4.04	**0.049***
		Female	7	10.87	1.36	
Normalized by extremity length	*Width at the largest part /extremity length*	Male	13	0.14	0.05	0.130
		Female	7	0.10	0.02	
	Distal end – AMT /extremity length	Male	13	0.15	0.04	0.321
		Female	7	0.13	0.18	

*p<0.05. **AMT:** anterior margin of tibia; **IML:** intermalleolar line, **SSTt:** skin-subcutaneous tissue complex.

was compared by calculating the ratio of these parameters to limb length, no significant difference was found between males and females for both variables (p=0.130, p=0.321, respectively) (**Table 1**).

There was no significant difference between the sides in terms of parameters related to the size and location of IMATS or in terms of limb and leg length (p>0.05).

According to Pearson's correlation coefficient, there was a negative correlation between the length of SSTt and IMATS and the distance of the lower end of IMATS to the intermalleolar line, and a weak positive correlation between the total length of the limb and the width of the largest point of IMATS. However, no significant correlations were found for the other parameters (**Table 2**).

Table 2
Relationship between the parameters by Pearson's correlation analysis.

	Leg length	Distal end – IML	IMATS length	Width at the largest part	Distal end – AMT	SSTt
Extremity length (cm)	**0.893*** (p=0.0001)	0.128 (p=0.589)	0.309 (p=0.184)	**0.566*** (p=0.009)	0.348 (p=0.133)	0.225 (p=0.340)
Leg length (cm)		0.139 (p=0.558)	0.398 (p=0.082)	0.439 (p=0.053)	0.426 (p=0.061)	0.112 (p=0.639)
Distal end – IML (mm)			**-0.540†** (p=0.014)	-0.026 (p=0.912)	0.216 (p=0.360)	**-0.467†** (p=0.038)
IMATS length (mm)				0.278 (p=0.236)	0.082 (p=0.731)	0.396 (p=0.084)
Width at the largest part (mm)					0.266 (p=0.258)	0.241 (p=0.307)
Distal end – AMT (mm)						0.000 (p=0.999)

*p<0.01; †p<0.05. **AMT:** anterior margin of tibia; **IML:** intermalleolar line; **SSTt:** skin-subcutaneous tissue complex.

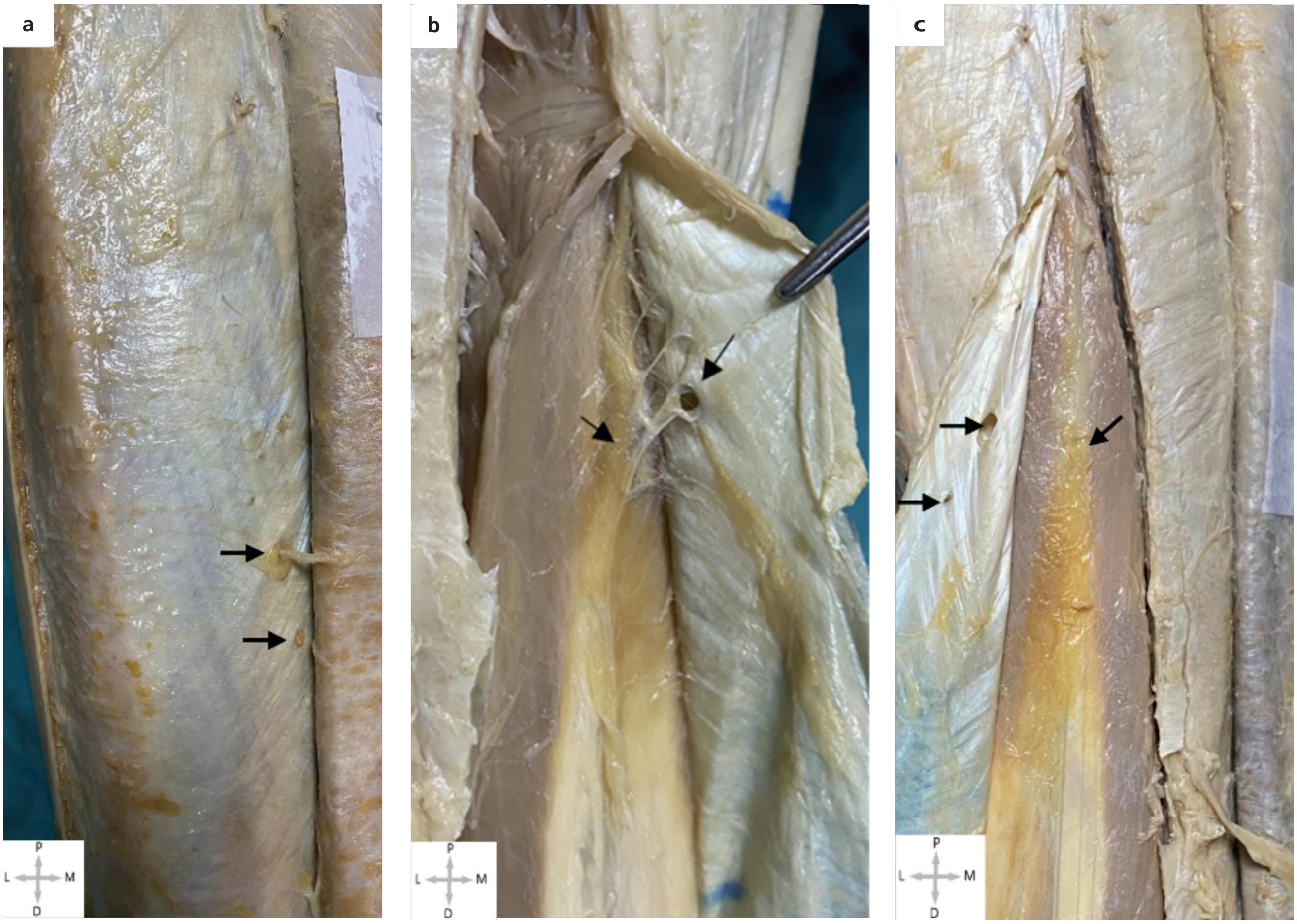

Figure 3. Relationship of the connecting vein between the superficial and deep veins with IMATS and CF (**a**) after skin-superficial fascia complex deviated laterally, appearance of the connecting vein piercing the crural fascia. (**b**) Connecting vein (**arrow**) from the inner aspect of CF attached to the IMATS. (**c**) After cutting the connecting vein, its hole on the crural fascia and its mark at the upper end of the IMATS.

Findings on segmental localization showed that the upper end of IMATS was located in zone 1 and zone 2 in 85% of cases and the lower end in zone 4 in 75% of cases. The level of connecting vessel attachment was most frequently located in zones 2–4 (n=16/20, 80%) (**Table 3**). Neither the upper and lower end of IMATS nor the appearance subtypes were significantly associated with the level of connecting vessel attachment ($p>0.05$).

The connecting vein findings regarding the location of the IMATS showed that in cases where the upper end of

Table 3
Distribution of the certain points on the zones.

	Q2 part		Q3 part		Q4 part		Total
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Upper end of the IMATS	7 (%35)	10 (%50)	3(%15)	-	-	-	20 (%100)
Lower end of the IMATS	-	-	-	15 (%75)	5 (%25)	-	20 (%100)
Largest point of the IMATS	-	3 (%15)	7(%35)	9 (%45)	1 (%5)	-	20 (%100)
Connecting vein point	2 (%10)	7 (%35)	5 (%25)	4 (%20)	2 (%10)	-	20 (%100)

the IMATS was at zone 1, the connecting vein attachment point was most frequently at zone 2 (n=4/7, 57.1%). In those with the upper end at zone 2, the vein attachment point was most frequently at zone 2 and 3 (n=9/10, 90%). In the cases with the upper end at zone 3, the vein attachment point was located at the zone 4 (n=2/3, 66.7%). Accordingly, the vein attachment point was mostly located in the two zones closest to the upper end of IMATS (n=15/20, 75%). In cases with the lower end was at zone 4, the connecting vein attachment level was most frequently at zone 2 and 3 (n=9/15, 60%), while in those with the lower end at zone 5, the vein attachment level was almost equally distributed at zone 2 and 3. In cases with the lower end is at zone 4, the connecting vein attachment level was most frequently at zone 2 and 3 (n=9/15, 60%). In those with the lower end at zone 5, the vein attachment level was almost equally distributed at zone 2 to 5. In cases with slim IMATS, the venous attachment point was mostly found at zone 2 and 3 (n=6/8, 75%). Similarly, in cases with large IMATS, it was most frequently located at zone 2 to 4 (n=9/12, 75%). In cases with long type, the vein attachment level was mostly located at zone 1 to 3 (n=6/8, 75%), while in cases with short type, the vein attachment point was most frequently located at zone 2 to 4 (n=11/12, 91.7%). There was no significant relationship between largest point and vein entry levels ($p>0.05$).

There was no statistically significant relationship of the IMATS upper or lower end levels with the largest part of IMATS ($p>0.05$). The largest part of IMATS was closest to the lower end of IMATS in 75% of the cases: In cases with the lower end in zone 4, the largest point was in zones 3 or 4 (n=13/15, 86.7%). In cases with the lower end in zone 5, the largest point was in zone 4 (n=2/5, 40%). The largest point was more frequently located in the zone 3 and 4s for both slim types (n=6/8, 75%) and large types (n=10/12, 83.3%). This point was also more frequently found in the same zones (3rd and 4th zones) for both long (n=6/8, 75%) and short types (n=10/12, 83.3%).

Discussion

All of the cadavers dissected in our study had IMATS, an intermuscular adipose tissue mass located in the anterior compartment, mostly in the mid-lower leg, and almost always along the same longitudinal boundary line. The largest portion of the IMATS was located mostly in the upper regions of the lower half of the leg. Morphological features of the IMATS, such as its continuation superficial to the TA and EDL, independent of muscle-muscle or muscle-tendon boundaries, and its consistent association with at least one connecting vein perforating the CF, specify the developmental characteristics of the IMAT.

The only study we could find mentioning an IMAT in the anterior compartment is the ultrasound and dissection study by Ortiz-Miguel et al.[22] which states that this mass enters between the TA and EDL tendons and separates them. According to our observations, IMATS was not inserted between the tendon or muscle fiber groups but was located in the superficial part of the muscle fibers and tendons and surrounded by an epimysial cover. Vettor et al.[5] reported that close anatomical contact between fat and muscle cells can elicit a reciprocal effect and that various myokines and metabolites in muscle can influence IMATS function.

There are conflicting statements regarding the relationship between IMAT dimensions and the amount of subcutaneous fatty tissue.[10,24] Fairclough et al.[24] reported that there was no correlation between the thickness of the subcutaneous fat tissue in the lateral thigh and the IMAT deep in the iliotibial band and suggested that the properties of the IMAT are constant, similar to the Hoffa fat pad, palmar and sole fat pads. In our study, while there was no correlation between SSTt and IMATS dimensions in our study, there was a weak correlation such that the distal end of IMATS approaches the intermalleolar line as SSTt increases, suggesting that the IMATS area may be expanding as the subcutaneous thickness increases. Nevertheless, for a stronger conclusion regarding the IMATS-subcutaneous tissue relationship, subcutaneous fat tissue measurements of different regions (thigh, abdominal wall, etc.) in non-formalin-fixed tissue need to be compared with IMATS dimensions.

It is controversial in the literature whether the amount of IMAT varies by sex. According to Manini et al.[7] thigh and calf IMAT volume is less in healthy young adult men than in women. Goodpaster et al.[10] reported that although women have more subcutaneous thigh fat tissue, there is no difference between sexes in terms of IMAT volume, and Katsiaras et al.[9] also found no difference between genders in terms of thigh IMAT cross-sectional area. Döner et al.[25] found that the IMAT surface area in the Kager triangle of the leg was greater in male. In our study, IMATS width and distance to the anterior edge of the tibia were greater in male. However, regarding their weak correlations with extremity length, which is greater in men, when we proportioned these IMATS parameters to extremity length, it was noteworthy that the sex difference disappeared. Döner et al.[25] found no side differences for the Kager fat pad, an example of IMAT. Similarly, in our study, no side differences were detected in IMATS parameters.

The mechanisms that change the fate of the differentiation process of satellite cells around myofibrils, which are considered as the source of IMAT, towards adipocytes are not clear. It is suggested that, in addition to many factors, mechanical effects and local cellular changes due to trauma also play a role in this.[5] The definition of IMAT as the visible storage of fat deposits resulting in the infiltration of adipose tissue between muscle fibers[4] may suggest that IMAT will be intertwined with the muscle mass from which it originates. Our findings, such as the fact that IMATS is mostly located to the outer surface of both EDL and TA without being segmented, confined along a narrow, oblique line and that it is not inserted between muscle fibers, indicate that the origin and growth history of IMATS cannot be explained only by molecular mechanisms, independent of the anatomical features of the compartment.

Adipocytes that differentiate from satellite cells or other stem cells to form IMATS appear to accumulate in a "selected area" rather than randomly within the compartment. Then, the factors that determine the "selected area" (is it an anatomical potential space, is it an area where the surrounding tissues are more exposed to friction and trauma due to the intensity of tendon movements, is it an area where the CF is less elastic, so requiring elasticity compensation? etc.) requires further research at the anatomical, biomechanical and molecular levels.

The vascular microenvironment is known to play an important role in controlling the fate of normally quiescent satellite cells, a specialized population of stem cells. Satellite cells are anatomically located close to capillaries and therefore can differentiate through molecular interaction with endothelial cells.[26] It has been shown that satellite cells can differentiate into myogenic lineages under different stimuli or into adipogenic lineages using alternative mesenchymal differentiation pathways.[5] Our findings of a constant spatial relationship of 1–3 connecting veins to the IMATS in each case, regardless of the size or type of the IMATS, are remarkable. This relationship, when evaluated together with the literature that satellite cells can differentiate depending on vascular-derived factors and turn into adipose tissue (i.e. IMAT) as well as myocytes, strengthens the claim that these vessels may be associated with the development of IMATS in a specific area in the anterior compartment. More research is needed to clarify the dimensions of such a relationship.

IMAT is considered to have the functions like fill potential anatomical gaps by deforming when a force is applied, to support movement between tendon or ligament and bone, to play a mechanical role due to the presence of a large number of nerve endings in the adipose tissue at the attachment sites, to reduce the load applied to each unit and neurovascular structures and to act as a shock absorber that distributes stress.[1,27,28] Our observations regarding IMATS were that it was a mass that, as its size increased, made room for itself between the muscles and CF on a certain line in the distal half of the compartment, rather than a mass filling an already existing anatomical space between the muscles.

In our previous study, in which we showed that the horizontal elasticity of the CF decreases towards the distal, it was suggested that the traumatic effect of the traction force applied to the CF may be greater in the mid-lower leg.[29] The location of IMATS, deep in the area with lower fascial elasticity, may be the "selected area" to absorb the traumatic effect of the pulling force of the CF. On the other hand, considering that satellite cells of muscles exposed to intense exercise or trauma can differentiate in an adipogenic direction, with the participation of neutrophils and macrophages in the regeneration and repair process and by mechanisms that have not yet been determined,[6] a local repetitive stress in the area may predispose to the formation of such fatty tissue.

It is known that the loading that the lower extremity is exposed to during aerobic exercises such as brisk walking, running, cycling can cause chronic injury, not alone but when combined with a repetitive cyclic pattern.[30] It is thought that the complaint of pain due to medial tibial stress syndrome along the posteromedial tibial border may be a result of inflammation of the IMAT in that area.[21] Considering that during performance, IMATS plays a role in absorbing the load and in distributing the load to the muscle-bone-fascia trio in the leg, it can be inferred that IMATS inflammation due to stress also plays a role in performance-related anterior middle-lower leg pain.

The limitations of the study are that the exposure of the embalmed cadavers to formaldehyde for different periods of time is a factor that may affect the fat volume in the tissue. However, it has been assumed that subcutaneous and intermuscular fatty tissues are equally exposed to this chemical. Volume measurement for IMATS could not be included in the study's method. Histological comparison of IMATS with fat pads such as Hoffa and Kager, whether it contains pain receptors or plays a proprioceptive role was not included in this study and may be the subject of future studies. IMATS was compared with the subcutaneous tissue in the area closest to the area. Whether IMATS dimensions changes in correlation with subcutaneous fat tissue thickness in the same person can be more reliably revealed by taking tissue from other parts of the body (e.g. thighs, abdominal wall, etc.). Only the fat pad superficial to the muscles was evaluated, and deeper fat deposits in the anterior compartment were not considered.

Conclusion

In this study, it was demonstrated that the IMATS is always located subfascially in a fixed, limited area on an oblique line running from lateral to medial top to bottom in the mid-lower part of all anterior compartments and does not penetrate between muscle fibers. The largest point of the IMATS is usually located in zones 3 or 4 and in the two zones closest to the lower end of the IMATS. It is still unclear why the IMATS always develops along a limited and almost identical longitudinal line and what determines whether it is short or long, wide or thin. The remarkable implication of the study is that this location of the IMATS overlaps with the CF region, which is biomechanically stiffer in the transverse direction as described in our previous study. The fact that a connecting vessel is always connected to the IMATS along a fixed longitudinal line, albeit at variable levels, is a finding that reinforces the idea that the developmental history of both the IMATS and the vessel may intersect.

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All authors contributed equally to protocol/project development, data collection, data analysis, manuscript writing/editing.

Ethics Approval

This study was approved by the Clinical Research Ethics Committee (26.04.2023-287) and supported by Mersin University Scientific Research Projects Unit (2023-1-TP2-4903).

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Unilateral linguofacial trunk

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Abstract

The external carotid artery is the main artery of the head and neck region. It has eight branches, and there are various variations in the emergence and distribution of these branches. In particular, frequent changes can be observed in the emergence of facial artery, and lingual artery. Knowledge of the vascular anatomy of the lingual artery and facial artery is important in terms of neck surgery and radical treatments. For this reason, in the present case report we aimed to report a case with linguofacial trunk and its morphometric and morphological features.

Keywords: external carotid artery; facial artery; lingual artery; linguofacial trunk

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Introduction

The common carotid artery (CCA) divides into external and internal carotid arteries at the upper edge of the thyroid cartilage about the level of the intervertebral disc between the 3rd and 4th vertebrae. The external carotid artery (ECA) serves as the main artery of head and neck region. The ECA also plays an important role in providing collateral blood supply to the brain through the many connections between the branches of the ECA and cranial branches of the internal carotid artery (ICA) and vertebral arteries.[1] The ECA has eight branches: superior thyroid artery, ascending pharyngeal artery, lingual artery, facial artery, occipital artery, posterior auricular artery, superficial temporal artery, and maxillary artery.[2]

It is known that ECA has many variations in the distribution of its anterior branches, including superior thyroid artery (STA), facial artery (FA), and lingual artery (LA).[3] These anterior branches present to form common origins named as: thyrolinguofacial trunk, thyrolingual trunk, and linguofacial trunk.[4] The linguofacial trunk, when present, is located above the superior thyroid artery, which appears to be the most common variation.[5,6] In the previous studies, the presence of linguofacial trunk (LFT) has been reported in a wide range of incidence between 6% and 20%.[6]

Knowledge of the vascular anatomy of the LA and FA has utmost importance for surgical, radiological, and diagnostic procedures of the head and neck region. In the present manuscript, we aimed to report a case with unilateral LFT and provide more information about the origin, course, and anatomical relationships of the LFT related to the head and neck anatomy.

Case Report

Anatomical variations of the branches of the external carotid artery were encountered during routine neck dissection of a 67-year-old male cadaver obtained from Dokuz Eylül University Medical Faculty Anatomy Laboratory. The cadaver was fixed with formaldehyde from the left common carotid artery. The cadaver was placed in the supine position and measurements were made using a Mitutoyo digital vernier caliper sensitive to 0.01 mm.

The skin, superficial fascia with platysma, and deep fascia were dissected. The distance between the hyoid bone and mental protuberance was 48.51 mm, and the distance between the hyoid bone and jugular notch of sternum was 82.16 mm. Hypoglossal nerve was preserved on both sides. The sternocleidomastoid muscle was cut about its midline on the left side and preserved on the right side.

The formation of the branches of the ECA was in the common anatomical pattern on the left side (**Figure 1**). The distance between the origin of the LA and the carotid bifurcation was 10.42 mm. The vertical distance between

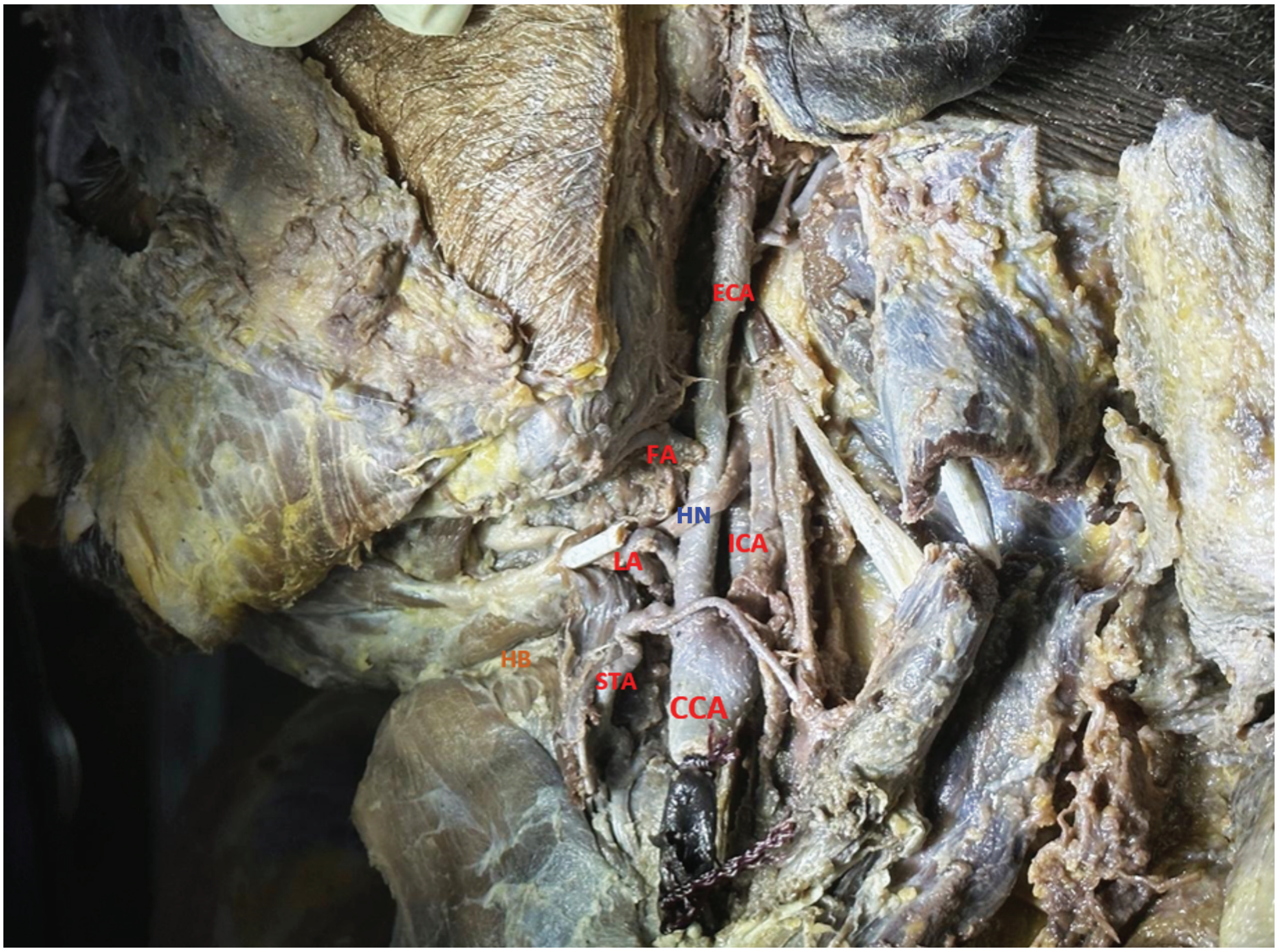

Figure 1. Facial artery and lingual artery emerging separately from the ECA, left side. **CCA:** common carotid artery; **ECA:** external carotid artery; **FA:** facial artery; **HB:** hyoid bone; **HN:** hypoglossal nerve; **ICA:** internal carotid artery; **LA:** lingual artery; **STA:** superior thyroid artery.

the origin of the LA and the horizontal plane passing over the carotid bifurcation was 5.07 mm; the vertical distance between the LA and the horizontal plane passing over the hyoid bone was 7.89 mm. The distance between the FA and the carotid bifurcation was 21.75 mm. The vertical distance between the origin of the FA and the horizontal plane passing over the carotid bifurcation was 19.93 mm; the vertical distance between the FA and the horizontal plane passing over the hyoid bone was 51 mm. On the right side (**Figure 2**), FA and LA branched from a common trunk. The length of the LFT was 9.19 mm. The distance between the origin of the LFT and carotid bifurcation was 21.44 mm, the vertical distance between the origin of the LFT and the horizontal plane passing over the carotid bifurcation was 16.23 mm. The vertical distances from the origin and bifurcation points of the LFT to the horizontal plane passing over the hyoid bone were 13.15 mm and 24.30 mm, respectively.

Discussion

The reasons behind the variations of the external carotid artery and its branches are not fully understood. Variations may be due to some deviations that occurred during the embryological process. The development of the variations begins with the combinations of the following factors: outgrowths from some vessels, involution of others, and assimilation of pre-existing channels that arise from undifferentiated precursor vessels.[5] Although these anatomical variations might remain unnoticed, they become more crucial when there are pathological cases, for instance, loss of elasticity or development of an aneurysm in the trunk.[7] In this case report, we aimed to represent a case with unilateral LFT.

In a recent study, Devadas et al.[5] studied with 40 cadavers and examined the variations of the branches of ECA in the neck. In this study, the anterior branches of

Table 1
The reported incidence of LFT in previous studies.

Study	Evaluated case number	Lingo-facial trunk (%)
Zumre et al.[7] (2005)	20	20
Ozgur et al.[8] (2008)	94	7.5
Sanjeev et al.[10] (2010)	119	18.92
Devadas et al.[5] (2018)	40	21.25
Lucev et al.[4] (2000)	20	20
Shintani et al.[11] (1999)	31	31
Gupta and Agarwal[12] (2013)	30	11.3

the ECA were reported in their normal branching pattern on 63 sides (78.75% of the total 80 cases). In the remaining 17 sides (21.25% of the total 80 cases), the formation of common trunks was observed, and the linguofacial trunk was reported as the most common variation. The linguofacial trunk was observed on 16 sides, and the thyrolinguofacial trunk was observed on one side. In this study, the LFT was observed bilaterally in 5 cadavers (12.5% of the total 40 cadavers) and unilaterally in 6 cadavers (15% of the total 40 cadavers). Similar to Devades et al., ECA and its variations have been studied in various studies. The incidences of the presence of the LFT have been reported to vary between 7.5–31% (**Table 1**).

In the present case, the LFT length was measured as 9.19 mm. In previous studies, Özgür et al.[8] reported this length as 11.46 mm, 6.58 mm and 4.36 mm in 3 cases; Fazan et al.[9] reported the mean length as 9.4 mm on the right and 7.6 mm on the left in 18 cases; Troupis et al.[6] measured the LFT length in one case and reported it as 7.3 mm. The length of the LFT varies between 4.36 mm and 11.46 mm according to the literature. In addition, the distances between the carotid bifurcation and the starting point of the LFT were reported as 7.9 and 11.6 mm by Fazan et al.[9] and Troupis et al.[6] respectively. In our case, the distance between the carotid bifurcation and the origin was 21.44 mm. Fazan et al.[9] reported that the ECA bifurcation was higher in their cases. In our cadaver, the bifurcation of the common carotid artery was at the upper level of the thyroid cartilage on the right and at the level of the os hyoideum on the left. We aimed to localise the origin of the LFT and triangulation points defined as the mental process, hyoid bone and jugular notch were used to assess the length of the neck. The distance between the carotid bifurcation and the sternoclavicular joint was 81.28 mm on the right and 84.25 mm on the left.

Figure 2. Representing the variation af facial and lingual artery branching from the linguofacial trunk, right side. **CCA**: common carotid artery; **ECA**: external carotid artery; **STA**: superior thyroid artery; **LA**: lingual artery; **FA**: facial artery; **LFT**: linguofacial trunk.

In conclusion, knowledge of the variations of the ECA and its branches is important from a surgical and radiological point of view. Clinicians should be aware of these variations when performing head and surgical, maxillofacial surgery, radiological and diagnostic procedures.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

All authors contributed equally.

Ethics Approval

The authors hereby confirm that every effort was made to comply with all local and international ethical guidelines and laws concerning the use of human cadaveric donors in anatomical research.

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Anatomical variation of the median nerve and accompanying subclavius posticus muscle: a cadaveric case report

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Abstract

The median nerve and subclavius muscle are two critical neuromuscular structures of the upper extremity. Although their anatomical variations are well described in the literature, a case report involving both anatomical variations in the same extremity is rare. Here, we report a case involving different anatomical variations in the median nerve formation and aberrant subclavius posticus muscle. During routine dissection, a rare anatomical variation was encountered in the left upper extremity of an adult male cadaver. In this case report, we observed two distinct findings in the left upper extremity of a 66-year-old male cadaver: a variant basilic vein passing between the lateral and medial roots of the median nerve and the presence of the subclavius posticus muscle. To our knowledge, a case involving an unusual basilic vein passing between the lateral and medial roots of the median nerve and an aberrant subclavian posticus muscle in the same extremity has not been reported to date. Knowledge of such variations may be useful for surgeons in avoiding iatrogenic injuries during anaesthetic and surgical procedures around the axilla and arm.

Keywords: anatomical variation; basilic vein; median nerve; subclavius posticus muscle

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Introduction

The median nerve (MN) is formed by the medial root from the medial cord and the lateral root from the lateral cord of the brachial plexus and converges anterior or lateral to the axillary artery.[1–7] The literature has extensively documented variations in MN formation since the early 1900s. Since then, there have been several case reports on anatomical variations of the median nerve roots.[1,3,4] But these studies are mainly based on variations of the median nerve formations and its relation to arteries in the arm and axilla. The current study highlights the presence of different anatomical variation at median nerve formation and describes a rare form of musculature anomaly.

The subclavius posticus muscle (SPM) is an aberrant muscle originating from the superomedial aspect of the first rib reaching to superior border of the scapula. This muscle has been reported to cause dynamic compression of either the brachial plexus or the subclavian vessels depending on its activation. The SPM's proximity to neurovascular structures suggests its potential role in thoracic outlet syndrome.[6,8]

It is important to know and report such anatomical variations of the median nerve with the basilic vein to avoid damage to the nerve during surgical treatment or anaesthetic procedures.[1] To our knowledge, there is no cadaveric study showing the relationship between the median nerve and the basilic vein. In this paper, we describe the relationship between the median nerve roots and the basilic vein and the location of the subclavius posticus muscle on the same side on a cadaver.

Case Report

During routine dissection of the left upper extremity of a 66-year-old man in 2023 in the dissection laboratory of

Istinye University Department of Anatomy, we observed a variant basilic vein passing between the lateral and medial roots of the median nerve and an aberrant subclavius posticus muscle. Both sides of the cadaver were dissected according to Cunningham's Manual of Practical Anatomy. No variation was observed in the right upper extremity. The skin, superficial fascia and deep fascia were separated, the middle part of the clavicle was removed and various muscles were projected to visualize the formation and variation of the median nerve. Photographs of the dissection procedures were taken for proper documentation (**Figure 1**). The medial and lateral cord branches of the brachial plexus were carefully dissected; their course and formation were noted and photographed (**Figure 2a**). During its short passage in the axillary fossa, the median nerve travels posterior to the pectoralis major and minor muscles and anterior to the subscapularis muscle. After crossing the ulnar nerve anteriorly, it leaves the axillary fossa under the inferior edge of the pectoralis major muscle and travels down the lower arm between the musculocutaneous nerve and the brachial artery. In the upper arm, the basilic vein is normally parallel to and medial to the course of the median nerve and its branches. Proximally, it drains into the axillary vein. The basilic vein does not ascend above the normal passage in the left arm. In the upper arm, the basilic vein travelled parallel to the musculocutaneous nerve, starting at the lateral border of the axilla and crossing the brachial artery anteriorly. The basilic vein travelled between the two roots of the median nerve to its junction with the axillary vein (**Figures 2a** and **b**). The course and branches of the median nerve in the forearm and hand were found to be normal. During dissection around vascular and nerve structures, the subclavius posticus muscle, which runs parallel to the cephalic vein, was also incidentally detected (**Figure 2b**).

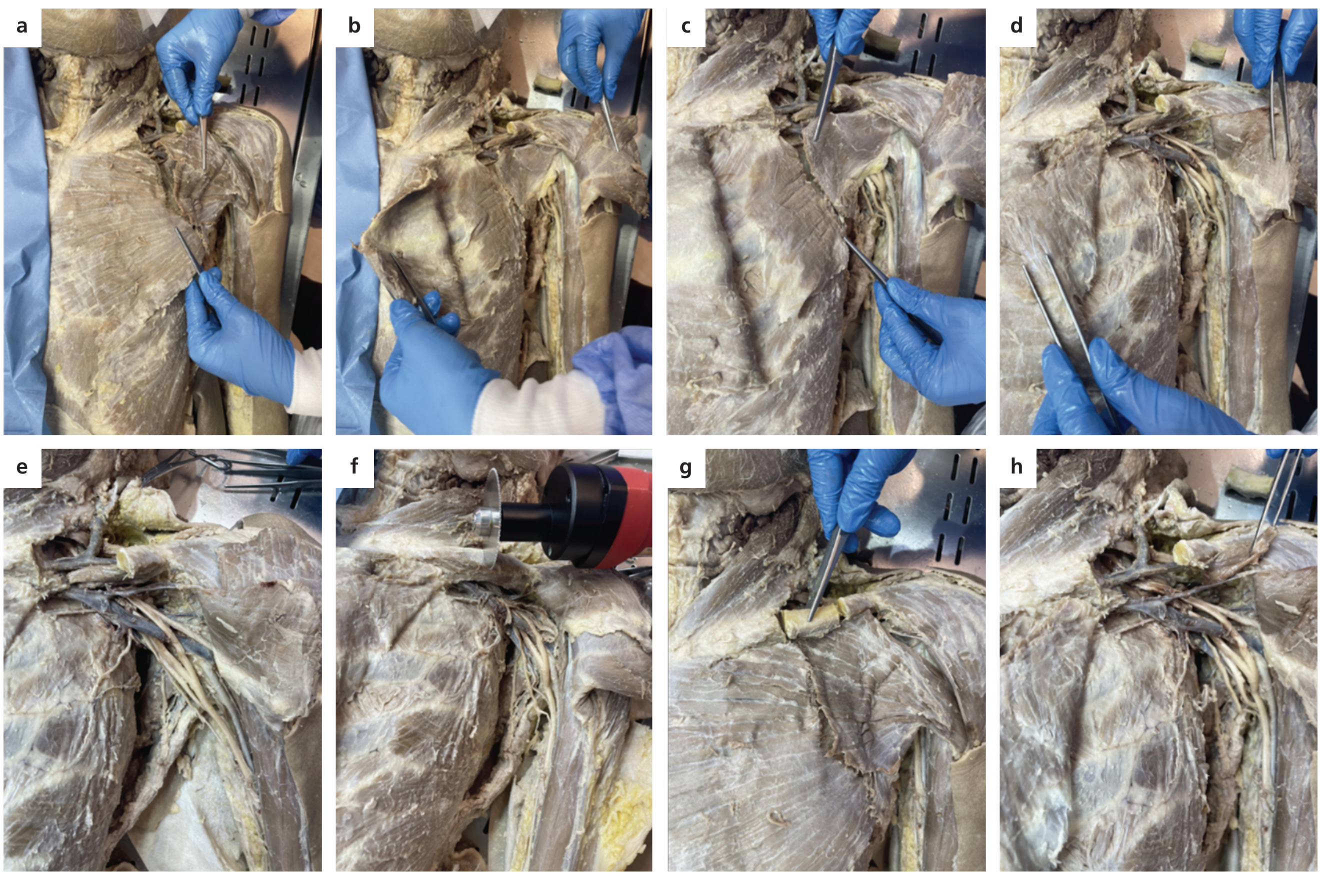

Figure 1. Step-by-step dissection of the axilla and brachial plexus after removing skin and superficial fascia. (**a**) identifying the pectoralis major muscle and cutting it from the midline; (**b**) retracting the pectoralis major muscle; (**c**) identifying the pectoralis minor muscle and cutting it from the midline; (**d**) retracting the pectoralis minor muscle; (**e**) reviewing the parts of the brachial plexus with cords and terminal branches, as well as locating vessels; (**f**-**g**) removing the middle third of the clavicle with oscillating saw; (**h**) retracting the subclavian muscle laterally.

Discussion

Anatomical variations of peripheral nerves pose a potentially important anatomical, clinical and surgical problem. One of these, the median nerve, is formed by the union of two roots, the lateral root and the medial root, which come from the lateral and medial cord of the brachial plexus, respectively, but the location of this union can vary. However, it has been found that both cords can merge most commonly in the axillary fossa.[2,3] Normally the basilic vein crosses the median nerve and unites with the brachial vein to form the axillary vein.[5] In the present study we found unusual formation of median nerve involving the basilic vein course that passed in between the two roots of median nerve and no previous study reported this kind of variation of median nerve formation. The course of the basilic vein, in close proximity to the median nerve, puts this structure at risk of injury and may result in pain from repeated cannulation during dialysis. Such moving upward of the basilic vein may impede the blood flow in the vessel during certain movements of the shoulder joint.[1,5]

Furthermore, an interesting finding observed in this case was the presence of the subclavius posticus muscle. During our routine anatomical dissection, the relationship of the median nerve to the subclavius posticus muscle was incidentally observed. The subclavius posticus muscle is a rare abnormal muscle that may be a potential cause of thoracic outlet syndrome because the subclavian vessels and brachial plexus are located inferior to the muscle.[6]

On the basis of embryological development, the variational pattern of the median nerve can be explained. The morphology of the MN originates from embryogenesis. The etiology of median nerve formation, with its potential variants, can be traced back to embryonic development and continues throughout the rest of a person's life.[1,7] The somites forming the limbs migrate and bring their respective nerve. The existence of this anomaly may be hitch on to random factor influencing the mechanism of formation of the limb muscles and the peripheral nerves during embryonic life. It is known that the brachial plexus seems to be a single radicular cone in the

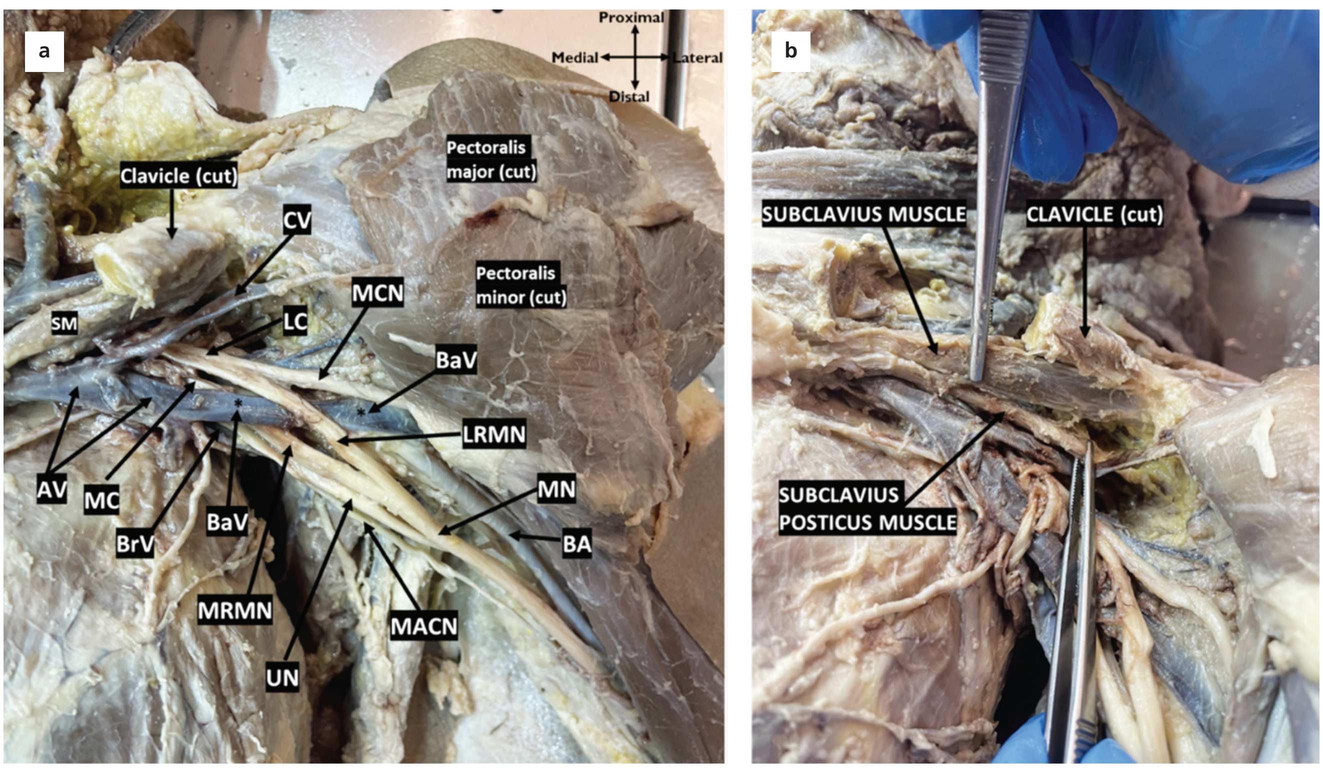

Figure 2. (**a**) Dissection of the left axilla showing the basilic vein (*) passing between lateral and medial roots of the median nerve. **AV**: axillary vein; **BA**: brachial artery; **BaV**: basilic vein; **BrV**: brachial vein; **CV**: cephalic vein; **LC**: lateral cord; **LRMN**: lateral root of median nerve; **MACN**: medial antebrachial cutaneous nerve; **MC**: medial cord; **MCN**: musculocutaneous nerve; **MN**: median nerve; **MRMN**: median root of median nerve; **SM**: subclavius muscle; **UN**: ulnar nerve. (**b**) dissection of the infraclavicular region exhibiting the subclavius muscle along with the subclavius posticus muscle.

upper limb bud. This cone divides longitudinally into ventral (ulnar and median nerve) and dorsal (gives rise to the axillary and radial nerve) divisions.[9,10] A report shows that the abnormal relation of the brachial plexus and its branches can be ascribed to unusual developmental pattern of cords and its divisions in relation to the axillary artery during embryonic life.[1] Embryologically, this variation can be explained by understanding the role of the formation, location, and course of the cords and the median nerve with their communicating branches. It may be also due to the factors influencing the mechanism of action of mesenchymal cells giving rise to peripheral nerves and limb muscles.

There are many case reports in the literature involving different variations of the median nerve and basilic vein, but we could not find a report similar to this case regarding the combined variations of the median nerve and basilic vein. The variations related to the formation of median nerve have been studied and presented by many authors at various times, but these studies are mainly based on median nerve formations by the union of three roots,[1,3,4,10] the arterial relations to the MN formation[4] or a communicating branch from the musculocutaneous to the median nerve.[4,9] In a previous cadaver-based study (42 anatomical bodies), it was concluded that the median nerve presented variation in its formation in 22.6% (three or more roots). These variations were more common in males than females and were bilateral in 19% of all anatomical bodies.[3] During the dissection of a 65-year-old male cadaver, Diramali et al.[2] showed that the medial brachial vein, which should be normally joined with the basilic vein just at the distal of the emergence of the median nerve, joined with the basilic vein after passing through two roots of the median nerve bilaterally. In a study on a 45–year–old male Indian cadaver, Vollala et al.[10] reported that on the left side, the brachial vein passed between the medial and lateral roots of the median nerve and drained into the axillary vein. Our case is a very notable case due to its clinical presentation. On the other hand, in our donor body, a proximity stood out with a study previously reported in a cadaveric case study by Ameet et al.[1] as distinct from our study, brachial vein passed in between the two lateral roots of median nerve.

The variation in the formation of the median nerve is of great clinical importance in terms of both the nerve itself and its relationship with neighboring structures. In the events of trauma and accidents of upper limb or neoplasm these variations may be encountered while repairing the nerves. Surgeons who perform radical neck dissection and other surgical operations in the upper arm and axillary region need to be aware of these anatomical variations.[2,10] Because any injury caused to this nerve in the axilla or upper arm may bring about unforeseen paralysis of the flexor muscle structures of the elbow and hypoesthesia over the area of cutaneous innervation of the median nerve.[1,3] This information may also help in explaining the interpretation of a nerve compression with unusual clinical symptoms. On the other hand, knowing the variations of the basilic vein can reduce the incidence of complications during an intervention aimed at this area.[10] Basilic vein is an acceptable site for venipuncture. Since the course of the vein, in close proximity to the median nerve, knowledge about this variation might be considered by the vascular surgeons when using an arteriovenous graft or fistula for hemodialysis access in patients with kidney failure.[5] For all these reasons, variations in the formation of median nerve and its relation to the basilic vein maybe of critical importance for anesthesiologists and surgeons, while they perform surgical procedures. This is an unusual anatomic variation that is inadequately documented, hereby its frequency is likely underestimated by anatomists and radiologists.

Conclusion

In this case report, we present a case of coexistence of the median nerve and the subclavius posticus muscle in the same individual. This case study demonstrates that both variations are rarely found in a single cadaveric body, a finding that, to our knowledge, has not been reported in the literature. Awareness and detailed knowledge of such an anatomical variation may be crucial to prevent iatrogenic injuries during anesthetic and surgical procedures around the axilla and arm. It also helps to avoid intraoperative confusion in complex traumatic injury patterns.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Author Contributions

SA: dissection, project development, manuscript writing; ID: dissection, project development, manuscript writing and editing.

Ethics Approval

This retrospective case study involving human participants complies with the ethical standards of the institutional and national research committee and the 1964 Declaration of Helsinki and its subsequent amendments or similar ethical standards. All authors have permission for participation and publication. The study was approved by Istinye University Human Research Ethics Committee with registration number 04/2023.K-23/92. As there were no concerns about identifying information, the authors obtained informed consent at Istinye University Bahçeşehir Liv Hospital where the images were obtained. All data used in this study are available for verification upon request.

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On the Front Cover:
Corona mortis anastomosis crossing the bone on the inner surface of the superior pubic ramus (**yellow star**). The closest crossing point between obturator nerve (**ON**) and corona mortis is shown with a **blue arrow**. From Kara ZG, Uz A. Anatomical features of venous and arterial corona mortis in fresh cadavers in the Turkish population and anatomical landmarks to be used during surgical procedures. *Anatomy* 2023;17(3):103–109.

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